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Engineering Specification Guidelines for Wetland Plant Establishment and Subgrade Preparation

by Kenneth P. Dunne, A. Mahendra Rodrigo, Edward Samanns

February 1998 – Final Report

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CP	Critical Processes	RE	Restoration & Establishment
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Wetlands Research Program

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by Kenneth P. Dunne, A. Mahendra Rodrigo,
Edward Samanns

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Final report

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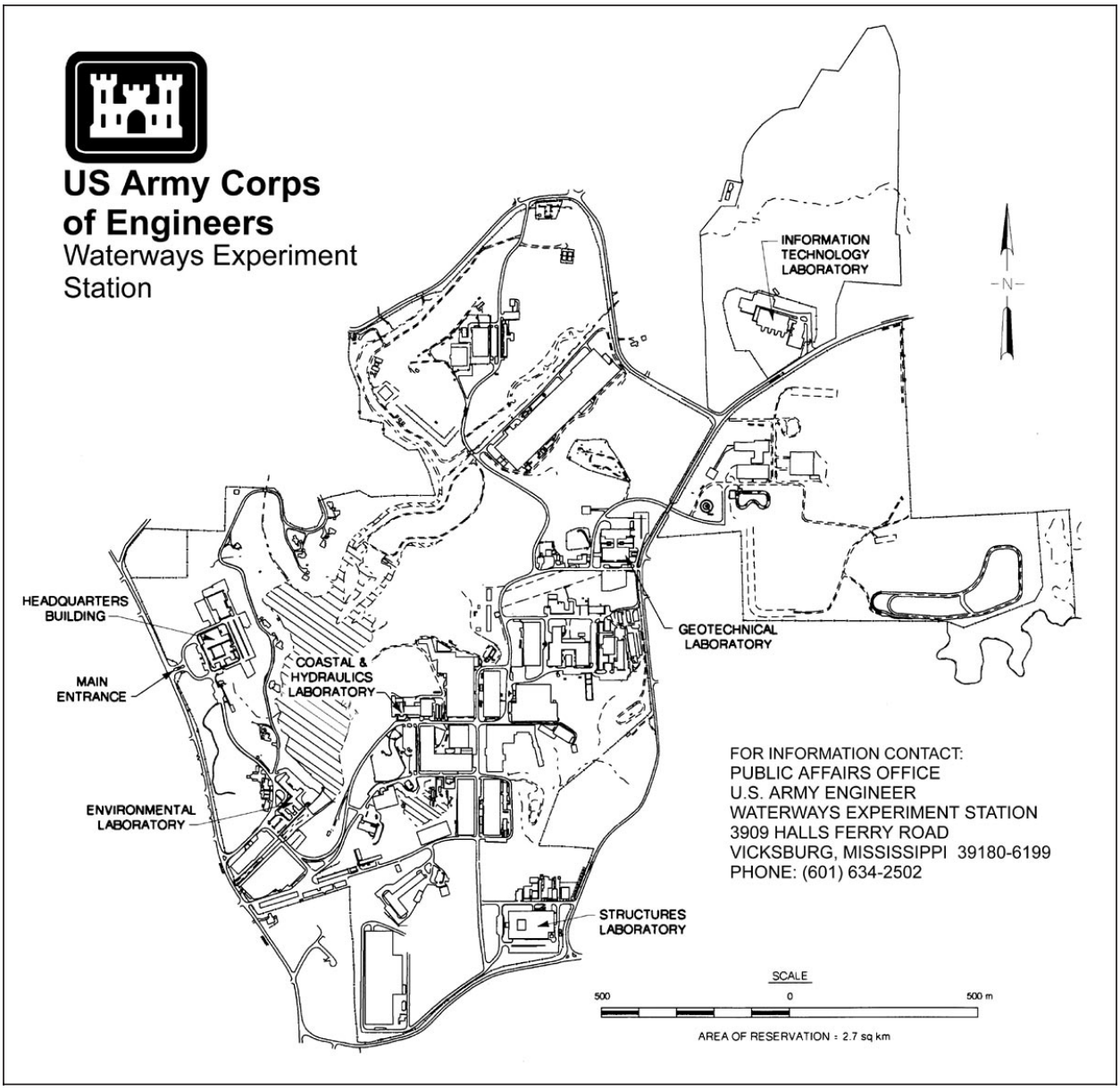

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Wetland Restoration

Engineering Specification Guidelines for Wetland Plant Establishment and Subgrade Preparation (TR WRP-RE-19)

ISSUE:

The creation or restoration of a viable wetland can be difficult to achieve. Often, the lack of success can be attributed to the fact that the contract for wetland establishment was inadequate or not specific enough to achieve the desired wetland function. Specific guidelines for the preparation of contract specifications would greatly enhance the possibility of a viable functioning wetland.

OBJECTIVES:

These guidelines for the development of wetland engineering specifications were compiled for biologists, engineers, and planners at Corps Districts and other agencies involved with wetland construction activities that require contracts. The availability of these guidelines should aid in the development of technically, contractually, and ecologically sound engineering specifications to ensure successful completion of specific tasks involving vegetation and substrate in wetland creation, restoration, and enhancement.

SUMMARY:

This report explains the process involved when proceeding from a wetland mitigation design concept to a full engineering package that is suitable for public bid and advertisement. The information provided is geared toward educating nonengineering professionals engaged in developing wetland mitigation specifications.

AVAILABILITY OF REPORT:

This report is available on Interlibrary Loan Service from the U.S. Army Engineer Waterways Experiment Station (WES) Library, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199, telephone (601) 634-2355.

To purchase a copy, call the National Technical Information Service (NTIS) at (703) 487-4650. For help in identifying a title for sale, call (703) 487-4780. NTIS report numbers may also be requested from the WES librarians.

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Preface

The work described in this report was authorized by Headquarters, U.S. Army Corps of Engineers (HQUSACE), as part of the Wetlands Restoration, Protection, and Establishment Task Area of the Wetlands Research Program (WRP). The work was performed under Work Unit 32760, "Techniques, Structures, and Equipment for Wetland Restoration and Establishment," for which Dr. Michael R. Palermo, U.S. Army Engineer Waterways Experiment Station (WES), was the Principal Investigator. Dr. Mary M. Davis, WES, acted as Project Supervisor. Ms. Denise White (CECW-ON) was the WRP Technical Monitor for the work.

Mr. Dave Mathis (CERD-C) was the WRP Coordinator at the Directorate of Research and Development, HQUSACE; Dr. William L. Klesch (CECW-PO) served as the WRP Technical Monitor's Representative; Dr. Russell F. Theriot, WES, was the WRP Program Manager. Dr. Mary C. Landin, Wetlands Branch (WB), Ecological Research Division (ERD), Environmental Laboratory (EL), WES, was the Task Area Manager.

The report herein was prepared under the direction of Dr. Davis and Mr. Roy Leach, WES, by Messrs. Kenneth P. Dunne, A. Mahendra Rodrigo, and Edward Samanns of The Berger Group, Louis Berger & Associates, Inc., East Orange, NJ, with additional materials provided by Mr. John Zentner of Zentner & Zentner Land Planning and Restoration, Sacramento, CA.

The report was prepared under the general supervision of Dr. Landin, Technical Task Manager; Dr. Morris Mauney, Chief, WB; Dr. Conrad J. Kirby, Chief, ERD; Dr. John W. Keeley, Assistant Director, EL; and Dr. John Harrison, Director, EL.

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Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
acres	4,046.873	square meters
cubic inches	16.38706	cubic centimeters
degrees (angle)	0.01745329	radians
feet	0.3048	meters
Fahrenheit degrees	5/9	Celsius degrees or kelvins[1]
gallons (U.S. liquid)	3.785412	liters
inches	2.54	centimeters
miles (U.S. statute)	1.609347	kilometers
ounces (mass)	28.34952	grams
pounds (mass)	0.4535924	kilograms

[1] To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the following formula: C = (5/9)(F - 32). To obtain kelvin (K) readings, use: K = (5/9)(F - 32) + 273.15.

1 Introduction to Contracts

Mitigation via the restoration or creation of new wetlands is often required as compensation to offset unavoidable wetland losses. The broad concept for such an effort is typically detailed as an attachment to a wetland permit submitted to Federal, State, or local environmental regulatory agencies. Often these attachments will include a conceptual plan for the mitigation. If the permit application is approved, these mitigation efforts are commonly, but not necessarily, developed via contract documents detailing in much greater detail what work is to be done. These documents are prepared by or directly for the permit applicant, and not the regulatory agencies. When plan documents are prepared for public contract bid, written text, called specifications, describing how the work is to be conducted and administered, is included in the bid package. This report will attempt to discuss the concept of contracting in wetland mitigation with emphasis on specifications, while providing limited guidance in the development of mitigation projects.

Aside from the site-selection process, which is probably the most important aspect of a mitigation program, there are four potential areas for quality control within the engineering and landscape segments of a mitigation program: (a) the plans and plan notes, (b) the specifications, (c) the engineer or project representative, and (d) the contractor. The fewer of these elements in the total mitigation program, the greater the probability of quality control problems occurring, and a failure with any one element may result in a diminished project. As indicated in the title, this report will focus primarily on the second element, the specifications, with limited references to other elements. A design sequence for wetland restoration and establishment can be found in Palermo (1982). Allen (1993) and Davis (1993) discuss design considerations for the vegetation establishment.

The full engineering package, typically called a bid package, should be viewed as a contract to do work as detailed in the package. The bid package includes not only plan drawings, but also written instructions concerning how the project will be managed and administered and instructions on how elements in the mitigation will be placed, installed, or planted. These instructions are called specifications.

When preparing a bid package, one should understand that the package will be considered a contract for work to be done. The contractor is

responsible for doing the work as described in the document (plans and specifications). As long as the contractor follows those guidelines, the contractor must be paid, even if the work is a clear and immediate failure. For that reason, it is important that all engineering specifications for wetland plant establishment and subgrade preparation be such that success of the wetland restoration or construction be ensured. The purpose of this report is to provide guidance to the nonengineering professionals charged with developing wetland engineering specifications.

This report was prepared for use as a tool for managers involved in contracting for wetland plant establishment. It explains part of the process involved when proceeding from a design concept to a full engineering package that is suitable for public bid and advertisement. The information provided here is geared toward educating the nonengineering professionals engaged in developing wetland engineering specifications. The objective is to ensure the best bid package and the best wetland success.

This report illustrates guidelines for the development of specifications for use in wetland mitigation by providing examples of specifications that could be adapted for use by the reader. In some cases, certain aspects have been simplified for the sake of clarity. It is expected that these specifications will be extensively edited by most users before their use, or that only segments or general concepts will be adopted. These specifications will not cover all possible topics related to the implementation of a mitigation program, but they should provide a place to begin the development of the required specifications.

For the remainder of this report, the word “engineer” will refer to the agent or project representative of the organization or applicant funding the project, not the contractor or the design engineer. The engineer will execute the work through the contractor as depicted in the plans and specifications. The engineer is also responsible for project administration and construction quality control. The “true identity” of the engineer, as referred to in the specifications, will be indicated in the general specifications for a project. This engineer could be the design engineer or the site engineer. When preparing specifications, a clear understanding of who the “engineer” is is required. If necessary and allowed, the specifications can be altered to allow some decisions to be made by the site engineer and others by the design engineer.

Bid Package

Plans, details, and specifications are all integral parts of the bid package, representing distinctive aspects. There are two basic types of bid packages—lump-sum and itemized bid packages. In lump-sum bid packages, the specifications do not include a method of measurement or method of payment section. The entire project will be bid as a lump sum fee for the contract. Depending on the contract wording, prices for

individual tasks can be negotiated with the engineer following the award of the contract, in case additional work is required or work is deleted. In an itemized bid package, the method of measurement and payment for each task, frequently called a pay item, is described. The project is then paid for at the bid prices for each pay item, as approved and accepted. In developing this report, the authors have arbitrarily decided to present the remaining discussions assuming the use of itemized bid packages. A potential problem with itemized bid packages, however, is associated with the acceptance of an unbalanced bid—a situation where the items completed early in a project are radically overpriced in the bid document submitted by a potential contractor, and the items completed later in the project are equally underpriced. Some contract documents allow for the rejection of unbalanced bids.

A specification can be a material specification, a construction specification, or a combination of both elements. Material specifications provide the characteristics, properties, and standards for the materials used in the project. Just as the steel rods (rebar) used in the construction of a weir structure will need to be described in terms of strength, elasticity, corrosivity, and composition, the germination and purity characteristics of collected seed must also be specified for an enhancement program. Construction specifications describe the entire construction process of a particular task or describe the required properties and standards to be met by the final product. For example, seeding specifications will indicate the depth into the soil the seed needs to be incorporated and whether mulching or fertilizing is required. Construction specifications frequently reference the material specifications.

Specifications are written in engineering legalese and should be viewed as part of a legal document. As such, the contractor's sole responsibility is to do the work as described in the plans, specifications, and details. As long as the contractor follows those guidelines, the contractor will be paid, even if the work is a clear and immediate failure. The sentence structure found in specifications is often repetitive, but the repetition is an attempt to limit interpretational differences between the engineer and the contractor. Some organizations limit this repetitive wording by including word lists in the general specifications whose usage implies the addition of the phrase "by the Engineer."

The drafting of specifications is a technical effort that must include certain elements: Description of the Item, Materials, Construction Methods, Method of Measurement, and Basis of Payment. The headings and format for representing these elements may vary somewhat between various organizations and practitioners, but the basic elements are represented. The most common deviation from this format occurs when the material specifications are separated from the construction specifications, but all the basic elements will still be represented once combined. The use of a separate heading entitled "Submittals" has merit in many applications.

The plan set will include topography showing existing and proposed features, possibly a grading plan and/or a landscape plan, various construction details, notes specific to the particular project, and quantities of pay items. A pay item is simply a task, such as excavation or seeding. Pay items may be paid for either as a lump sum for the item or by a unit of measure. For example, seeding could be paid for as a single total payment for the project or by the square yard. The specification will dictate how the item will be paid. The specifications provide a clear description of the work to be done under a particular pay item, including materials to be used, methods of construction, method of measurement, and basis of payment. Sometimes it will be appropriate to indicate the type of equipment that will be used in the work. Construction plans represent "What to Do" and "Where to Do," while specifications represent "How to Do" a particular task. Occasionally, specifications simply indicate what an area should "Look Like" after completion of a task. Although a sound design is required for the development of a constructed or restored wetland, the quality and completeness of the specifications plays a major role in the success of the mitigation. Specifications safeguard against poor construction practices and use of materials with inferior quality. Mitigation designs are likely to fail as much from poor specifications as from poor designs.

The bid package must include both the plan sheets with pay items and the specifications. When any additional tasks such as earthwork is involved, most bid packages will also include the necessary detailed information such as soil boring logs, soil sieve analyses, soil classifications, and an earthwork summary. Frequently, groundwater monitoring data will be presented. This supplementary information is included, as it will strongly influence bid prices and can be shown either on the plan sheets or as an appendix document.

Although guidelines for doing the required work are found inside the specifications, many important aspects of an individual project are best included as plan notes and not in the specifications. Plan notes may include construction guidelines, prohibitions, a construction sequence, a mandatory construction staging, bio-benchmark data, planting instructions (Figure 1), clarification of plant nomenclature, or important hydrological information. The inclusion of taxonomic notes on the plan sheets can often clarify plant needs and can be used to override the nomenclature found in Kartesz and Kartesz or other taxonomic references that may "lump" more taxa than desired.

A bid package generally consists of the following items:

a. Plan sheets. The number and type of sheets in a plan set will vary with the project. A typical plan set could include the following:

(1) Cover Sheet with Location Map.

TO BE PLANTED

Item No.	Symbol	Plant Name	Stock Type	Min. No. Stems	Min. Stem Height	Min. Stock Diameter	Center Spacing	Contract Quantity	As-Built Quantity
437005	EPSM	*Eleocharis smallii*	Non-Dormant Peat Pot	6	6″		2′ x 3′	720	
437006	MACA	*Machaerocarpus californicus**	Dormant Bulb/Corm/Tuber			1.5″	2′ x 2′	1436	

* *Machaerocarpus californicus = Damasonium californicum*

TO BE PLANTED

Item No.	Symbol	Plant Name	Stock Type	Caliper & Min. Stem Height	Center Spacing	Contract Quantity	As-Built Quantity
440005	TADI	*Taxodium distichum*	BR	⅜″ Root Collar, 18″ Tall	8′ - 10′	4805	

Figure 1. Examples of planting tables that could be shown on the landscape sheet

(2) Plan Index Sheet.

(3) Quantity Sheet with Pay Items.

(4) General Notes Sheet.

(5) Survey and Tie Sheet.

(6) Typical Section Sheet.

(7) Construction and Grading Plan Sheets.

(8) Landscape Plan Sheets.

(9) Soil Erosion and Sediment Control Plan Sheets.

(10) Standard Detail Sheets.

(11) Structural Plan Sheets (if any).

(12) Earthwork Cross Sections (if any).

For some projects, there will be multiple sheets for some categories. Use of additional sheets is not uncommon and may include sheets dedicated to construction sequencing or staging, plan notes, or other elements such as safety and traffic control. Placing too much information on a single sheet should be avoided, as it affects the clarity and makes plan review extremely difficult. The most common "overstuffing" occurs when landscape sheets are combined with grading plans.

b. Pay items. All work elements in an engineering package must be paid for in some manner. As described previously, some projects will be paid for as a single lump-sum fee. Other projects will be paid for as accepted pay items. These accepted pay items may be measured by numerical units (e.g., number of plants installed and accepted, or the cubic yards of soil excavated) or as a lump sum for the item (e.g., clearing the site before excavation). Here the reader will have to learn to differentiate between lump-sum fees and lump-sum items. Using a combination of unit pay items and lump-sum pay items is common in an itemized bid package.

For itemized bid packages, the pay items will be presented on the various plan sheets. Many pay items are prefixed with "Construct" or "Place." The identification of these pay items will be consistent throughout the plans and should correspond exactly to the wording on the quantity sheet. Each of the pay items on the quantity sheet will have an associated numeric or alphanumeric code. In most formats, the coding of the individual pay items, as shown on the quantity sheet, will correspond to the coding for the individual specifications. This coding will be between three and seven digits in length, depending on the conventions used.

Once the code is known, the specification can be referenced by this number. The exact wording for the pay items will be found in the specification under the Method of Measurement and the Basis of Payment. For example, on landscape sheets, one might see the wording "Place 6,405 Square Yards—Seeding Type, Wet Meadow" with arrows and shading indicating the limits of this work. On the quantity sheet, one will find a table with a column or row labeled "752009—Seeding Type, Wet Meadow," with entries for each of the individual landscape sheets and a combined project total for that pay item. The numeric code 752009 is a direct reference to the specification. Because planting items are scattered across each of the landscape sheets, a summary planting and seeding table is normally shown on each landscape sheet. This table may also reference the specification's numerical code (see Figures 2-4).

It is important to realize that individual pay items are not restricted to describing a single action. A single pay item for emergent marsh planting could address plant supply, plant installation, fertilization, all staking requirements, and seemingly unrelated work such as the submission of as-built plans—plans depicting what was actually accomplished in the project.

Most specifications will pertain to a single pay item. However, a single specification can have more than one pay item, with each item having a distinct method of measurement and basis of payment. Where there is more than one pay item per specification, coding can be modified or extended to indicate that more than one item is covered under the specification. For example, reinforced-concrete pipes of different sizes can be incorporated in a single specification with separate pay items for different-sized pipe.

Many specifications will reference construction details, but details are not specifications and should not be used as substitutes for specifications, though many such drawings are labeled as specifications. Often, such drawings lack full material descriptions for all the required elements shown in the detail. A benefit to referencing details is that changes in detail drawings between projects need not require a change in the specification. The specification simply states that the work shall be performed as shown on the detail. However, small changes to "standard" detail drawings, such as changing the distance on staking silt fence, are likely to be ignored because of familiarity with the standards. Numerous construction details pertaining to wetland mitigation have been prepared by the Natural Resources Conservation Service (NRCS), formerly the Soil Conservation Service. Such details can be quickly transformed into engineering specifications.

To limit poor plant handling, a significant portion of these specifications are directed at "DO NOT" statements. This greatly contributes to the length of the guideline specifications. Some specification writers strongly object to this practice and advocate a more direct "DO" approach.

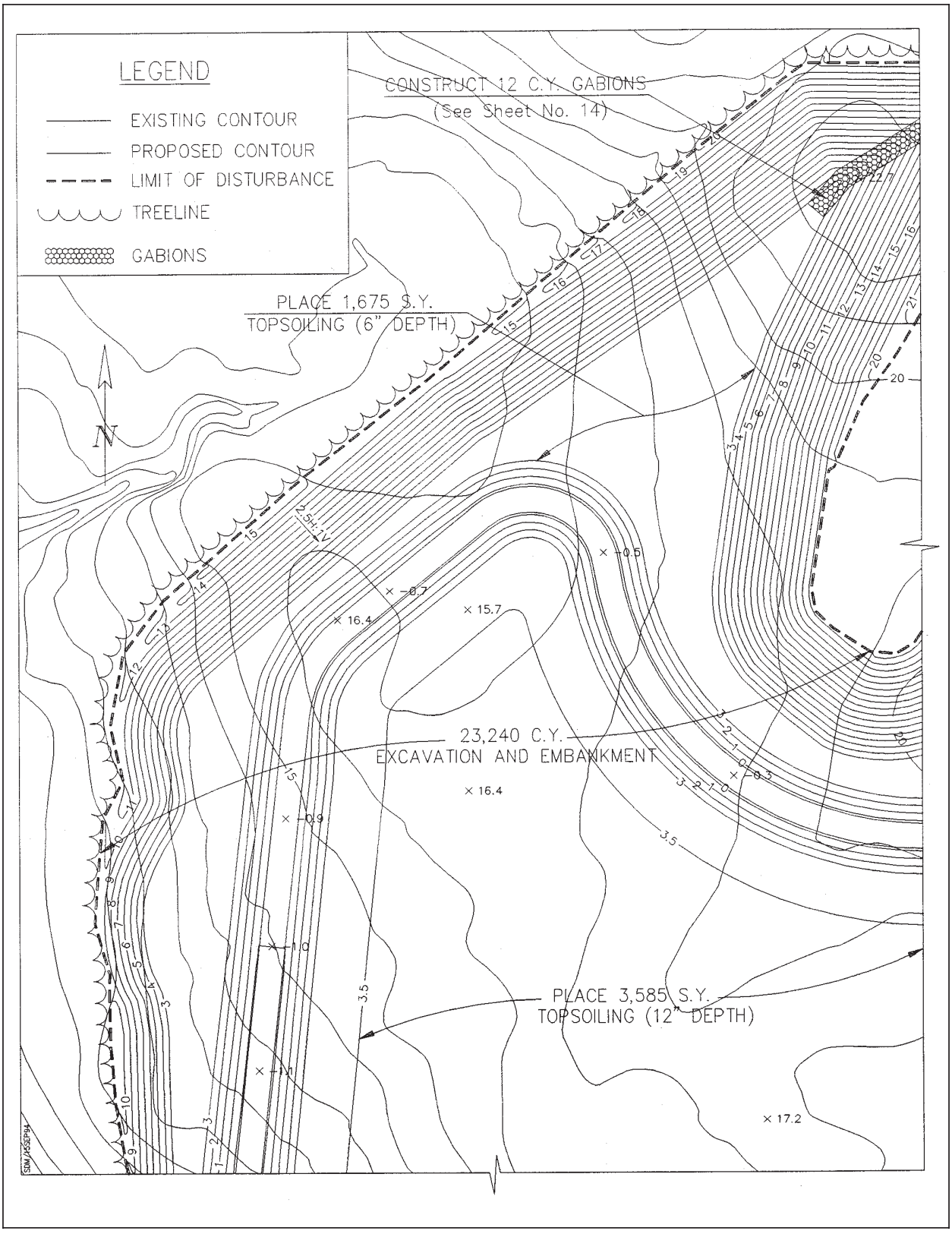

Figure 2. Segment of grading plan with pay items (channel alignment data table not shown)

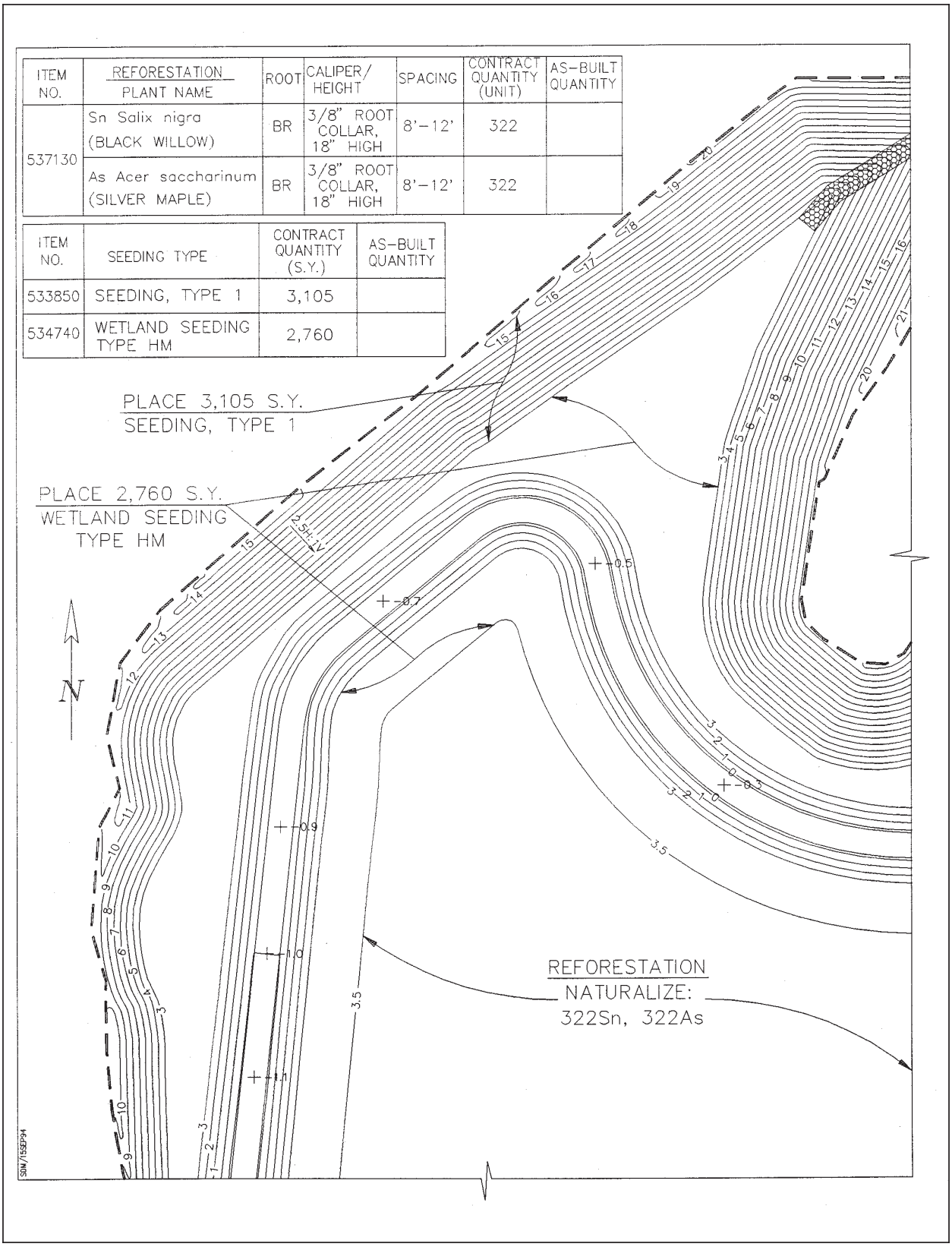

Figure 3. Segment of landscape plan with pay items

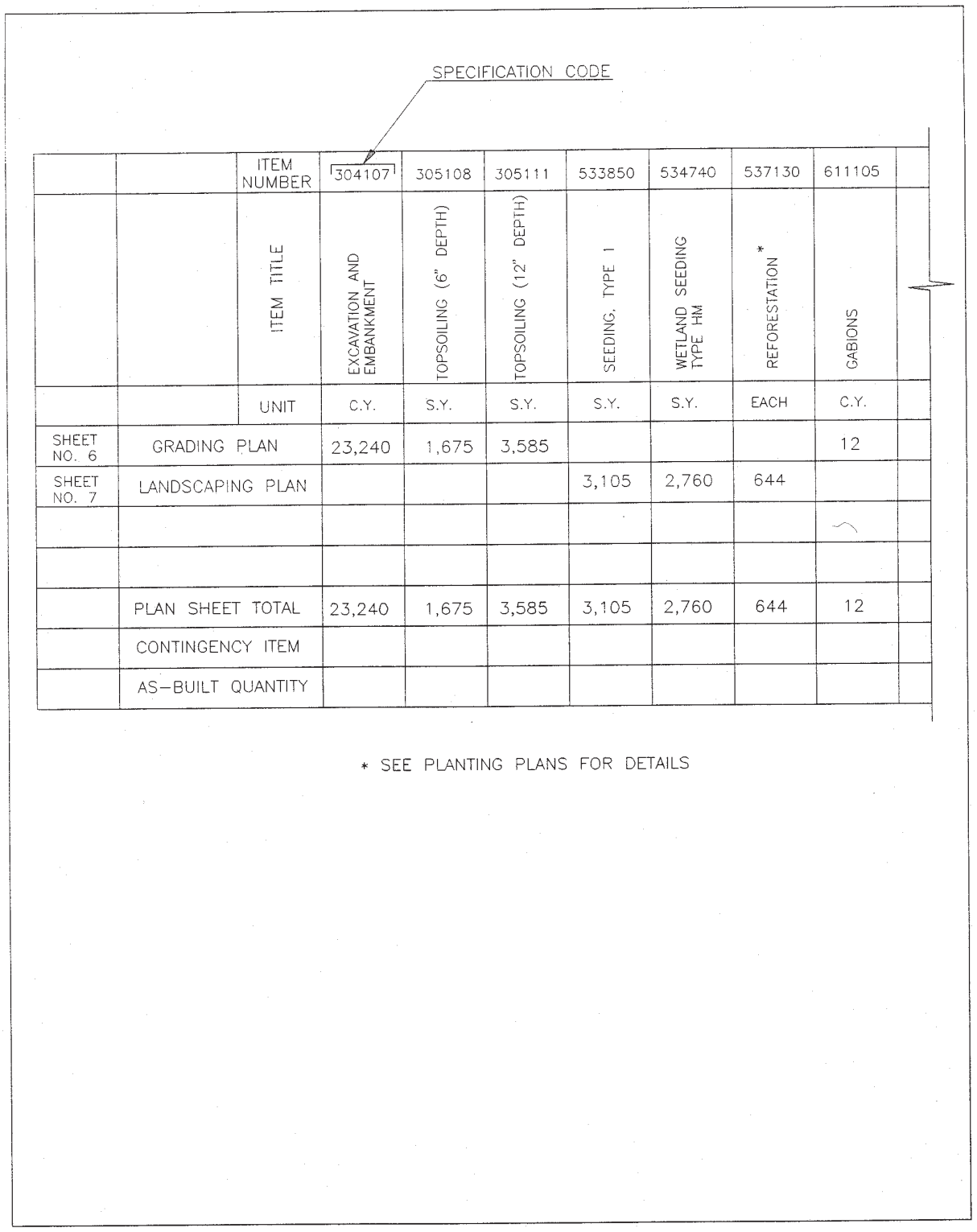

Figure 4. Segment of quantity sheet with pay items from Figures 2 and 3

Standard and Supplementary Specifications

Many mitigation projects or aspects of the projects have the potential to be constructed under previously published specifications. A common source for these specifications will be the volumes published by some large engineering organizations, such as utility and transportation authorities. These organizations possess their own specifications and details, usually termed "Standard Specifications" and "Standard Details," mainly due to the repetitive nature of the work. For transportation organizations, these specifications will include earthwork, pipe placement, various soil erosion control measures, tree and shrub planting, and various seeding programs. Landscape contractor associations are also likely to publish regionalized standard specifications for use by their members.

All elements within a standard specification need not pertain to a specific project. When using a standard specification, the specification may contain unnecessary information for a specific project. For example, a planting specification may contain information on the correct procedure for planting balled conifers; but if the plans do not call for that type of planting, those segments of the standard specification will simply be ignored. The specification is not edited. Detrimental elements contained in standards can be modified or withdrawn via plan notes or through an addendum.

Frequently, these large organizations also have a database of "Supplemental Specifications" for types of work that are only occasionally bid. Access to supplementary specifications may be more difficult, as most are not published as a single volume and are readily accessible only through a database network. Having these resources greatly reduces the specification writing effort. The design engineers will then reference these standards and supplementals by numeric code and title when preparing the plans. When required for a particular contract, new specifications will be written and/or the standard specifications amended to allow for the inclusion of "unconventional" items that are not covered by the existing specifications. The contractor then simply looks up the specification in the standards or is given a copy of the appropriate supplementals. A distinct advantage to using standard specifications or comprehensive supplementary specifications is that key elements of the specification will not be deleted and then passed onto future specifications, where the deleted information could prove useful or critical to a project.

Besides standards and supplemental specifications, there are many engineering specification reference standards published by organizations such as American Society for Testing and Materials, American Association of State Highway and Transportation Officials, and American Society of Civil Engineers. Much of this work is related to materials and testing methods.

Standard engineering specifications will be appropriate for many non-landscape aspects of a mitigation program, but of particular concern to wetland mitigation is dewatering and working in the "wet." Most standard excavation specifications will contain some reference to dewatering, indicating that all dewatering costs will be incidental to the excavation. If the dewatering effort is straightforward and the contractor can estimate the costs with reasonable accuracy at the time of bidding, then it may be prudent to make dewatering incidental to the excavation item or any other representative item. If extensive dewatering is anticipated, it is usual practice to design a dewatering system and pay for dewatering as a separate specification or make the dewatering incidental to excavation, but require the construction and maintenance of all dewatering elements. The difficulty in working machinery in saturated soils, even if firm underfoot, should not be underestimated (Leach 1993). With freshwater systems, improper or inadequate dewatering can easily destroy any chance of the mitigation succeeding. That is, design grades will be difficult to achieve, the work will likely fall far behind schedule, and numerous biological problems may be born. Carefully consider the dewatering issue. Working in the "wet" is possible, but only with the proper equipment and only after consideration for the biology.

Some organizations utilize what are called special provisions within a bid package. The information and content in the special provisions will override all other specifications. This method allows for changes in standard practices without editing the existing standard and supplemental specifications.

As much of the landscape work associated with wetland mitigation represents new construction and engineering practices, there is no standard specification source to reference. However, many engineering organizations are adding supplemental specifications targeted at wetland mitigation to their database for use in future projects. The use of standards and supplementals does have an inherent drawback in that their blind use can lead to major problems when the specifications do not address the required work or are missing key quality control elements. Garbisch (1989a,b) and Garbisch et al. (1996) warn against the use of standards for this reason, but the use of proven standards will limit the possibility of including specifications in bid packages that lack critical elements. In addition, the concept of "specifications" presented in this document is much narrower than that of Garbisch and does not include project-specific plan notes, sequences, or details.

Quality Control

Specifications will not correct design errors, nor can the specifications guarantee that the work will be done as shown or as specified; however, quality specifications will increase the likelihood that the project will be constructed as intended. The quality control during the plan and

specification development stage plays an important role in the success of a project. A constant dialogue between the specification engineers and the plan development engineers should be maintained to ensure compatibility of the specifications with the plans.

In the real world, the site engineer or project representative can make or break a project. The ability of the engineer to administer the work is largely dependent on the content of the specifications. A good engineer will attempt to correct any deficiencies in the plans and specifications via consultation with the design engineer. A poor engineer will allow for sloppy work, missed plan elements, and improper interpretation of the specifications and plan requirements. Many contractors will gauge the requirements of the engineer and perform the work to satisfy the individual engineer and not the specifications. Sometimes, a site engineer will assume authority for making plan changes without consulting the design team. Most design engineers will view this as a breach in the protocols associated with sealed plans (liability factor). Seemingly minor engineering changes can easily have pronounced biological implications.

As indicated earlier, it must be recognized that a bid package is a contract for work to be done. The contractor is responsible for constructing the design as shown on the plans, as specified, and nothing more. When developing mitigation plans, it is best to assume that the contractor has little if any interest in the overall success of the mitigation. As such, the plans and specifications must be as complete and as thorough as possible. In developing plans and specifications, the design team should be aware that once the bid package has been awarded, the design team has no further authority.

As with a good engineer, a good contractor will attempt to correct any deficiencies in the plans. However, what may seem to be a poor design element to the contractor may be an integral part of the actual design. It is important that any changes in the plans or specifications be strictly controlled. Before any changes are actually carried out, the changes should be approved by the design team via the site engineer.

One of the most discouraging aspects of a mitigation project will occur when what is euphemistically called a “Difficult Contractor” is awarded the bid. With public projects, it may be legally impossible to keep such contractors from bidding on the work. Directing the work of such contractors is extraordinarily burdensome to the engineer, with the contractor making every attempt to do the work as the contractor sees fit. Only complete and strict specifications and the best engineering supervision can minimize the damage done by such contractors.

2 Contract Considerations for Establishment of Wetland Plants

The specifications presented in Chapter 3 of this report and in the accompanying appendixes are guideline specifications targeted at either plant establishment or geotechnical elements directly related to wetland establishment or restoration. A general construction engineering specification is not included here, but such a specification will be required for a complete bid package. The general construction engineering specification covers issues related to contract administration, the authority of the engineer, protocols for plan changes, preparation of as-built plans, and a variety of other topics, and tends to be lengthy. Specifications for common engineering or landscape items are also not presented. The Construction Specification Institute, Inc., located in Alexandria, VA, offers a variety of standard specifications for purchase.

In drafting these specifications, it was the authors' goal to cover all or most of the important topics and allow the user to remove or modify segments that are not relevant to the specific projects. It is hoped that these specifications can be revised periodically and republished, and that the number of topics covered can be increased, including topics related to wetland haying, soil restorations, soil amendments, organic amendments, sod movement (Munro 1994a,b), habitat features, bioengineering, and other innovated applications. The specifications do not address the need for mycorrhizal establishment to the extent that is warranted, particularly for projects in droughty climates (Miller 1987). Mycorrhizal establishment is best done via direct soil incorporation, injection, or plant inoculation. In wetland mitigation, its adoption is restricted, as most of the commercially available inoculants target dry environments. The pH of the soil plays a key role in determining the composition of the inoculum. The specifications presented here are targeted at vegetation and subgrade pay items, but not at soils targeted for the growth of the plant materials. For most applications, a firmed soil is required to offer good seed-to-soil contact or to provide for a good planting medium, but excessive compaction must be avoided.

The number of specifications presented is limited to the most common practices, but care was taken to include specifications that allow for a variety of approaches to wetland plant establishment. Where there is a concern for proven practices and techniques, those specifications have not been included; however, those techniques could be included in future specification releases. For example, the use of large live staking for riparian restorations has not been included, as there is still some question as to the longevity of such plantings, specifically as it relates to developing the proper shoot/root biomass ratios. Certain specifications may be easily modified for other uses, such as the freshwater marsh planting specification for wet meadow plantings. Shrub planting was not included, as most regional upland shrub planting specifications will be applicable. However, the specification and planting details should be reviewed with special attention to the idea of maintaining proper drainage. In some situations, the shrubs may have to be mound-up or the backfill soil modified, depending on the characteristics of the in situ soils.

The specifications presented are not intended to be design documents, and the specifications will contain little design feature information or biological insights. This information is found on the plans. If older mitigation plans are being used as an information source for new projects, one should be aware that the mitigation philosophies have quietly, but radically, changed over the last decade. The idea of developing "quick maturing, high value mitigations" to instantaneously replace lost wetland resources, a concept which predated in-kind mitigation and which greatly limited mitigation options, has been abandoned.

Except for the seeding programs, the planting specifications do not contain any references to planting densities. Planting tables and densities should be shown directly on the plan sheets. The freshwater marsh planting specification contains only a single species-specific reference, and no references to planting depth as it correlates to water elevation are given. Indicating quantities or plan-specific information in both the plans and the specifications is very likely to lead to discrepancies and errors, and should be avoided. The planting specifications are directed at providing high-quality plant materials, proper plant handling, and the installation of those materials. The specifications do not indicate what plant materials are installed, where the plant materials are installed, planting densities, or how many plants are installed. Garbisch (1986, 1989a) and Garbisch et al. (1996) provide input into elements that should be included in planting specifications and plan notes. Information on design guidance can be found in the publication *Engineering Field Handbook - Chapter 13: Wetland Restoration, Enhancement, or Creation* (U.S. Department of Agriculture (USDA), 1992. 210-EFH, 1/92). Galatowitsch and van der Valk (1994) and Payne (1992) are particularly valuable, as these works approach wetland mitigation from a solid basis in the ecological sciences while including practical design information, such as the proper use and design of water control structures and mitigation-siting criteria. Both volumes are well referenced.

Engineering specifications normally do not include any references to why an action or procedure is required. The same is true for the plan sheets. For several of the more esoteric guideline specifications, the "whys" are presented simply to educate. If desired, these "whys" can be deleted.

For projects that involve significant earthmoving, the advertisement date for the contract can have a strong influence on the quality of the mitigation effort. Following advertisement, bids are collected and analyzed for compliance. After the award of the contract, it will take several months to mobilize and complete the preliminary work items and the associated paperwork. A November or December advertisement date will give sufficient time to allow a full summer of earthwork. A later advertisement date will likely reduce the prime working window and force the work into late fall or winter. In much of the country, work done in late fall is often hampered by excessive water, which limits grading precision and erosion control; seedings are often substandard due to a limited establishment period.

Staging, the proper timing of the individual elements of a project, is as important as the elements themselves. For increased visibility, the control of this timing is usually shown in a construction sequence or on notes that appear on the plan sheets. Alternatively, the construction staging can be shown in the special provisions or in the general provisions, a type of overview specification for certain projects. Trying to control the timing of a project via item specifications is not recommended and will mostly likely fail. If no staging sequence is shown on the plans, the contractor will determine the staging with little regard to the underlying biology. With vegetation establishment, timing should not be only thought of as acceptable planting or seeding windows, but should include all soil work. When excavating wetland soils from a donor site, the allowable excavation windows should be mandated, thus lessening the potential for premature germination of the seed bank, "cooking" the seeds and viable root fragments, or oxidizing the organics.

With wet meadow and forestry projects, it is best to complete all grading and any grass seeding operations prior to mid-September. With freshwater marshes, the timing of the construction is likely to be influenced by biological considerations that may shift the desired grading operations into the winter months. For example, where soils are being plowed or excavated, it may be critical to control the timing of the exposure to reduce the potential for obnoxious weed-seed rain (Brown 1995). Planting a variety of emergents on an excavated, dewatered soil that has been collecting cattail seeds for a summer is likely to lead to the development of a cattail marsh and not a marsh reflecting the subsequent planting or seeding programs. Although it is frequently reported that cattail will not germinate underwater, this is not true. Cattail will germinate underwater, given the proper environmental cues. These cues include exposure of mineral soils during the previous growing season, a high light regime in the water

column, or a combination of these factors. Note: The development of a cattail marsh may be a perfectly legitimate project.

For some projects, phased plantings or seeding programs may offer the best chance at success. With a phased approach, the planting and seeding elements are staggered over the first few years of the project. Such an approach allows for the planting/seeding to mimic the anticipated successional timing. A hardwood planting may be delayed until the second or third year of secondary succession, avoiding competition with annual grasses on a bare mineral soil. With phased projects, considerable thought should be given to determine the "correct" number of contracts that need to be awarded.

With wetland mitigation, the concept of "survival guarantees" for planted materials has been corrupted to an extreme and is far beyond the original intent of landscape guarantees. Traditional landscape guarantees are generally voided for planting in saturated soils and other unfavorable settings. The use of guarantees is appropriate for some mitigation designs or elements, such as riparian establishment in the Western States that includes an irrigation element or certain seeding elements, but may be inappropriate and inadvisable for other elements. Regional factors and past practices will be important considerations in determining whether a guarantee is appropriate for a particular item, but the use of guarantees should not restrict the design to "safe" elements. As presented here, the marsh plantings and the forestry plantings do not have any long-term "guarantee" period associated with the work. However, it does assume that a competent engineer is overseeing the project and putting the required emphasis on proper material handing and installation. If a guarantee for plant survival is required, the often tedious and repetitive nature of the material and handling aspects of the guideline specifications may not be the best approach to specification development. On the other hand, it may prove to be the only defense against unintentional carelessness, inexperience, or a difficult contractor.

If extended planting survival guarantees are mandated as part of the specifications, then site-hydrologic data and or hydrological analyses will be useful to the bidders. Absence of this information may result in the refusal of experienced mitigation firms to bid on projects because of uncertainties about the hydrology. Where these extended survival guarantee requirements have been inserted in the specifications, the hydrological analyses may be included as part of the bid package. However, it is likely that many engineers will resist the release of the calculations and favor changing the landscape guarantee requirements. Even if not included in the bid package, the contractor may request access to these calculations through the engineer; however, the design team is likely to provide this information only if the contractor can justify his/her request.

The item specifications do not adequately address many of the problems associated with late work and late plantings. A good construction sequence will help, but it will not prevent late work. The biological

consequences associated with late work can be severe, and the entire project schedule may need to be reevaluated. Planting a year late during the specified planting window may be a better idea than planting 1 month late, but outside the window. While in this "delay" period, one must actively manage the site to provide optimal planting conditions during the next planting window. The general specification will be important in determing corrective actions under late work, but much of the responsibility will fall on the site engineer to negotiate with the contractor. If the site engineer does not coordinate with the design team, the project is likely to be compromised.

It is important to realize that the use of quality specifications is only one approach to successful environmental restoration. Occasionally, highly competent biologists, soil scientists, and engineers are allowed to plan and direct the work while in the field. Such an approach can lead to the use of innovative techniques and restoration applications that would be difficult to place on a plan sheet or in a specification. This approach allows for the quick adoption of new ideas and design features and allows these specialists to take advantage of unforeseen opportunities without developing a laborious paper trail and attending near endless meetings to approve design changes or new payment structures. For example, Gallagher, Barnkd, and Cintra (1996) planted large tree stumps, root wads, as part of a stream corridor restoration. The planted root wads facilitated the development of a complex microtopography as well as providing a valuable propagule source. The major obstacle to widespread use of this approach is centered on payment issues to the contractor and ensuring that sufficient funds have been allocated for the project and not the quality of the work. Currently, the U.S. Fish and Wildlife Service's programs *Partners in Wildlife* and the *Conservation Reserve Program* are very active in developing wetland restoration and creation programs using this approach on private lands throughout much of the country. The bulk of these efforts is directed at site evaluation, project design, and project construction. Typical construction elements under this program include limited grading operations, small earthen dam and emergency storm spillway construction, water control structure design and placement, and seeding programs for erosion control. Less emphasis is placed on wetland planting or wetland seeding programs with vegetation development following natural successional processes. This program is nonregulatory, and project options available under this program are not necessarily applicable in a regulatory setting.

Many of the specifications mandate that the user define the genetic origin of the materials. However, no guidance is given as to the appropriate extent of the genetic limitations. Davis (1995) discusses the use of local genetic sources in restoration. Garbisch et al. (1996) warns against the excessive restriction of genetic sources. As written, the specifications will allow for the growing of the stock outside the genetic range. Besides providing the genetic sources, one needs to review this element of the specifications.

The specifications will often mandate soil testing. For most applications, this requirement should be removed from the planting and seeding specifications. Soil testing is better handled under soil specifications targeted for either planting or seeding. It is suggested that one use State agricultural testing laboratories for the soil testing and modify the specification to correspond to this testing. These tests are inexpensive. Different laboratories will use different tests or report the results in different formats. Each laboratory will have pamphlets explaining the meaning of most tests, so it is best to use that laboratory's reporting format and modify those segments of the specification. Soluble salt testing is a good example of a reporting format that varies from State to State. The test for soluble salts should be considered a mandatory test, as it may reveal past soil abuse, such as the presence of iron pyrites or acid-mine drainage. If iron pyrites are present at high concentrations, this test will not identify iron pyrites specifically, but the high values obtained will suggest osmotically stressful soils and highlight the need for additional testing. If one anticipates unusual or saline soil conditions, the soil testing laboratory should be advised prior to the laboratory conducting the testing so that the analytical equipment can be properly configured. As part of the standard testing, the laboratories will make recommendations for the placement of fertilizer and soil amendments (i.e., lime, iron sulfate), but a target crop needs to be identified that carries an implication of the desired pH of the soil.

System Energy and Site Selection

As stated earlier, site selection is probably the most important element in the mitigation process, and the restoration or creation designs should be compatible with the overall characteristics of the watershed, especially the energies inherent to the system, be they wind, wave, or riverine. A primary goal of all restoration or mitigation projects is to merge with the existing landscape characteristics. This is most easily done in low-energy landscape positions. When forced to develop creation projects in high-energy positions, there is a very good chance that the energies will destroy the project and/or the system will require large structures or armoring to curtail or absorb the energies. The size of the structures or armoring would then be determined not on any biological need, but the need to withstand a certain design storm, i.e., the 50-year or 100-year event. Under these circumstances, a project is likely to quickly move away from the goal of merging with the landscape. The potential for future maintenance will also be greater in high-energy systems. In high-energy areas, soil erosion control elements that incorporate vegetative elements should be established only during periods when the seeding or planting has the good probability of taking hold. Late fall erosion control seeding programs are likely to fail. Because of the difficulty of merging projects into high-
energy landscapes, development of creation projects in high-energy locations should be avoided whenever possible—exceptions being some forms of coastal habitat restorations and riparian mitigations that actively try to

merge with the landscape or correct serious ecological concerns. Often, it may be simply best to abandon these high-energy sites. When compared with low-energy landscape positions, high-energy sites have few advantages and many disadvantages.

Usage

It is paramount that the user be able to justify the adoption of these or any other specifications or techniques before their actual use in a project. With careful site selection, many mitigations can be successfully accomplished without using any subgrade preparation measures. Tidal mitigations and the vast majority of riparian mitigations that are dependent on overbank flooding will not require any subgrade preparation. Wetland creations targeted at depressional wetlands located on the sands of the Atlantic Coastal Plain will not need any subgrade preparation, but will require the exposure of the seasonal high water table. With vernal pool mitigations in California or playa mitigations in Texas, the uncovering of buried natural hardpans offers an alternative to establishing new hardpans; but the specifications included here may be useful in testing the permeability or infiltration characteristics of the uncovered hardpans.

The adoption of a planting or seeding program should be very dependent on the overall landscape characteristics of the watershed, especially the features near the proposed site. The more degraded the landscape, the greater the probability that a planting or seeding program will be required. As such, each mitigation effort must be viewed as independent from other past projects, and it must be recognized that what is appropriate at one location may not be appropriate for another location. One should not plant simply to plant. The real question is “Why am I planting?”

A planting or seeding program is an attempt to direct or at least influence plant succession and community development. Before employing any planting or seeding program, it would be prudent to consider the anticipated vegetation succession patterns without conducting any planting or seeding operations. Such successional considerations should extend out at least several decades and may possess multiple trajectories and end points. Although one should think long term, one must be aware of the immediate consequence of any action or nonaction on the development of the vegetation (Reinartz and Warne 1993; Shear, Lent, and Faver 1996). When trying to determine likely successional patterns, the anticipated seed rain, including the potential for noxious weeds, coupled with the dormancy and germination requirements, and the between-species competitiveness of that seed rain must be considered in concert with the fertility, texture, depth, and friability of the soil and the seasonal and yearly hydrological variability (Pickett, Collins, and Armesto 1987; Leck, Parker, and Simpson 1989; Luken 1990; and Kentula et al. 1993). Nutrient availability and organic content will change with successional age (Boggs and Weaver 1994). For a series of small, created wetlands in Wisconsin, Rei-

nartz and Warne (1993) showed that the variation in distance to a wetland seed source accounted for 34 percent of the variation in plant diversity and 66 percent of the variation in the richness of native wetland plant species. However, dispersal distances for many systems are very short and should not be overestimated (Pickett and McDonnell; Pederson and van der Valk in Leck, Parker, and Simpson 1989).

Hydrological energies or the perceived need to quickly stabilize the soil may shift the decision toward planting or seeding. In certain situations, animal-plant interactions related to herbivory or propagule dispersal may play a role in determining whether to plant or seed a site or to allow for unaided natural succession. Processes associated with natural disturbance (as defined by Pickett and White 1985; Kirkman and Sharitz 1994; Taylor et al. 1994) will also have to be factored into the decision of whether to plant or seed. When selecting planting and seeding mixes, competitiveness should be given more weight than mere physiological tolerance, including water-depth limitations. Limits on plant physiological tolerances and adaptations, especially as it relates to high-light or low-light competitiveness, must be acknowledged. Many communities will take time to develop the internal architecture and structure capable of supporting a mature species assemblage.

Over the last two decades, the ecological sciences have thoroughly rejected ideas associated with predictability, community equilibrium, steady state, and balance of nature (Botkin 1990; Pickett and Parker 1994). Flux, variability, contingency, and uncertainty are the dominant themes in recent literature. Zedler (1996) emphasizes the importance of rejecting predictability in the development of mitigation strategies.

Wetland mitigation and restoration are advancing as scientific disciplines. *Restoration & Management Notes* and *Restoration Ecology* are periodicals published by the Society of Ecological Restoration. They focus on the development and implementation of restoration science, but are not limited to wetland topics. *Wetlands,* the journal of the Society of Wetland Scientists, has a stronger focus on the basic science of wetlands, but cantains information on wetland mitigation and restoration. A required reference source for most, if not all, forms of wetland mitigation is *Wetland Creation and Restoration: The Status of the Science* (Kusler and Kentula 1989). This volume is national in scope and is particularly valuable, as it identifies many limitations of mitigation. Garbisch et al. (1996) is an excellent reference and is particularly valuable in that it details many of the problems associated with the implementation of mitigation projects and offers solutions to many of those same problems. A more complete introduction into most of the more esoteric topics approached in the rationales can be found in Mitsch and Gosselink (1993). *The Ecology of Woodland Creation* (Ferris-Kaan 1995) is a British volume that addresses several topics not covered in this series of specifications including soil restoration. *Soil Ecology* (Killham 1994) is an excellent introduction into soil biology with near-equal emphasis on plant soil interactions, soil microbiology, chemistry, and the physical environment. Although there is a lack of wetland-

specific discussions in this volume, the work covers a variety of topics that should be of interest, including carbon flow, nutrient cycling, mycorrhizae, and the ecology of polluted soils. Wolf, Lee, and Sharitz (1986) is an annotated bibliography of wetland creation and restoration from 1970 to 1985. Organized by author and indexed by species and topic, this volume allows for rapid access to the "birthing" literature of mitigation. Schneller-McDonald, Ischinger, and Auble (1990) is a hard copy of the Wetland Creation/Restoration Database, as maintained by the National Ecology Research Center, Fort Collins, CO. This annotated bibliography may be the most complete reference source for wetland restoration. Kent (1994) contains chapters dedicated to both coastal and freshwater mitigation. Zentner's contribution to this latter volume provides an overview of the design process with clear emphasis on proper project implementation, as well as the underlying science. Clearly, this is the outlook that should be adopted. Without the ability to marry solid science with skillful implementation, the science of mitigation and restoration will not progress (Johnson and Bradshaw 1979; Cairns 1991; Bradshaw 1993). Hopefully, this volume will aid in achieving quality implementations, but it is not a design manual.

3 Guideline Specifications

Specifications for a number of plant- and soil-related pay items have been prepared for inclusion in this report. These specifications are intended not as "standard" specifications for wetland mitigation, but to provide guidance, by example, for developing specifications. The specifications are conservative. If these specifications are used, it is expected that most will be extensively edited before their use. Editing, including the removal of unnecessary information, is especially encouraged with the seeding specifications. These specifications are heavily geared toward material descriptions, the proper handling of the materials, and the proper installation of the materials. As indicated earlier, these specifications will not cover all possible topics related to the implementation of a mitigation program, but they should provide a place to begin the development of the required specifications or to refine existing specifications.

Most of the guideline specifications are presented in a five-part format: (a) description, (b) materials, (c) construction methods, (d) method of measurement, and (e) basis of payment. The importance of the method of measurement and basis of payment sections should not be underestimated, as these sections will emphasize what types of work are considered incidental to the item. For example, within planting specifications, there are references to many nonplant items, such as fertilizer and stakes. These items are not pay items, but are considered incidental to the item under consideration. Although incidental, these items must still have an accompanying material specification. When reviewing the specifications, the user will see material specifications for various pieces of machinery and tools. Material specifications for equipment will only be required when the equipment is specialized or there is some concern that the contractor will be tempted to use equipment that is really not appropriate for the work. Most machinery need not be specified. Any materials that will be left onsite should be fully described.

For some specifications, a segment of definitions has been inserted. If desired, the specifications can be revised to place all submittals and testing within a distinct category. All specifications have been developed as unit pay items. Transfer into a three-part specification, CSI (Construction Specification Institute, Inc.) format or payment as a single lump sum should not be difficult. To facilitate this transfer, an example project-specific specification for riparian and marsh revegetation targeted at the

Western States has been included. This type of format is very common. John Zentner's contribution and approach to specification development is direct and limits the engineering legalese. Again, the emphasis in this latter specification is placed on quality materials, proper plant handling, and installation.

The use of these specifications assumes that a competent engineer will be assigned to administer the project and that the engineer will have sufficient time to dedicate to the project. With some projects, the wetland mitigation is only a minor part of the total project, and the engineer does not have sufficient time to oversee the mitigation aspects. As a result, the engineer is not able to perform his/her quality control functions, and the project is not constructed to the full potential of the design. If an engineer cannot be assigned to the project, the reader is strongly advised to review the acceptance and guarantee provisions of the planting specifications because these provisions were written assuming that an engineer was overseeing the work. Alternatively, one should simply hire from among the most experienced regional firms to conduct the mitigation activities without advertising the contract for low bid.

Terminology

The guideline specifications frequently make reference to the terms "Department," "Engineer," and "Contractor." These terms can be changed as desired. For example, many specifications will reference a project representative or contracting officer instead of an engineer.

The term "Department" is a reference to the organization sponsoring the project. In some specifications, a reference to requiring departmental approvals is an attempt to have the engineer check with either the design team or the organization's staff biologists when making certain decisions.

The engineer is employed by the sponsoring organization (Department) and is responsible for ensuring that the project is constructed as shown on the plans and as specified.

The contractor is the firm contracted to construct the mitigation as shown on the plans and as specified.

Seeding

Leaving aside soil erosion concerns, the primary reason for adopting any seeding program in restoration is the anticipation that the natural-occurring seed rain is not of sufficient quantity or diversity to establish the targeted wetland or a desirable wetland community. Clearly, this

judgment must weigh the probability of obnoxious weed colonization, competition, and successional development. These judgments should be based both on short-term and long-term considerations that extend beyond any permit mandates.

The seeding methods discussed will allow for seeding via a wide variety of techniques, from simply hand raking to hydroseeding. High technological methods are not favored or disfavored. Determination of the preferred seeding method will be project specific. The specifications emphasize proper seed bed preparation, and the specifications will require the user to identify seed quality. Ordering seed via bulk pounds is not necessarily a poor choice. Knowing the germination, purity, and weed characteristics of a seed mix is desirable, but not mandatory. For isolated sites that will not experience a desirable seed rain, seeding is the lowest cost method for establishing an acceptable plant community. Anticipated successional patterns should be considered when determining the composition of any seed mix.

Broadcast seeding

The early, if not immediate, introduction of a substantial number of plant species by means of broadcast seeding is likely to enhance the long-term diversity of mitigation projects and reduce the potential for near monoculture establishment (Reinartz and Warne 1993). Such seeding programs can easily be conducted in addition to various planting strategies. This specification is targeted at the establishment of a desired species mix via hand labor, more so than for soil erosion control applications.

This specification (see Appendix A) will allow for seeding by simple methods without the use of specialized equipment. All work can be accomplished by hand labor. The summer 1994 issue of *Restoration & Management Notes*, especially Packard (1994), is highly recommended for those interested in hand-seeding applications and restoration processes. Where establishing a diverse plant community is a goal, one can seed without an establishment guarantee, but seed quality, placement, and project staging should be major concerns. The determination of the genetic origin of materials is left to the user. If desired, this may be omitted from the specification. Lippitt, Fidelibus, and Bainbridge (1994) is an excellent reference for entry into seed-handling protocols and testing.

Truax manufactures a broadcast seeder that is similar to their drill seeder in that it is able to handle a variety of seed sizes simultaneously (cool-season box, fluffy box, and a small seeded box). A cultipaker, chain harrow, or a series of chains are then attached to the seeder to promote good seed/soil contact and cover.

The seed-handling protocols outlined in this specification are targeted at wet-meadow and wet-prairie environments, and the specification was written assuming a fall sowing, thereby allowing the environment to

satisfy any necessary stratification or vernalization requirements for seed germination. All stratification involves moist seeds at above-freezing temperatures (cold-wet, cold-moist, and warm-moist). Moist or wet storage at temperatures between 34 and 40 °F[1] and warm-moist storage appear to facilitate oxygen diffusion through the seed coat, thereby promoting germination once placed in a suitable environment (Young and Young 1986). In many regions of the country, late winter and early spring represent the actual period when seeds are stratified—uninterrupted cool and moist field conditions (not frozen) with fluctuating temperatures. Not all species have a stratification requirement. Cold-dry storage will rarely result in enhanced germination of seeds that require stratification (Young and Young 1986).

Afterripening is a different concept from stratification. With afterripening, seeds are thought to need an extended period of time (several months) to allow for embryonic maturation. Low temperatures may facilitate afterripening, but there is no requirement for moist conditions (Young and Young 1986). Salvaggio (1996) describes seed-handling protocols for a number of eastern wetland species, some of which appear to have a stratification requirement and others only an afterripening requirement.

The specification protocols will not be appropriate for all wetland species or seeding projects, especially those in high-energy environments, erodible sites, or when dealing with many of the submersed aquatics. When selecting the seeding period and types, one will have to weigh both the design parameters and the advantages and disadvantages inherent to different seeding windows. For much of the country, a distinct advantage of fall seeding is that the seeding can be easily delayed by several weeks to avoid working in excessively wet or flooded soils, while not risking the loss of the early spring growing period. In high-energy environments or erodible sites, fall sowings may be a wasted effort, as wind or water energies could easily displace the entire seeding. In these high-energy situations, late spring sowings may be the only practical option, and one may be forced to adopt cold-wet or cold-moist seed storage and handling depending on the species and the region of the country. Late-winter or early spring sowings lower the risk of erosion losses, as compared with fall sowings, but proper placement can be more difficult due to excessive wetness. Sowing in the late winter or early spring may allow for natural stratification; but stratification periods will vary between species and populations, and there is no guarantee that the stratification requirements for all species in a mix will be met. A late-spring seeding with stratified seeds will extend the seeding window and should allow for good soil preparation and good seed placement; but seed handling will be more specialized, and there is a risk of premature seed germination and the loss of the appropriate

[1] A table of factors for converting non-SI units of measurement to SI units is presented on page ix.

thermoperiod fluctuation necessary for maximum germination. Granivory (seed predation) and erosion losses should be lowest with late-spring seedings, and single-application weed control is best done in the late spring, following the protocols for warm-season grass seedings. Hoffman, Redente, and McEwen (1995) provide a good overview and reference access to the topic of granivory.

Galatowitsch and van der Valk (1994) recommend a late-spring/early summer sowing with stratified seeds for the prairie region. This work expresses concern for both frost heaving and seed loss to granivory as a result of a fall sowing, but a primary concern was for excessive seed drying, especially with the *Carex* sedges. Thompson (1992) indicates a strong concern for both winter granivory and early cool-season weed competition with fall sowings and endorses a spring seeding window with stratified seeds. Most seed supply firms do not provide stratified seed. Commercially available seed cultivars are selected not to have a stratification requirement. Again, where seeds are properly stratified or do not require extended periods of stratification (greater than 30-45 days), late-winter and early spring sowings are likely to be successful. Once stratified, the seeds should not be excessively dried, or there is the possibility that the seeds may enter extended dormancy.

With a late-spring seeding approach, seed handling will likely be somewhat more complicated, as many species will have to be stored for at least 30 days under a cold-moist, cold-wet, warm-moist, or a warm-moist/cool-moist program to break dormancy. For some species, the stratification period may be longer. Thullen and Eberts (1995) report the need for cold stratification to break seed dormancy in *Scirpus acutus*. At 4 weeks of storage at 4 ^{o}C, germination reached a range of 40-60 percent. At 12 weeks storage, the germination increased to over 80 percent. When compared with a 4 ^{o}C fluctuation, a diurnal temperature fluctuation of 15 ^{o}C increased germination by 20 percent. Longer cold-storage periods were shown to increase germination in 11 species of *Scirpus* (Isley 1944).

Seeding depths given in the specification will need to be carefully verified. The depth given in the specification assumes that a fall seeding and additional erosion protection via soil cover is given for small seeds. With a spring sowing of prestratified seed or freely germinating seed, the sowing depth will have to be again reviewed. With all seeding, good soil-to-seed contact is mandatory while at the same time providing the appropriate physical environment for germination. For small seed, this may require a simple surface sowing and then sufficient contact pressure to ensure good soil-seed contact. Garbisch et al. (1996) suggest that when seeding with a species in excess of 500,000 seeds per pound, the seed should be sown, pressed into the soil, and then covered with a thin film of soil. With seed containing less than 500,000 seeds per pound, the seed should be subsurface sown to a depth not to exceed twice the seed thickness. If required for proper seed placement, the same ground can be seeded more than once by simply designating more than one mix, with each mix being a different pay item—for example, the large seeded species are first incorporated into

the soil, then the small seeded species. The principle of staged seeding as a community matures is outlined in Galatowitsch and van der Valk (1994).

Specifying seed quality based on a minimum germination percentage will alleviate many of the concerns when selecting the appropriate seeding window and will allow for a spring sowing. Where there is a concern for stratification and the desire for a spring sowing of nontested seeds, the specification can be modified to include a stratification protocol for spring-sown seeds (Thompson 1992; Galatowitsch and van der Valk 1994).

Under the cold-moist storage adopted by Galatowitsch, seeds are gathered at the time of maturity, dipped in a 1-percent bleach solution to curtail bacterial or fungal losses, and placed in cold-moist storage in sealed bags or containers at about 40 ^{o}F.[1] For the remainder of the storage period, the seeds are kept moist, not wet and not frozen. Seeds are periodically checked for fungal infection. Following removal from storage, the seeds are again dipped in the 1-percent bleach solution prior to being sown. This procedure is followed even for early and midsummer maturing species, and at no time are the seeds dried. The critical difference between this specification and the approach of Galatowitsch and van der Valk does not relate to the requirement of cold-moist or cold-wet stratification for groups such as wet meadow species, but to simply whether the seeds can be dried to the typical range of between 5- and 13-percent seed moisture, as most seeds are dried. If they can be dried prior to stratification, both seeding protocols would be "correct."

With many of the aquatics and some of the marsh emergent species, proper seed handling will require cold-wet or cold-moist seed storage and not dry storage of the seed, as indicated in this specification. *Peltandra virginicum* (Araceae, arrow arum), *Orontium aquaticum* (Araceae, golden club), *Zizania aquatica* (Poaceae, wild rice), and *Vallisneria americana* (Hydrocharitaceae, wild celery) will be killed if air-dried (Muenscher 1944). Emergents more typical of strong drawdown environments, even if the drawdowns events are episodic, are likely to be more tolerant of air-drying than those from permanently saturated or flooded environments. The successful germination of *Eleocharis coloradoensis*, a spikerush, requires the adoption of a cold-wet storage program (Yeo and Dew 1977).

Muenscher (1944) reports on the long-term storage of a variety of aquatics and emergents under cold-wet storage (in water, 1-3 ^{o}C). Of the 15 species reported, only the *Vallisneria* showed a marked reduction in germination after 5 years of storage. With aquatics, Muenscher recommends cold-wet or cold-moist storage with spring sowings to reduce seed loss generated through wildlife predation, unwanted seed movements, or

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[1] Personal Communication, 1995, S. M. Galatowitsch, University of Minnesota, Minneapolis, MN.

excessive burial. Muenscher (1936) outlines the procedures for cold-wet storage of aquatic/emergent seeds. However, if a drawdown environmental cue is required to release seed dormancy of a given population, simple cold-wet storage may not represent the required dormancy release, and one could end up sowing dormant seed. Payne (1992) outlines protocols for seed handling and vegetative propagation for a variety of aquatics and emergents via extensive references to Kadlec and Wentz (1974). Shirley (1994) outlines the basic requirements and protocols for short-term, cold-moist seed storage and handling.

As written, the user will have to select one of three options relating to the seed under Materials. One should delete the unwanted options. Option 1 is a more exacting material specification, as it includes minimum percent germination and purity characteristics. It is superior to specifying seed solely based on pure live seed (PLS), as it will exclude poor crops. Option 1 will be more difficult to work with when dealing with species that are outside the standard seed trade, as little information will be available on expected germination or purity rates. Where the information is lacking, the user may be forced to adopt Option 2 or Option 3. The use of Option 2, the bulk seed poundage without reference to PLS or germination testing, should only be adopted as a last resort. Not only will the viability of the seed be unknown, but seed purchased only by weight may be poorly cleaned, and one will be paying as much for the debris as for the seed. The advantage of Option 2 is that it easily allows for the expansion of species pool to be incorporated into the mix. Purchasing seed by weight may run into a "legal" problem. These authors have been told that most, if not all, States require that all seed sold have a valid germination test. If true, seed that passes through more than one firm would be required to have a valid germination test. Such a requirement would be an obvious protection to both the agricultural and horticultural industries. These authors have also been told that these laws are applicable only to agricultural crops and commercial grasses and flowers, and are not applicable to restoration. It is strongly recommended that the user verify the requirements of applicable seed laws with a knowledgeable source prior to adopting Option 2.

BEST PRACTICE: ORDER SEED WITH MINIMUM-PERCENT GERMINATION AND PURITY CHARACTERISTICS; THEN PLACE SEED AS PURE LIVE SEED.

Important: As an alterative to germination testing, tetrazolium testing (Grabe 1970) coupled to minimum viability percentages could be utilized to develop minimum standards for seed quality. Such testing will indicate that the seeds are alive, but it will not indicate that the germination requirements for the seed have been satisfied—one could be sowing dormant seeds. Limits on the value of tetrazolium testing are outlined in Lippitt, Fidelibus, and Bainbridge (1994).

As this specification is targeted at diversifying seeding programs, the specification does not require the use of certified seed or other seed-tag

classes. The specification can be modified to require this tagging—CERTIFIED SEED, SOURCE IDENTIFIED CLASS, SELECTED CLASS, or TESTED CLASS.

Recommendations for seeding rates will vary depending on the source of the recommendation. Many turf grass and soil erosion control protocols will call for 1,000-2,000 newly established seedlings per square foot (Musser and Perkins 1969). Utilizing a target of 1,000 seedlings per square foot can quickly lead to seeding rates in excess of 100 lb per acre, a rate common to many turf grass and soil erosion control programs. In order to calculate the required seeding rate under this protocol, the following information is necessary: (a) percent purity, (b) percent germination, (c) seeds per pound, (d) expected mortality rate, and (e) stand composition. This information should be readily available for all commercially available bulk seeds with the exception of the mortality rates, which are likely to prove difficult to find. The expected mortality rates will be dependent on the species in question, seed size, seed quality, and seeding method. Realistic estimates of the quality of seedbed preparation and the quality of the initial maintenance are also required in estimating the expected mortality rate. Instead of supplying all of this information, seed suppliers typically recommend seeding rates by pounds per unit area. These recommendations will factor all the parameters mentioned above, including the expected mortality rates. Unless told otherwise, these rates will be for broadcast seeds. These recommendations should not be interpreted in terms of PLS per unit area, and any transfer of this estimate to another species will not be valid. For example, creeping bentgrass (*Agrostis palustris)* has approximately 6,500,000 seeds per pound and a typical seeding rate of about 50 lb per acre for drilled turfgrass applications (a sowing in excess of 6,200 PLS per square foot), assuming a purity of 98 percent and a germination rate of 85 percent. A drilled turfgrass application of tall fescue (*Festuca arundinacea)* would require between 2,000 and 3,000 PLS per square foot.

Utilizing the method described in the preceding paragraph to determine seeding rates will not be practicable or desirable for many forms of restoration or mitigation. For many warm grass seeding programs, the regional NRCS offices will prepare recommendations for seeding that call for the sowing of between 20 and 40 PLS per square foot. Such sowing densities will be appropriate for many seeding programs, especially those utilizing hand-collected seeds or expensive commercial seeds. If such an approach is adopted, it is best to know the PLS per pound for each of the species in the mix. One will likely be placing less than 10 lb of PLS per acre. Two or three pounds of PLS per acre may be appropriate for small-seed mixes. In some cases, it may be appropriate that the PLS requirement be targeted at only a segment of the mix and not the full mix. Such a procedure would be prudent when the mix contains some commercially available bulk seeds and some seeds that are not commonly collected. One will likely want to emphasize the rarer species (Packard 1994). The user is warned that several of the “wild wetland” seed mixes being advertised contain species that can be obtained in large quantities from seed supply

houses, particularly the grasses *Agrostis*, *Alopercus* and *Poa*. The seeds of these grasses should be appropriately priced and not used to "weight" high-cost mixes.

The incorporation depth for the seed will have to be supplied by the user. A minimum depth of one-quarter inch and a maximum depth of one-half inch will be appropriate for many small seed mixes. With larger seed mixes, a minimum depth of one-half inch and a maximum depth of one inch may be more appropriate. The user is strongly urged to consult the restoration literature as to appropriate seeding rates and depths.

Sand and perlite are two examples of inert materials that can be used in preparing a broadcasting mix. Other materials, including sawdust, rice hulls, and vermiculite, will prove equally or more effective in some applications, and these materials should be adopted. Perlite was included, as it is highly visible and will aid in the identification of seed placement. However, the user must realize that perlite will float, and, as such, perlite should not be used in areas that will be subject to immediate flooding. No inert blending mix will be universally suitable. Seed size and the quantity of seed that is available for the work will be important in determining the blending mixture.

Imprint seeding

Imprint seeding was developed in the Southwest and is primarily used to restore degraded rangeland (Dixon 1989; Dixon and Carr 1994). For these rangeland applications, one of the chief benefits of imprinting is to increase soil infiltration values and reduce the surface runoff rates. For these rangeland restorations, many practitioners will advise against tilling the soil to limit destabilization of the existing soil structure, with the preferred method being no tillage or possibly ripping. Under this method, existing vegetation is simply imprinted into the soil (using an imprinting roller) to act as mulch. The impressions left by the imprinter collect litter, water, and blown soil, thereby promoting the establishment of the sown seedlings.

An imprinting roller is essentially a drum roller onto which various solid geometric shapes or patterns have been welded. These imprints may run the full length of the roller or be arranged as studs or as a combination of full length and studs. By driving the roller across suitable ground, the imprint pattern is transferred into the soil. The patterns differ with the manufacturer, but diamond and V-trough designs are common; however, specialized "sawtooth" trough patterns are available for slope work. On a single roller, the patterns may be variable, and the orientations of the impressions on the same roller may rotate a full 90 deg.

Warning: This specification (as found in Appendix B) borrows heavily from the work of Bob Dixon of The Imprinting Foundation, Tucson, AZ, including the original manuscript of Dixon and Carr (1994). Unlike

the other specifications, this specification was prepared specifically for this document and has not been field tested. Also, this specification assumes that the work will be done on relatively flat ground or on gentle slopes. On steep slopes, the imprint patterns must be appropriate both in design and orientation, and the specification will need to be modified. If the pattern is misaligned, there is the potential for severe erosion. If one is working on slopes, reference should be made to Dixon and Carr (1994).

For rangeland restorations, the depth (height) of imprint impressions ranges from 2 to 7 in. with a 4-in. depth common. In areas with a heavy vegetative cover or considerable woody debris, larger impressions and rollers are used. The compaction pressure required will be dependent on soil texture and soil moisture. Excessive soil compaction must be avoided. The best soil moisture conditions for imprinting are the same as for agricultural plowing. Dry soils may not be able to hold the impressions. The full-imprint design is achieved when the design penetrates the soil about halfway because of the embossing effect. At the halfway point, the load-bearing capacity of the soil or upward acting resistive force should just equal the downward acting imprinting force.[1]

Since this specification was developed, St. John and Dixon (1995) published additional guidelines for land imprinting. This publication includes recommendations for the use of seed mixes that contain early successional nurse species, wheat bran as the inert material, seed collection, mycorrhizal inoculation, different acceptance criteria, and suggestions to reduce the probability of excessive soil compaction including specifying maximum soil bulk densities. Soil bulk density is defined as the ratio of the mass of dry soil to the bulk volume of soil and varies with structure and texture of the soils (Blake and Hartge 1986). Bulk density is frequently measured as the dry weight of a soil at 105 ^{o}C compared with an equal volume of water. Sands will have typical bulk densities of 1.20-1.80 g/cm^3. Clays and silts will have typical bulk densities of 1.00-1.60 g/cm^3. Peat soils have lower values, 0.20-0.30 g/cm^3. Unless compacted or farmed, near-surface mineral soils will not normally reach the denser limits of these ranges, and most values will range between 1.25-1.45 g/cm^3. Root growth is noticeably constrained at densities above 1.6 g/cm^3; at 2.0 g/cm^3, all macropore space is nearly eliminated (all the above values derived from Brady 1990). In most engineering situations, in-field measurement of bulk density can be done by the nuclear method (ASTM D 2922): Standard Test for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth) with additional testing for moisture content by the nuclear thermalization method (ASTM D 3017): Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Method (Shallow Depth). The advantage of these nuclear methods is that no laboratory or oven time is required. But these methods may not be appropriate for this

[1] Personal communication, 1994, R. M. Dixon, The Imprinting Foundation, Tucson, AZ.

application due to the shape of the imprints, i.e., no horizontal surfaces. Bulk density can be measured via other methods than the nuclear method (Blake and Hartge 1986). Alternative methods include coring, excavation, and coated-clod density (Allmaras et al. 1993). Coated-clod determinations of bulk densities frequently yield high bulk density values because this method does not take into account interclod spaces. Cone penetrometers can be used, but soil-water content will need to be determined to estimate bulk densities. If excessive compaction is a concern, the specification can be modified as per the guidelines found in St. John and Dixon (1995), which includes a table of maximum allowable bulk densities for some soil textures.

Important: The watering provisions in this guideline specification should be carefully reviewed. In some situations, watering should be treated as a separate pay item where one will pay for the water by the gallon and not incidental to this item. In many situations, such as in the winter-wet Northeast, no watering will be required, and all references should be deleted from the specification. The identification of the correct seeding period is critical.

Imprinting tools that rip/seed/imprint in a single pass may require large tractors such as a Caterpillar D8. These machines may have rollers that approach 3 or 4 ft in diameter. In wetlands, such large machines may be suitable only for fall or dry-season applications. Small rollers may be only 1 or 2 ft in diameter. Rollers are typically between 6 and 8 ft in length. Many imprinters are manufactured with attached gravity seeders, and the smaller roller types can be worked with light dozers. To avoid impact to adjacent seeding passes, the crawler must be matched in width with the roller or narrower.

In wetland mitigation, imprint seeding could be used to increase the diversity of microsites available for colonization and hopefully the long-term diversity of the restoration/mitigation. The use of an imprinting roller without any seeding should have some applications in wetland restoration/mitigation, especially where good seed rains can be expected, and in the restoration of agricultural wetlands. Other tools to increase the available microtopography on restoration sites are being development including the disk-chain diker (Wiedemann in Monsen and Kitchen 1994). This tool has elements of an imprint roller and a massive chain harrow.

Cool-season hydroseeding

The cool-season hydroseeding seeding specification (see Appendix C) is a two-step operation: site preparation and the placement of a seed/fertilizer/lime/mulch slurry. Although this two-step process is relatively common, many workers prefer to place the amendments and mulch as separate steps. Some seeding programs will require that the lime and fertilizer first be broadcast over the seeding area and then be cultivated into the soil to a specified depth, usually about 4 in. Following seedbed

preparation, the area is then hydroseeded. In a final step, a straw mulch is applied with a blower and tacked. Tacking can include an additional paper mulch. Many specifications will allow for a three-step process: (a) site preparation, (b) seed/fertilizer/lime slurry or seed/fertilizer/lime/mulch slurry, and (c) tacked mulch. Those advocating placing the tacked mulch as a separate step argue better seed-to-soil contact. Those advocating hydromulching argue better fertilizer presentation and moisture availability to young seedlings, as the hydromulch acts as a reservoir for water and fertilizer. Rabbitt and Miller (1969) offer a series of specifications targeted at turf grass establishment that cover many of the topics that are addressed in these specifications.

The material specification given here for mulch is a hydromulch and is not suitable for blower application. Guar gum tackifiers were not specified, as this specification is targeted at erosion control. The amount of water required for the hydroseeding operation is dependent on the amount of mulch being applied. If the mulching rate is reduced, one will need to lower the minimum water requirements. Seeding rates should be adjusted to reflect the mulching rate. New products, such as Weyerhauser's Soil Guard (a slurry mix of seed, wood fibers, fertilizer, and a bonding agent that hardens to form a continuous seeded erosion control blanket), offer a viable alternative to the use of fiber mulches, as described here, and some applications requiring erosion control blankets. The specification does not cover the use of moisture-retention agents, whose use may prove beneficial in compost applications or gypsum plasters. Unless indicated otherwise on the plan sheets, the specification does not allow for the use of dyes. Dye utilization is the standard practice in the hydroseeding industry, as this allows for excellent tracking of the seed placement. The dyes used in hydroseeding operations are not toxic according to all the manufacturer literature reviewed, and the authors know of no reason not to utilize them in most applications. The use of dyes was excluded after questions from aquatic biologists concerning possible impacts to water clarity if the dyes were misused.

Early spring and early fall are better seeding periods than either late spring or late fall. In high-energy situations, the fall seeding window may need to be reduced to permit maximum stand development. For almost all applications, early fall seedings targeted at soil erosion control are considered to be superior to spring-seeding operations. This will be especially true for wetland mitigation/restoration, where wet soils may restrict access in the early spring. Trying to place seed on wet ground can be extremely frustrating, especially as the seeding window narrows and the best weather for grass establishment has passed. Even on relatively firm soils, passing vehicles across saturated ground is difficult. Because of these anticipated difficulties, the two-step process was chosen for inclusion in this report because it requires fewer machinery passes and does not require a blower. Where seeding will occur on wet ground, the specification could be modified to require the use of low-pressure balloon tire hydroseeders and/or hydroseeders equipped with a progressive cavity pump (positive displacement pump) to extend the slurry range. As an alternative to

hydroseeding, the Fermi Laboratory (Illinois) conducts prairie restoration seedings using a modified salt spreader equipped with low-pressure tires (reported in Galatowitsch and van der Valk 1994). Aerial seeding via helicopter or plane is not an uncommon practice. Cost savings are often cited when compared with hydroseeding methods; but nurse crops are often used, and ground preparation may be necessary on slopes. Dolling (1986) gives methods and costs when comparing hydroseeding with aerial application.

There is disagreement about using recirculation agitation in hydroseeders. Some manufacturers use primarily recirculation agitation; others use mechanical. This specification adopts a cautious approach and leans towards mechanical agitation. With recirculation agitation, there is some fear that seed passing through the pumps will be damaged. If one is comfortable with recirculation agitation, he should modify the specification. With standard commercial seed mixes and application rates, the authors are comfortable using recirculation agitation. Bowie Industries, Inc., and Finn Equipment Company manufacture hydroseeders featuring mechanical agitation as the primary mixing mechanism. An option for drill seeding was not included, as drill seeders are not designed to work on wet ground or on steep slopes. In the future, drill seeding may be a viable option for wet ground, but the authors are aware of only one or two wet-ground drill seeders, both of which have been manufactured under special contracts.

Installing soil erosion control blankets on top of a seeding is a common practice, especially on steep slopes and other erodible features. These blankets are manufactured from a variety of materials, including jute, straw, wood fibers, and coconut. The use of soil erosion control blankets was not addressed in the specification. For unit item payment, erosion control blankets should be handled as a separate pay item to avoid complications in pricing, where some areas receive blanket cover and other areas do not.

The initial question when considering adopting any grass seeding mix must be in regard to need for and the ultimate goal of the seeding program. Using a seed mix to achieve soil erosion control, especially on steep slopes and along watercourses, will occasionally be in conflict with the desire for native species establishment. This conflict is generated by the lack of native species that are both commercially available and immediately effective in erosion control settings. This lack of native materials may lead to the adoption of seeding mixes with persistent non-native elements, especially fescues. Although largely non-native, pasture grass seed mixes (*Dactylis, Phleum*) offer an alternative to fescues.

In trying to determine whether a seeding mix is required, the anticipated successional pattern, seed-rain characteristics, overall species richness of the landscape, and potential for noxious weed invasion should be factored into the decision, in addition to the need for soil erosion control. Where a rich seed rain can be expected, such as with some riverine and

tidal systems, the need for seeding may be very low. But in those landscape positions where there is little real chance of a beneficial seed rain and the design of the hydrological characteristics of the mitigation are not compatible with what seed rain can be expected, the placement of seed may be required. The requirement for seeding will be greatest for those projects that involve massive earthmoving or where the past land practices have resulted in badly degraded landscape or soils, and where the hydrological characteristics of the design favor the establishment of easily dispersed noxious weeds that are common to that region, particularly *Phragmites*. State law and regulations related to soil erosion may also mandate the adoption of a seeding program or soil stabilization program even when no seeding may be the best biological option.

Seeding rates for hydroseeding targeted at erosion control will be many times higher than those for most other restoration practices. This is the practice of the hydroseeding industry, and these higher seeding rates have been retained in this specification. With many seed mixes, it is not intended that the composition of the mix mirror the vegetative cover that establishes. This is especially true for soil erosion control mixes. Some species in the mix will be chosen for quick establishment and soil stabilization, but they are not necessarily competitive over the long term. Other species are slow to establish, but once established are very aggressive. Within 2 or 3 years, these aggressive species will dominate or even exclude many of the other species in the mix. The timing of the sowing, water availability, and, if established, the frequency and height of mowing will strongly influence the eventual composition of the stand.

For soil erosion control, cool-season mixtures have certain advantages over the use of warm-season mixes. For much of the country, cool-season grasses have two seeding windows, fall and spring. With warm-season mixes, there is only a single spring-to-early-summer window. Mulching to aid soil stabilization is not a hindrance to the germination of cool-season grasses, as has been reported on occasion with warm-season grasses. Finally, cool-season grasses are much quicker to establish than warm-season grasses, assuming adequate water and good soils. **Warning:** Most, if not all, cool-season grasses have been selected under topsoil conditions with good soil moisture. On soils that have less than about 15- to 20-percent silts and/or clays and that are low in organics, most cool-season grasses will perform poorly with time and may be subject to erosion if located on moderate or steep slopes. Where this condition occurs, one should consider adding about 25 lb of warm-season grasses to the hydroseeding mix. If added to the mix, these warm-season elements may not become strongly established in the upper canopy until a drought event adversely impacts the cool-season elements. Under these circumstances, tracking the warm-season seeds into the soil is not necessary. Seeded alone, the warm-season grasses are not likely to perform the erosion control function.

The availability of bulk seed sources for wetland mitigation is limited and often extremely limited in terms of “true” native species. Notable

exceptions are *Arctagrostis, Calamagrostis,* and *Deschampsia,* which were developed in Alaska (Helm 1995). Some cool-season species that are suitable for erosion control work are native to both North America and Eurasia. However, the determination of the "true" genetic origin of the variety being sown will be obscured, and most selections are probably Eurasian. An exception is streambank wheatgrass *(Agropyron riparium = Agropyron dasystachyum* ssp. *dasystachyum* var. *riparium),* native to the northern Rocky Mountain region and the Northwest. Several species that are available in bulk and that are tolerant of wet soils are in the genus *Agrostis* (largely non-native sources). The taxonomy and nomenclature of *Agrostis* is not straightforward, with the following binomials being subject to some confusion: *A. alba, A. gigantea, A. stolonifera,* and *A. palustris.* (The combination *Agrostis alba* was actually first used by Linnaeus for a species of *Poa,* so this combination cannot be accepted in the scientific literature). Besides these four binomials, there are a number of taxonomic varieties. Currently, many taxonomists recognize only two species from this group, *A. gigantea* and *A. stolonifera* with several varieties. Unfortunately, many of the named varieties do not segregate out into any real species patterns, and the varieties are widely mixed. In the seed trade, this confusion is not present. Creeping bent is highly stoloniferous, with much of the selection based on its suitability for golf course uses, particularly in greens (*A. palustris* (trade name) = *A. stolonifera*). Redtop is rhizomatous and is used as a minor component of many turf and highway mixes (*A. alba* (trade name) = *A. gigantea*). When developing wet-tolerant seeding mixes, some users appear to favor the use of creeping bent grass, others redtop. Neither grass would appear to be aggressively persistent following abandonment.

Seeding regimes should not simply be thought of as being either an annual or perennial mix. With wetland mitigation, the use of short-term perennial species can be a viable option for many stabilization considerations. Short term is a tag for those species that should readily give way to colonizing species. *Agrostis alba* (*Agrostis gigantea*, redtop, FACW-OBL) and *Poa trivialis* (rough stalked bluegrass, FAC-FACW) are two species that are short-term perennials that can be used in wetland seeding programs, but neither excel at steep-slope stabilization. *Agrostis alba* should slowly lose dominance within 5 or 6 years, although it occasionally will dominate longer. *Poa trivialis* does not perform well in full sun with moisture stress. An advantage to the use of these short-term perennials is that many of these species are not as tall as the annual grasses used for immediate stabilization and do not leave a dense litter, as does annual rye or *Echinocloa*. In addition, these short-term perennial species generally do not form persistent dense monocultures and will allow for species recruitment. Species recruitment is facilitated because on wet ground many of these short-term perennials will only be a few inches tall by the end of the first spring and not their full height. The authors have used a mix of *Agrostis alba*/*Poa trivialis* in an environment where disturbed wet soils are typically colonized by *Phragmites*. Within 2 years, the stand became dominated by *Leersia oryzoides* and *Juncus effusus,* while excluding all *Phragmites* invasion. **Warning:** Conditions where annual grasses

leave a dense litter into the next spring are likely to favor midsummer perennial establishment in the second year, not cool-spring establishment. This may discourage early spring establishment by some sedges and favor species that germinate later in the season, such as *Typha, Leersia,* and *Bidens*.

These authors rarely use annual rye in a wetland seeding mix because of its height and dense litter and prefer using the short-lived, short-stature perennials. These authors also avoid the use of *Phalaris arundinacea* (canary reed grass) whenever possible, as this species can form persistent monocultures and is considered a pest species in much of the country. Where this species is now well established and is frequently called native, old floras and floodplain forest descriptions often lack references to *Phalaris*. Many first-year annual grasses that are common to old field succession are likely to be tolerant of seasonally saturated soils, the key selection filter being bare mineral soils and not necessarily the degree of soil saturation.

In cool/humid areas of the country, most seeding mixtures targeted at soil erosion control will include a tall fescue component (*Festuca arundinacea*). This tall fescue component is somewhat slow to establish when compared with the other elements of these mixes, but once established is very persistent and is likely to be the dominant element within 2 or 3 years following seeding. Once established, tall fescue is tolerant of saturated soils and prolonged inundation. Because of this persistence and its alleopathic nature, tall fescues cannot be recommended for use in seed mixes that are targeted at native assemblages. Its use in wetland mitigation is best confined to steep slopes or areas where there is a high probability of significant and deleterious soil erosion. A possible additional use for *Festuca arundinacea* would be to curtail any *Phragmites* invasion. A stand of *Festuca arundinacea* would likely slow down secondary succession, but over the long term this use would likely be preferable to the *Phragmites*. The use of tall fescue or meadow fescue (*Festuca elatior* and *Festuca pratensis)* should only be considered after rejecting all other seeding and stabilization options, including short-term perennial seedings and the use of high-quality topsoils.

The annual *Echinocloa* is similar in terms of height and litter mass to the tall cultivars of annual rye, so its use must be limited to proper applications. It can easily be broadcast seeded and does not require fertilizer or tracking. Unfortunately, the only *Echinocloa* available as bulk seed is the non-native *Echinocloa crussgalli* (Japanese millet/duck millet). When properly used, *Echinocloa* has great value, as it is quick to establish and is extremely tolerant of prolonged shallow flooding. In addition, the plant is a prolific seeder, with the seed having high wildlife value. This species is common throughout much of the country including the playa wetlands on the southern High Plains (Haukos and Smith 1994). On favorable sites, *Echinocloa* seeding may result in the development of a dense litter that will persist into the following spring. This litter may retard the initial growth in the second spring, but by midsummer of the second year, strong colonization by

native perennials should occur, assuming that the system and surrounding landscape characteristics will favor perennial establishment and assuming that a desirable native seed rain is present. *Echinocloa* will self-seed, but it is slow to germinate under a dense litter. *Echinocloa* shows a preference for bare mineral soils. As *Echinocloa crussgalli* is non-native, its use should be predicated on its not becoming a nuisance species. *Echinocloa crussgalli* should not be used in areas where it is not already common and not in California vernal pool settings.

Warm-season hydroseeding

The warm-season hydroseeding specification (see Appendix D) is targeted at establishing warm-season grasses in the eastern United States, especially *Panicum virgatum* (switchgrass). In the East, warm-season grasses are most easily established immediately following agricultural abandonment. The establishment of warm-season grasses in wet old fields will be complicated by larger and more diverse cool-season weed seed banks. Establishment on sands will be easier than on silts or clays. Warm-season seedings should be very competitive on soils with less than 20-percent fines by weight, but they will not be restricted to such soils (Dickerson, undated publication). The user should be aware that drill-seeding operations will be difficult or impossible to conduct on wet soils. Drill seeding may only be practicable with late-spring or early summer sowings.

To help distinguish between the metabolic pathways in the grasses, C_3 grasses are referred to as cool-season grasses and C_4 grasses as warm-season grasses. On sandy soils or droughty soils, those grasses with the C_4 photosynthetic pathway will be strongly favored over those in the more "standard" C_3 photosynthetic pathway. In C_4 metabolism, the initial carboxylase enzyme is different from that under C_3 metabolism, and there is a structural isolation of the carbon fixation cycle. These anatomical and biochemical features allow C_4 plants to fix carbon efficiently under much lower partial pressures of CO_2, as compared with C_3 plants. The ability to fix CO_2 at lower partial pressures allows for the plant stomata (pores) to remain closed for much longer periods of time, thus conserving water. C_4 plants have a distinct advantage in dry and all types of saline habitats where water stress is likely to occur, but are not restricted to such habitats. For example, the C_4 grass, *Muhlenbergia glomerata*, is an obligate freshwater wetland species restricted to cold fens.

On fertile loamy soils with good water-holding capacity, cool-season C_3 grasses will have a competitive advantage. These grasses will show strong growth in both the spring and fall with maintenance of occupied space during the summer months—browned, but not dead. Most warm-season grasses do not exhibit strong spring growth. Many of the commercially available C_3 grasses are largely Eurasian in origin, imported as pasture grasses during colonial times. Some C_3 grasses include orchard grass (*Dactylis glomerata*), Timothy (*Phleum pratense*), and several of the

fescues and bromes. With a few exceptions, these European grasses are more competitive on nonacid soils. All soil-erosion control mixes developed for the northeastern United States are composed of these non-native C_3 grasses.

On sandy acid sites with less water-holding capacity, the non-native C_3 grasses will suffer significant water stress during the summer months and not be able to maintain space. As a result, the C_4 grasses will be favored. The perennial C_4 grasses are largely native grasses and include many panic grasses (*Panicum*) and other natives (*Andropogon, Schizachne*). The winter architecture of fields dominated by European C_3 grasses and those of native C_4 grasses is different. Many of the native C_4 grasses stand erect during the winter, providing both structural cover for wildlife and seed heads for foraging. Of particular habitat value are stands of switchgrass (*Panicum virgatum*). The European C_3 grasses were selected for haying and lay relatively flat during the winter months and provide less wildlife cover and seed forage.

In some regions of the country, the climate strongly favors the establishment of warm-season native grasses, and proven specifications for their establishment are available from many Government agencies, including the NRCS and various highway organizations. For example, the Texas Department of Transportation has dozens of different native warm-season grass mixes, as part of their standard specifications. If one is are located in a region of the country where warm-season grasses are commonly sown, local specifications should be used. Because of the potential for cool-season weeds to dominate a warm-season seeding program, the use of proven specifications developed in the prairie or Western States, but used in the East or other high-rainfall areas, should be adopted only after a full review of the specification and the potential for cool-season dominance is considered.

Unless a range drill is used, the specification differs from most standard seeding specifications because of the requirements for dragging and tracking (Gaffney and Dickerson 1987; Godfrey and Dickerson 1988; Dickerson, Kelsey, and Godfrey 1989). The specification can be modified to allow the use of other firming equipment, but the equipment must be of be of a design to generate good seed to soil contact. Although this specification should work outside the East and other high-rainfall regions, it must be recognized that these dragging and tracking provisions will be unnecessary in some regions. The specification also deviates from most seeding programs, as no establishment criteria are included. Establishment criteria should be used with most cool-season seeding programs, but may be inappropriate for some warm-season seeding programs. For many of the warm-season grasses, including *Panicum virgatum*, the establishment may be slow with strong growth not apparent until the end of the second growing season and any establishment criteria will be difficult to administer properly. As such, no plant establishment period is contained in this seeding specification, and the engineer is required to be diligent concerning the materials, installation, and sequencing. It must be recognized

that even if everything is done right, if the weed seed load and rainfall are high, warm-season grass establishment may be poor.

With warm-season seeding programs, the difficulty of successful establishment generally increases as the amount of summer rainfall increases. This difficulty has been strongly exacerbated by the naturalization of numerous non-native weedy grasses and forbs and the restriction of wildfires. Many of these non-native species are cool-season species that can be very aggressive and can easily crowd out the native warm-season elements. In those parts of the country where warm-season grasses dominate, this competition may not be a problem; but where cool-season grasses and weedy herbaceous plants are aggressive and persistent, cool-season species can dominate a newly sown site even before the warm-season grasses germinate. Where the concern for weedy dominance is high, soil cultivation on 2-week intervals for a full growing season may be required as part of proper site preparation. By cultivating to a depth of 4-6 in. for a full growing season, it is hoped that most of the weed seed will be reduced or eliminated through forced germination. Prior to the actual seeding, frequent dragging operations are conducted to remove newly emerged weed seedlings. It is critical that this dragging not turn the soil, or a new crop of weed seeds will be exposed, and the value of all previous dragging operations will be lost.

With this specification, one must be very careful in the selection of seeding and spring dragging window dates. The windows can overlap, but the degree of overlap should not result in conflicts. For example, the specification is written so that the spring dragging window under fall cultivation should open at least 4 weeks prior to the opening of the seeding window, thereby allowing for at least three dragging operations to occur prior to the spring seeding.

Although this specification is targeted at the use of warm-season grasses, the seeding techniques contained in the specification and the concepts discussed are applicable to many seeding programs targeted at establishing native plant communities with the caveat that fall seeding may be appropriate for most sedge-dominated mixes. It should be emphasized that the seeding mixes contained in the specification are of minimal importance as compared with the underlying concepts and techniques. Shirley (1994) offers a more complete discussion of site preparation, seeding equipment, seed handling, and site maintenance. As the U.S. Department of Agriculture (USDA) is active in developing warm-season seeding programs throughout the East, it is likely that this research will require that this specification be modified within the near future. Where there are questions, it is strongly advised that a regional USDA plant material specialist review the seeding program.

If desired and after careful consideration, the specifications can be modified to allow the use of chemical treatments to curtail the germination of weeds, or allow Furidan seed treatment for insect control. *Panicum virgatum* has some tolerance to the chemical Atrazine, but most

native forbs are not tolerant. The use of many chemicals, including Atrazine, is restricted in some States, and only the most recent literature and regulatory guidelines should be consulted.

The authors are not comfortable with the mowing aspect of the specification, and there is some reason to believe that it should be dropped entirely from the specification. The initial draft of this specification contained a much more aggressive mowing program with lower heights. The adoption of an aggressive mowing program was rejected after a review of both northeast and southeast regional NRCS literature for establishment of warm-season grasses (Glennon, undated publication). This regional NRCS literature did not indicate the need for a low-height mowing program or any other mowing program and strongly advised against mowing at heights of less than 8 in. for *Panicum virgatum*. As written, the mowing regime is limited to a single second-year spring mowing with a flail shredder. Flail shredders and flail mowers generate litter that should easily decay without forming a dense thatch that could smother the warm-season seedlings/offshoots or retard soil warming. Both John Deere and Brillion Iron Works manufacture flail shredders/mowers, but these machines are not fully equivalent and have differing mowing height ranges. It is likely that some workers will reject the mowing aspects of this specification and favor the adoption of a strong mowing regime during the first year (4- to 6-in. height) with allowance for taller late summer growth using a flail mower.[1] This first-year mowing regime would then be followed by a near-ground mowing in the next spring prior to the green-up of the warm-season species with the potential for the continuation of the mowing program through late spring. Other workers simply favor a single 8-in. mowing height until the stand is ready to be released. Where a litter has developed, some workers will advocate the physical removal of the litter in the second spring. The near-ground mowing and removal of the litter are an attempt to simulate some aspects of fire and promote soil warming, which aids the germination of warm-season species. The adoption of a burning program is likely to strongly favor the maintenance of warm-season grasses; but burning is not required for stand persistence, and many NRCS regional publications do not recommend its use. Although there is disagreement, where burning will be used, it is recommended that burning not be used until the third growing season (Shirley 1994).

There are a number of manufacturers of glyphosate fertilizers. The biology of glyphosate is discussed in Carlisle and Trevors (1988) and Malik, Barry, and Kishore (1989). Contrary to information found in much of the current literature, Aheran, Triol, and Berlyn (1996) report that glyphosate remains active for several weeks after treatment, and the activity is capable of both stunting and killing seedlings. One may consider revising the

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[1] Personal Communication, 1994, Neill Diboll, Prairie Nursery, Westfield, WI.

specification to reflect this concern. Monsanto Company, St. Louis, MO, manufactures two glyphosate herbicides under the trade names Roundup and Rodeo. These herbicides differ based on the type of carrier chemical, called the surfactant. According to Monsanto literature, Rodeo has limited water-use restrictions. This is in contrast with Roundup, which is not approved for use in aquatic systems, largely because of characteristics of the surfactant. Some experienced restoration workers have reported adopting vigorous herbicide pretreatment protocols (midspring, midsummer, early fall, spring tillage, a second midspring spraying with the glyphosate herbicide, and then seeding) prior to conducting a seeding program on established old field or meadow vegetation. Late-afternoon herbicide treatments are reported to be the most effective, a verbal communication that needs verification. Alternatively, some workers will cultivate and drag the site for a full growing season, starting in the spring. Such programs are targeted at removing all phenological species groupings: spring growers, summer growers, fall growers, cool-season plants, and warm-season plants.

It is important to remember that warm-season grasses are an integral element of much of the North American environment and are not restricted to the prairie States. Even along the mid-Atlantic seaboard, several native warm-season grasses may become dominant even without the presence of a fire regime. Besides *Panicum virgatum*, *Andropogon scoparius* (little bluestem) and *Andropogon virginicus* (broom-sedge grass) may be dominant with lesser amounts of *Sorghastrum nutans* (Indian grass), *Andropogon gerardii* (big bluestem), and *Dicanthelium clandestium* (deer-tongue grass). Except for *Andropogon virginicus,* all these grasses are commercially available in bulk from selections developed by the USDA, and new material releases should continue for the foreseeable future. Few releases have been specifically selected for wetland environments; however, USDA literature does indicate that many of the *Panicum virgatum* selections are suitable for low-ground or waterway seedings, including “Alamo,” “Blackwell,” “Cave-in-Rock,” “Kanlow,” and “Nebraska 28.” Galatowitsch and van der Walk (1994) classify “Blackwell” as a weed to be avoided along with *Phalaris arundinacea* (canary reed grass) and *Lythrum salicaria* (purple loosestrife).

Plant releases from the USDA can be found in the SCS (now NRCS) publication *Improved Conservation Plant Materials Released by the SCS and Cooperators through December 1992* (USDA, National Plant Materials Center, Bellsville, MD). This publication documents the genetic origin of the releases. The user is strongly advised to use the services of the regional USDA Plant Materials Centers and regional NRCS plant material specialists on proper seeding regimes, variety selection, seeding dates, and fertilizer treatments. Clear regional differences are seen in seeding rates with much lower rates for the same mix in the prairie than in the East. It will be important to verify the correct seeding dates for one’s area. When compared with drill seeding rates, hydroseeding and broadcast seeding rates are typically 1.25 or 1.5 times the drill rate for the same mix in the same area. Unless the seeding protocol is given, it is best to

assume that the rate is for broadcast seeding. Occasionally, the NRCS will recommend seeding windows based on soil temperatures and not a calendar date. Having the NRCS recommend a minimum 55 ^{o}F soil temperature for sowing most warm-season seeds would not be uncommon. A minimum soil temperature requirement lessens the chance for warm-season seed rotting in a cold wet soil.

Recent work in establishing warm-season grasses has led to changes in recommended seeding rates (lower rates), so one should be careful when reviewing seeding rates and adopt the current recommendations—many of the more recent recommendations are for less than 4 lb of PLS per acre, drilled. Most of the regional USDA Plant Materials Centers publish guidelines for the selection of conservation plants. These guidelines are of great help by detailing genetic origin, suitability for lowland seedings, architectural characteristics of the plant, disease susceptibility, flowering times, establishment protocols, closing dates for seeding windows, and areas of adaptation by MLRA (Major Land Resource Areas - USDA, Soil Conservation Service, Agriculture Handbook 296 (1981); Map Revised, 1978).

Although there is some debate on stratification requirements, it is commonly recommended that the warm-season grasses be sown at roughly the same time as the spring window for cool-season grasses, i.e., late winter to early spring. If adopted, these early seedings of warm-season grasses will be competing directly with cool-season weeds. There is a strong body of recent work that suggests that delaying the seeding until late May or early June may be a method to curtail cool-season weed colonization without seriously retarding warm-season grass development (Shirley 1994; Galatowitsch and van der Walk 1994). An exception to the late spring sowing may be deer-tongue grass (*Dicanthelium clandestium*), which has been reported to require a cold stratification of 3 to 4 weeks (USDA, Plants for Conservation in the Northeast, Conservation Plant Sheet 34). Stratification requirements for a number of native grass and forbs can be found in Young and Young (1986) and Shirley (1994).

In those portions of the country where cool-season grasses are aggressive and persistent, the following recommendations are appropriate for the establishment of warm-season grasses:

a. One should not include any cool-season grasses within the warm-season mix, especially fescues or annual rye. Many regional NRCS plant material specialists and USDA plant material researchers have abandoned the idea of mixing warm-season and cool-season grasses because of repeated failures with the warm-season component of the mix so that only the cool-season element establishes. If a nurse grass is absolutely required, sow oats at the rate of one bushel per acre (32 lb of PLS).

b. If applied by hydroseeding, the seed mix must be tracked into the soil with a heavy bulldozer or tracked machine with good growsers.

c. Nitrogen fertilizer should not be applied until midsummer, the period when warm-season grasses can most competitively use the fertilizer. Earlier application will favor the cool-season plants. A second application of nitrogen fertilizer is highly desirable during the middle of the second growing season. An exception will be for very coarse soils, where it may be appropriate to apply nitrogen with the initial fertilizer. (Note: Some practitioners do not follow this last guideline and always apply fertilizer during the sowing operation; others never apply fertilizer at any time).

The mandate not to include cool-season elements in the mix would be negated on droughty soils. Under these circumstances, the warm-season elements may take several years to become established—the cool-season grasses dominating until a harsh, dry summer. Once established in the upper canopy, the warm-season grasses should continue or expand their importance; but the cool-season elements may remain codominant.

It must be emphasized that the procedures for warm-season grass establishment vary between workers, even when two workers are from the same region of the country. In some cases, the recommendations will be in direct conflict. Conflicts occur largely in three areas, mowing requirements (described above), the preferred seeding windows, and the requirement for mulch. Some experienced workers and researchers indicate a need for a fall or late-winter sowing to satisfy stratification requirements, thereby breaking seed dormancy. Others report little problem with late spring sowings or even early summer sowings of warm-season grasses. Some individuals reject the use of mulch because it retards the soil warming, a key element in germinating warm-season grasses. At the same time, others report favorable results with mulch, especially for late-spring sowings. In order to get around these contradictions, some individuals tend to split the difference—no mulching in the late winter or early spring, but mulching in the late spring or where soil erosion is a concern. This specification does not call for mulch. When using a hydroseeder, adding a wood fiber mulch to the slurry at a rate of about 500 or 600 lb per acre will provide both a minimal mulch and allow for more accurate seeding applications, as the mulch will act as a seed carrier. (Note: *Panicum clandestium* appears to be an exception to these guidelines, in that mulching and fertilizing is recommended).

To further favor the native species, a few workers are reporting favorable results and good establishment by dropping the pH to about 4.5 prior to seeding. Most cool-season grass specifications require a soil pH above 5.0 or 5.5. In addition, warm-season grass seeding programs should have some competitive advantage over cool-season grass seedings with soils showing signs of moderate aluminum toxicity. In those situations, topsoiling may not be desirable when trying to establish a warm-season grass cover.

Range drills are manufactured by a number of companies including Truax, Tye, John Deere, Nesbit, and Great Plains. Alfalfa seeding equipment manufactured by Brillion has been modified by a number of workers for use in restoration. Truax range drills can be equipped with a separate "legume" box for small-seeded forbs. Truax also manufactures a broadcast seeder that is capable of handling a variety of seed types and sizes at the same time. Common modifications to broadcast seeders include adding cultipacker rollers for better seed placement. Cultipackers may perform poorly on wet ground.

If warm-season grass establishment is so troublesome and somewhat problematic, why provide specifications for its use? The answer is straightforward: if successfully established, native warm-season grass stands offer superb wildlife habitat, regardless of season, and are among the most aesthetically pleasing habitats. *Panicum virgatum* "shelter" was specifically selected for providing winter wildlife habitat from ecotypes gathered throughout the Northeast. As it relates to wetland mitigation, many warm-season grasses (particularly *Panicum virgatum* and *Panicum clandestium*) should be adaptable to seasonally saturated soils or soils subject to winter-limited ponding (*Panicum virgatum*), or the mixes could be used as nurse crops within a reforestation program. Another reason for including a warm-season specification is to emphasize the abysmal lack of bulk seeds for wetland restoration work. For many projects, a mix using *Leersia* (rice-cut grass), *Glyceria* (manna grass), or a mix of *Carex* and *Scirpus* would be preferable to the grasses currently available, but presently bulk seed sources for these plants are unfortunately lacking or extremely expensive. Fortunately, the availability of seed for wetland restoration is now improving, but wetland mixes are still being advertised that are or could be "stuffed" with low-cost commercial grasses.

An excellent source on restoration seeding is Monsen and Kitchen (1994). Although it is targeted at rangeland restoration, the biology is not altogether dissimilar. The reference sections are extensive.

Contract growing and seed collection

Contract growing is typically awarded as a separate contract well in advance of the larger construction contract. The specifications of the construction contract (see Appendix E) would then mandate that the contracted materials be used in the project. With contract growing, the key element is time. If enough lead time is given, contract growing will help ensure that the quantities of plants or seeds specified can be delivered when required. It is senseless to specify large quantities of plant materials without investigating the feasibility of obtaining that quantity within the required time frame. Such responsibilities belong to the design team and not the contractor.

If one has a good idea of the number of seeds per pound, he can order dry seed via pounds of PLS. With moist or wet-stored/shipped seed, one

can order seed via the necessary number of PLS to achieve the desired sowing density of PLS. By requiring an estimate of the number of dry seeds per pound and a cubic volume, the supplier will be able to estimate the volume of seed that needs to be shipped based on the germination testing.

For some projects, the nursery may ask or demand payment via a schedule—a series of partial payments based on calendar dates or project milestones. These authors have entered such contracts, but only after considering the nature of the work, the reputation of the nursery, and the amount of money that is involved.

Broadening the diversity of the planting or seeding program is another advantage of contract growing. If sufficient lead time is allowed for, it should be possible to obtain plant materials that are not "advertised" via contract growing or the use of early purchase order requirements. For example, submersed and deepwater graminoids have great potential for use in marsh mitigations, but are woefully absent from the wetland nursery industry and are difficult to obtain outside contract growing (Reference Voss (1972), page 54). Unless provisions can be made to propagate materials or obtain materials via wild collections, it is equally senseless to specify plant materials that are not commercially available.

Contract growing can solve potential problems associated with improper genetic origins or nonadapted ecotypic variation by allowing nurseries enough time to gather sufficient propagules for propagation from the region and, when appropriate, the altitudinal range or habitat type or even locale, as detailed in the specifications. Besides poor survival and establishment, inappropriate plant origins can lead to improper flowering and poor seed production. However, it must be recognized that problems associated with genetic origins are species-specific and may have strong regional influences.

If wild collection of whole plants is not acceptable, the specification should prohibit the use of wild collection as delivered stock and specify that nursery-grown stock is mandatory. If genetic stock is to be derived from a specific locale via seed propagation, this can be specified, but problems with propagation may occur because of poor seed production, infertile seed, seed dormancy, or improper seed handling especially with species that are "new" to the contracted nursery.

Documents supporting this specification must address the eventuality that the contracting party cannot accept the planting materials because of unforeseen delays in construction or for any other reason. In no way should the material supplier be financially penalized because the contracting party is unable to accept the materials. At the same time, the nursery should not be able to "double sell" the plants without compensating the contracting party.

Dealing with undersized stock is a real problem that can be awkward for all parties involved. If stock size is likely to strongly influence the survival of the stock, one should place a minimum sizing requirement. Alternatively, one should demand a survival guarantee for the stock or reject the stock without compensation. Such a guarantee is best based on a minimum-percent survival, stem density, or other parameter that anticipates some level of loss.

The seeding collection segment is of concern, especially as it relates to germination testing and the underlying elements of stratification and seed dormancy (Please reference the rationale under Broadcasting seeding (nonaquatics) section for a discussion of seed quality and stratification).

The germination and stratification requirements of many of the native species are not very well-known, and germination testing can give a false impression of the true viable seed when the germination requirements are poorly understood. At the same time, germination testing is the best method to ensure against poorly stored or handled seed. State seed laboratories can be extremely helpful in determining the feasibility of performing germination tests for a given species or genus. As an alternative to germination testing, tetrazolium testing (Grabe 1970) coupled to minimum viability percentages could be used to develop minimum standards for seed quality. Such testing will indicate that the seeds are alive, but it will not indicate that the germination requirements for the seed have been satisfied—one could be sowing dormant seeds. In some cases, a more practical alternative would be to specify a bulk seed quantity or weight with strict seed storage/drying requirements (Justice and Bass 1978; Young and Young 1986). A discussion of various types of seed-stripping equipment can be found in Morgan and Collicutt (1994).

Warning: Mixing of different seed types/shapes into a single seed bag should be avoided if a multibox drill seeder will eventually be used for sowing the seed. Clean seed generally makes drill seeding operations easier with better seed placement.

Acorn collection

The acorn collection specification (Appendix F) illustrates a method for broadening the availability of seed for forestry applications, as well as proper acorn handling and collection techniques. For most projects, the mapping segments of the specification can be eliminated; but in those areas where acorn collection is not common, this specification may be a method of increasing the availability of local seed sources. The strict mapping requirements allow for some “institutional” or regional memory of high-quality collection sites.

As written, the specification requires the user to insert location limits for the collection. If desired, these limits can be narrowed to indicate

habitat, proximity to the restoration site, elevational criteria, exposure, geographic province, or soil type.

For some species within the red oak group, an examination of the acorn for cotyledon color may be appropriate (Bonner 1993). For those red oak species with a high-fat content, the cotyledon color at maturity should be dark yellow or orange. Water storage for nuttall oak (*Quercus nuttallii*) has been reported by Johnson (1979).

The specification is conservative in that it does not address insect control or long-term storage (Bonner 1993). This can be done within the context of this specification because the shipping requirement to the designated nursery or seed-handling firm is limited to a 3-day window following collection. With this specification, acceptance determinations occur not in the field by the engineer, but by the staff at the nursery or seed-handling firm.

Forestry

When a planting program is anticipated, the adoption of forestry practices represents a viable alternative to using traditional landscape practices. Both approaches have their place in mitigation. Forestry practices will allow for large-scale plantings at lower costs, but the species availability and planting sizes will be much more restricted than in the landscape industry. For large projects, the total cost for an installed bareroot hardwood sapling should be less than $1.00 per plant, assuming stock purchase from a forestry nursery. Where planting crews are common, the price will be lower. As with the landscape industry, species availability can be extended via contract growing of forestry stock, but such contracts would have to be finalized in Summer/Fall Year 1, for planting in Spring Year 3. For example, the authors have adopted this approach to obtain stock of *Quercus michauxii* (Swamp Chestnut Oak), a species not normally available in bulk quantities.

Although the attached specifications are written in a landscape industry format, the content represents standard forestry techniques. Contract specifications prepared by the USDA Forest Service are similar, but do not contain the numerous DO NOT DO statements found in the attached specifications. The emphasis on controlled lifting operations is derived from USDA contract documents. All of these guideline specifications have been used in actual restoration projects, following limited edits and removing unwanted elements that can represent a significant deletion of material. Significant problems have not been experienced when conducting work under these planting specifications.

Saturated soils represent a major physiological stress to most woody plants, even in those species common to wetlands. As the period of saturation increases, the survival rates of planted stock will likely decrease.

Planting in sufficient microtopographic relief to promote soil drainage will be a key survival determinant, particularly with oaks, the target of many planting programs.

Professional forester

For large-scale reforestation projects, the use of a professional forester to oversee the planting operations is highly recommended (see specifications, Appendix G). The professional forester can be viewed as an extension of the engineer in terms of maintaining quality control during the planting operation. For most projects, an engineer will simply not have sufficient time or the expertise to administer a large planting operation properly. The need to maintain rigid quality control during the planting operation is mandated by the difficulty in detecting abused or even dead stock by simply inspecting the site immediately following the installation of the stock. At that time, planted bareroot stock with desiccated root systems will largely look the same as properly handled and planted stock. The appendix of *A Guide to the Care and Planting of Southern Pine Seedlings* (USDA 1989) provides some guidelines for supervising crew operations under variable weather conditions.

Reforestation

The reforestation specification (Appendix H) incorporates most elements that are common to reforestation programs. It differs from the vast majority of reforestation programs in that these elements are contained in a single specification. For many projects, it will be appropriate to divide this specification into several distinct specifications that can be awarded as separate contracts. Guideline specifications for contract growing, consulting forester, and forestry planting have been provided. When subdivided, the supervisory role of the engineer or professional forester must be emphasized in the specification for the actual planting. The use of a professional forester to supervise the planting is strongly recommended. Although directed at the Southeast, Duryea and Dougherty (1991) is an excellent reference source for many of the topics hinted at in the specification. The handling practices contained in the specification are conifer-handling practices. New practices, such as open-cold-dry storage of hardwoods, are not addressed in this specification.

Typically, a private landowner will obtain the plants directly from an established nursery whose material quality is known to the landowner. The landowner then contracts a professional planting crew to install the plant materials. In many situations, the landowner hires a professional forester to transport the materials from the storage facility, supervise the planting crew, and ensure that the plants are properly handled and installed. The professional planting crew's responsibility is limited to proper onsite handling, installation, and providing the proper planting tools. Generally, planting crew members are paid on the basis of the

number of plants properly installed and not on a hourly basis. Plant materials, cold storage, onsite cold storage, and material transport are not the responsibility of the planting crew. Thermal-reflective tarps (heat shields) are best provided by the professional forester and not the planting crew. Tarps provided by the planting crew may be in poor condition, few in number, or altogether lacking.

In many regions, State forestry departments are very active in providing forestry services to the landowner. Such services may include specifying sizing and plant material origin, providing the planting materials from State-operated nurseries, providing planting contracts and specifications, contract advertisement, awarding bulk planting contracts for several landowners, the operation of regional cold-storage facilities, the lease of cold-storage trailers equipped with power generators, machinery lease, and inspection services.

Cold-storage practices differ across regions of the country. In the Southeast, cold-storage facilities' primary use is for regional pines, and the materials are stored at temperatures just above freezing with strong prohibitions against freezing. In the Northwest, the commercial conifers may be stored just above or just below freezing. When stored below freezing, a gradual thawing period is required. The specification contains two alternatives; one of these alternatives will have to be edited from the specification, or the choice can be specified as a plan note.

With container stock, such as tublings and plugs, most specifications will not mandate the use of a particular growing media. If desired, such information can be made part of the specification or be subject to review and approval as part of the submittal requirements. Many high-quality forestry nurseries use blends of *Sphagnum* peat moss and vermiculite, Grades 2 or 3, as the growing media for the stock, but the specific ratios in the blends may change depending on the species being propagated or even the season of propagation (USDA, Forest Service, Agricultural Handbook 674, Volume 2). Lower quality peats include *Hypnum* peat moss, reed and peat moss, and peat humus. The submittal section of the specification will allow the nursery to amend the growing methodology easily, subject to approval by the Department.

On an upland site, the number of pine trees that an experienced crew member can properly install may approach or even exceed 3,000 trees/day. On difficult wet sites, this number may be reduced by half. Because hardwoods are much larger than most conifers, this number will be further reduced. An experienced planter should be able to place about 1,000 hardwoods/day. Regardless of the site conditions or plant type, inexperienced crew members will not approach these numbers, and tubling installations will be much slower. If a large planting program is anticipated, it is strongly advised that a minimum number of planting crews be specified on the plans as a plan note. Such a note is especially important in those portions of the country where the planting window is only a few weeks long. If a large reforestation project is planned for a region of the country

where professional planting crews are not common, the design team should be aware that locating experienced planting crews may be a real problem, especially when the contract is awarded inside a larger contract. There is a least one company offering a machine planter for use on rough ground and deep slash—Wildland Planter, R. A. Whitfield Manufacturing Company, Mableton, GA.

Reforestation programs differ from standard landscape practices in that there is no plant establishment period. If the plants are properly handled and installed, the responsibility of the planting crew is ended. Because there is no plant establishment period, the strong focus on proper plant handling is intentional, and the performance of the engineer or consulting forester will largely determine the success of the project. Although the plant-handling practices may appear to be "Draconian" to those more experienced in landscape practices, these restrictions and planting guidelines are not outside best forestry practices and are intended to emphasize that bareroot saplings are relatively fragile and easily desiccated. Improper material handling can easily result in a dramatic increase in mortality rate of the stock, but in many situations the damage will not be evident at the time of planting. The enforcement of the material handling aspects of the specification is dependent on the weather conditions. On hot sunny days or windy days, the handling specifications will be more rigidly enforced than on cool cloudy days, free of wind. Severe wind will cancel a planting day.

When revising and simplifying this specification, the use of thermal tarps to protect the trees should not be abandoned. Packaging will dictate what elements can be relaxed. The use of covered stockpiling locations (in addition to the thermal tarps) is a best practice promoted by some forestry agencies and nurseries, but it is not commonly implemented in most parts of the country.

From *A Guide to the Care and Planting of Southern Pine Seedlings:*

"Despite constantly improving reforestation technology, many public and private forestry organizations report declines in early survival in southern pine plantations. Experienced managers have come to expect lower survival rates than they were used to 20 to 30 years ago, and they are seeing failures that cannot be attributed to insects, diseases, or adverse weather. The most common reasons for these failures are breakdowns in what can be thought of as the 'reforestation system.' At various points between the nursery bed and the field planting site, seedlings are 'critically wounded' by events that workers consider to be insignificant. Combinations of these 'insignificant events' add up to poor seedling survival or complete plantation failure."

The above publication is highly recommended for those interested in proper tree handling procedures, planting techniques, weather restrictions, and as an introduction for those interested in chemical treatments for disease prevention. A short contract form and a planting specification are

contained in the appendix. The publication also illustrates problems associated with improper genetic origins. Where regional genetic sources exist, it is strongly advised that these sources be specified. *The Container Tree Nursery Manual* (USDA, Forest Service, Agricultural Handbook 674, Landis et al. 1989-1992) is a recent series of publications on the proper use and handling of containerized stock. Volumes 6 and 7 of *The Container Tree Nursery Manual* should be published over the next few years and should address many of the issues contained in this specification. It is important to note that the use of chemical treatments in reforestation has not been addressed in this specification.

As Atlantic white cedar is rarely grown for commercial forestry, the propagation information concerning Atlantic white cedar is provided as an example of a safeguard that can be included in a material specification to ensure that the plant suppliers are aware of the constraints associated with the propagation of a certain species. The submittal subsection allows for an easy modification to the propagation procedures, and the nursery will not be constrained from adopting a different propagation procedure based on past or future experiences. **Note:** It is the understanding of these authors that there may be a shift away from tubling stock of Atlantic white cedar towards bareroot stock. One should verify this stock type.

In many parts of the country, root collar sizing is graded in units of thirty-seconds of an inch simply to avoid dealing with fractions of different denominators. In other parts of the country, all specifications are in inches except for the root collar sizing, which is graded in millimeters to aid packing-shed culling practices. The number of first-order lateral roots is a key material specification criterion and is at least as important as the root-collar sizing, if not more important, and much more important than height—a factor which is strongly influenced by growing densities of the beds.

There is no universal agreement or magic formula for proper plant sizing, and setting minimum sizing standards is not as common as the publication of optimum standards. In at least some regions, the U.S. Forest Service will prepare yearly planting guidelines for commercial forestry and plantings on Federal land. In some East Coast nurseries, all pine stock is culled at a root collar size of 4/32 in. and a height of 4 in. The three-eights-inch root collar sizing with an 8-in. taproot for bareroot hardwoods follows the recommendations for increased outplanting survivalship found in *Bottomland Hardwood Reforestation in the Lower Mississippi Valley* (Allen and Kennedy 1989).[1] The use of hardwood stock with a target root collar diameter of one-fourth inch or even three-sixteenths inch is common, and some workers prefer to use materials that are no taller

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[1] Personal Communication, 1993, J. Allen, National Wetlands Research Center, Slidell, LA.

than 30 in. The use of smaller hardwoods should allow for easier and more consistent planting. Specifications for smaller hardwood taproot lengths are preferred by some nursery managers because of lifting constraints imposed by equipment limitations. On the other hand, some nursery managers are reluctant to prune hardwood taproot lengths to less than 10 in. because of concerns for improper shoot-volume to root-volume ratios, especially with three-eights-inch root collar stock. Lateral lengths are very difficult to control, especially in the direction parallel to the axis on which the lateral pruning cuts are made while the plants are in the propagation beds. Long laterals in excessive of 2 or 3 ft are not uncommon in some hardwood nurseries, and the presence of such long laterals may slow down the planting or require field root pruning, a step that is best avoided. Long laterals are most common on stock older than 1 year. Pruning of excessively long laterals in the packaging shed is not easy, as the long lateral lengths are difficult to identify among the root masses. If a shipment of long laterals is received, one will be forced to allow root pruning and/or air culling of the laterals. Improper shoot-volume to root-volume ratios have the potential to be a real outplanting problem and are not addressed in this specification. If desired, the specification can be amended to include a shoot-volume to root-volume ratio, but these authors are not aware of proper guidelines for bareroot hardwoods, especially when factoring root collar sizing and plantability. *A Guide to the Care and Planting of Southern Pine Seedlings* contains shoot-volume to root-volume ratios for Southeast pines. Regardless, it is important to remember that stock should not be of such size that the plants cannot be both reliably and efficiently hand planted. The choice of planting tools must take into account the plant material sizing criteria, but the choice planting tool should not arbitrarily determine taproot lengths. Scagel et al. (1993) is a useful publication targeting the sizing of Northwest conifers.

The generic hardwood specification will not fit all hardwoods and may need to be revised for some species. Pin oak (*Quercus palustris*) and Swamp Chestnut Oak (*Quercus michauxii*) conform to the specification. Water oak (*Quercus nigra*) has a strong tendency to be much shorter than the minimum height specified while easily reaching the minimum root collar dimension. Willow oak (*Quercus phellos)* is often a little shorter than the specified minimum height, but it is freely branched. Green ash (*Fraxinus pennsylvanica*) is often single stemmed, but taller than the maximum height. The taproot of many species of hardwoods is quickly lost, leading to the development of bulky, freely branched root systems. One should not expect nice clean easily plantable hardwoods. For material acceptance, emphasis should be placed on root collar size and the number of lateral roots.

When tubling stock or plug stock is specified, it is highly recommended that the regional literature be reviewed or that a forester and/or forestry nursery be consulted as to the best sizing, shipping, and handling procedures for the stock. The favored protocols will vary from region to region. In the Northwest, the use of extracted plugs are very common. In the Southeast, many users request tublings (stock shipped in the growing

cells). In those parts of the country that have strong altitudinal gradients and rain shadows, the plant sizing and genetic origin of the stock will be relatively specialized even within a single species or a relatively small geographic area, and consultation with a knowledgeable forestry organization should be mandatory. Because of these concerns, the specification for plug stock has been purposefully written in such a manner as not to include recommendations for root-collar sizing or plant height of the plug stock.

The use of hardwood container stock for reforestation is relatively new, and proper sizing criteria have not been widely established. The U.S. Army Engineer District, Vicksburg, is currently conducting hardwood outplanting trials using containerized stock with growing cells having a capacity of 5.6 cu in., a cavity width of 1.5 in. and a cavity depth of 3.4 in., with root collar dimensions that are between 0.25 and 0.38 in. and a minimum height of 15 in. The International Seed Company of Alabama uses this cell size for producing approximately seven million containerized seedlings of various Southern pines and hardwoods per year. Containerized seedlings have some distinct advantages over the use of bareroot stock, including fall and late-spring plantings, thereby avoiding planting during the wettest months and allowing for winter root growth. One disadvantage of fall planting is the potential for exposure to winter flooding and a prolonged soil erosion period. If proven successful, smaller hardwood containerized stock may have a decided advantage over larger bareroot stock by permitting a much larger proportion of the root mass to be placed in nonsaturated soil conditions. (See Barnett and McCilvray 1993; Humphrey, Kleiss, and Williams 1993).

Much of the focus of this guideline specification is related to curtailing poor handling practices. To further reduce the potential for abuse, materials have been chosen that are judged less prone to being mishandled. This does not mean that, if properly handled, other materials are inferior to those specified. As the number of handling permutations between (a) open and sealed packaging and (b) uncoated and coated root systems made for an awkward specification that was judged to be subject to plan sheet errors and bidding errors, only a single permutation for bareroot stock is presented. Along these lines, the specification does not allow for shipping as open-baled trees. Baled trees are much more prone to abuse through desiccation than kraft-polyethylene shipping, but less prone to damage via overheating or poor ventilation. Where seedlings will be temporarily stored without refrigeration, baled stock is preferred. The specification also requires the bareroot stock to be clay or gel treated. If baled stock or untreated root stock is desired, the specification can be easily modified to allow for different handling procedures, the watering of the stock, and the addition of a maximum installation period for the stock following pickup or delivery from the nursery. Unless reused, the use of wax-impregnated boxes is generally not economical. When baled plants cannot be immediately planted, plants can be healed into the ground to curtail desiccation. However, USDA (1989) strongly advises against healing in plants, and no healing-in guidelines are provided in these specifications—the most

conservative and least subject to harm via poor plant handling or a delayed planting.

Literature summaries outlining the results of root dips on the survival of conifers can be found in Sloan (1994a,b). These publications question the benefit of the use of root dips on conifers and concluded that root dips may be detrimental to seedlings during storage. At the same time, it should be recognized that Sloan emphasizes proper plant tending—"One purpose of root dips is to protect seedlings against exposure or anything else that could go wrong before planting. Instead, managers should make every effort to prevent seedlings from being exposed to sun and wind, to maintain the vigor of the nursery stock before planting, and to properly plant each seedling."

The specification neither distinguishes between transplanted saplings and seedling stock nor specifies the age of the stock (i.e., 2-0, 1-1, 2-1). If desired, the specifications can easily be modified to the preferred stock type. The material specifications, especially for the conifers, will have to be modified to reflect species-specific and site-specific characteristics as to desired root collar size and plant height. Because of commercial forestry practices, conifer material specifications are readily available for many species, or regional State nurseries should be consulted. Recent publications and information sources should be consulted, as the regional recommendation may change yearly.

This specification is appropriate for planting most tree species, but there will be some exceptions, and the methods described are targeted at planting on wet soils. The "wetness" of a site will influence planting depths and the placement of the root collar. On upland sites, recommendations for root collar placement may be 1 to 2 in. deeper into the soil than on wet sites, which would be 2 or 3 in. deeper than grown in the nursery. When developing planting depth specifications and reviewing planting depth recommendations, one must be cognizant of this "wetness" factor. In soils with high water tables and in highly permeable soils, the engineer or consulting forester should determine proper planting and acceptance criteria, especially as it regards J-rooting. However, shallow root collar placement should not be allowed (Stroempl 1990).

In many species of conifers, trees are outplanted at sizes much smaller than the conifers described in this specification. When using conifers, it is advised that besides amending the material specifications, the specified planting depth should be reviewed. For example, containerized long-leaf pine (*Pinus palustris)* should be planted between one-half and three-quarters inch below the soil line and not 1 in. as specified above. In the past, survival of hand-planted bareroot stock of long-leaf pine has generally been very poor when compared with machine plantings. *A Guide to the Care and Planting of Southern Pine Seedlings* recommends that long-leaf pine be established only via machine plantings. However, specialized hand-planting tools have been developed in the past few years, and hand planting of containerized stock of long-leaf pine is not uncommon. As

some species, including many members of the *Salicaceae* (Willow Family - *Salix* and *Populus*), grow very rapidly, the hardwood specification may need to be modified for those species. In some instances, live staking with fresh cuttings may be a better planting option.

The specification does not approach the topic of "wet-grown plant materials"—materials that have been grown in saturated soils for at least one full growing season or a major portion of one full growing season. Some individuals specializing in mitigation work strongly believe in the use of "wet-grown plant materials," especially in soils that are saturated for extensive periods. Other knowledgeable workers do not accept the requirement for the use of such materials. The formation of thickened or fleshy water roots should be avoided in woody plants, as these roots lack root hairs and generally perform poorly following outplanting. If "wet-grown materials" are desired, the material specifications can be modified, but such modifications will greatly reduce the number of plant sources. If wet-grown is the preferred stock, it is strongly suggested that the design team research the feasibility of the specification as to whether the specification is "realistically biddable" (i.e., wet-grown material can be obtained in the required quantities and within the necessary time frame of the project). In addition, the specification would likely have to be modified to allow the use of smaller materials and abnormal root development to reflect additional physiological stresses encountered during the wet-grown propagation period and/or to allow for an additional growing season for the propagation. For wet-grown plant materials, the use of contract growing should be seriously considered.

Topics not fully covered in the specification is mycorrhizal inoculation (USDA, Forest Service, Agricultural Handbook 674, Volume 5, Chapter 2) or the use of cupric carbonate ($CuCO_3$) for chemical pruning, a method to promote fibrous root growth in containerized stock (USDA, Forest Service, Agricultural Handbook 674, Volume 2, Chapter 1). Mycorrhizae greatly enhance both water uptake and nutrient uptake, particularly nitrogen and phosphorous, and provide protection against various plant pathogens and other physiological stresses (Agricultural Handbook 674; Killham 1994). Whenever possible, it is recommended that all stock be inoculated. The inoculation would be especially important with unproven stock types. The only reason that inoculation was not made mandatory is that segments of the technology are relatively new, especially the VAM inoculants (vesicular-arbuscular mycorrhizae; endomycorrhizae). These authors have specified vegetative mycelium inoculation of young oak stock with ectomycorrhizae (ECM -*Pisolithus tinctorius)* and VAM inoculation (*Glomus* spp.) of Atlantic white cedar at a cost of 1.5-2.0 cents per seedling (Marx et al. 1984; Marx, Maul, and Cordell 1992; Marx and Cordell 1995). Because of the greater density of seedlings in the growing beds, the cost for conifer inoculation is much lower. Spore inoculation of ectomycorrhizae is possible at a cost of less than 0.5 cents per seedling. *Rhizopogon* is a genus that is also commonly used in spore ectomycorrhizal inoculation of conifers in the Northwest. The use of ectomycorrhizal inoculation with *Pisolithus tinctorius* is complicated on wet sites because

this species is best adapted to well-drained soils with an acidic pH range. VAM can be mixed, banded, or injected into the growing media or planting beds. If mycorrhizal inoculation is specified, the nursery operation should be conducted so that the procedures are compatible with the development of the mycorrhizae. Excessive watering, overfertilization, or the application of certain fungicides may result in killing the mycorrhizae. VAM plug and tubling slurry dips are now available for inoculation just prior to removal from the nursery, but this is likely to be more expensive than bed inoculation. Tea-bag size packets of endomycorrhizae inoculum (*Glomus* spp.) are available for placement at the time of planting. From Agricultural Handbook 674:

ECM: *Abies, Betula, Fagus, Larix, Pseduotsuga, Picea, Pinus, Quercus, and Tsuga.*

VAM: *Acer, Chamaecyparis, Fraxinus, Libocedrus, Liriodendron, Liquidambar, Platanus, Prunus, Sequoia, Sequoiadendron Taxodium, Thuja, and Tilia.*

ECM and VAM: *Eucalytpus, Juglans, Juniperus, Populus.*

As opposed to landscaping practices, standard reforestation practices do not include fertilizer placement by the planting crew. If fertilizer is a priority item, it is suggested that the user consult the forestry literature as to the best fertilization practices. A number of different tea-bag-sized packets are now available for forestry use including slow-release fertilizers, slow-release fertilizers plus hormones and vitamins, ecto and endomycorrhizae (VAM), and direct seeding packets (seed, fertilizer, mycorrhizae, and peat moss). At least one company is marketing packets of fertilizer with calcium peroxide for planting on saturated soils. The idea is that the calcium peroxide will slowly release oxygen to the root mass over the first growing season. A topic not approached in the specification is the use of nurse crops. The installation of nurse crops would be a separate pay item from reforestation. Some workers are reporting favorable results by combining standard reforestation programs with herbaceous and/or woody nurse crops, provided that there is adequate soil moisture (Clewell 1994).

Unfortunately, the author of this specification is not well versed in tropical forestry, but much of the information on plant handling and management of planting crews is directly applicable. The U.S. Forest Service publication *Caribbean Forester* is a good information source. Some information on container types, including polybags and Hawaiian dibble tubes, is contained in USDA, Forest Service, Agricultural Handbook 674, Volume 2, Chapter 1. Hopefully, a tropical specification supplement can be prepared in the near future.

It must be recognized that the tools and procedures for tree planting were largely developed for planting relatively small conifers. Planting larger bareroot hardwoods using tools originally designed for small pines can be awkward and can quickly lead to poor planting practices, especially the stuffing of root systems. Augers develop wider planting holes, but

there is some concern with firming the subsequent planting. The planting bar procedures contained in the specifications and associated details date back to at least the 1950s and may have originated with the Alabama Forestry Department. The 1955 detail, found in Forbes (1955), includes all the figures presented in the accompanying detail except Figure 3, and there is a major modification to Figure 1. This modification requires that the planting bar be inserted vertically and not at an angle, as in the 1955 detail. Depending on the author of recent details, Figure 1 may show a vertical insertion of the planting bar as presented here or require the insertion at an angle as found in earlier details. The vertical insertion of the planting bar is now the more accepted practice.

In the vast majority of recent forestry details, Figures 7 and 8 are not included and the closing dibble bar hole is not specified. However, in a review of a recent video prepared for forestry plantings by the Weyerhauser Corporation, Figures 7 and 8 are again introduced. The reason for the placement of the closing dibble hole is to reduce the potential for the creation of air pockets or water-filled pockets immediately adjacent to the newly planted trees. Such air pockets rapidly promote root desiccation and provide poor soil conditions for future root growth. Water-filled pockets immediately adjacent to the sapling can easily result in the "drowning" of the root system and the death of the tree. As this manual is for wetland mitigation, Figures 7 and 8 have been included. If desired, the specification can be easily modified, and these figures can be deleted from the detail.

The OST bar is commonly referred to as a dibble bar. Dibbling is an old word for acorn planting. Unfortunately, other types of planting tools are referred to as dibbles, but these dibbles are not at all similar to a dibble bar. These "dibbles" have a pointed cylindrical head that is specifically designed for installing container stock. Where a dibble planting has been specified but the planting tool is not performing well, hoedads or shovels and not dibble bars should be used to plant the stock. In the Northwest, plugs are planted with hoedads and not dibble bars because of concerns for excessive compression of the plugs root mass. Hoedads used for plug stock generally have narrower blades than hoedads designed for bareroot plantings. Planting with shovels is an acceptable practice in many parts of the country. The specification is worded to allow the use of shovels or any other planting tool, including specialized tools, with the permission of the engineer or consulting forester. Of the planting tools available, many forestry crews will prefer to use hoedads for most types of plantings including bareroot and plug-planting operations. The rear of the hoedad blade is kept sharp to allow for root pruning. Hoedad installations will have a tendency to lean greater the 20 deg, a minor concern. Some foresters will not allow the use of hoedads and require the use of planting bars for all bareroot stock because of the perceived "better plant" with a bar. For inexperienced planters, the use of a planting bar is much easier than "swinging" a hoedad.

In certain portions of the country, cold-storage facilities and cooler sheds especially designed for forestry work are common. For example, the State of Virginia operates 32 regional cold-storage facilities. Where such facilities are not common, it may be possible to rent cold space from a large orchard or vegetable grower. If no cold-storage facility is available, a shipping schedule that minimizes onsite storage should be developed.

As this manual is intended for wetland mitigation, at least two planting problems will arise that are atypical of most planting reforestation programs: standing water and waterlogged soils. Except for bald cypress (Conner and Flynn 1989), pond cypress, and possibly water tupelo, few trees can be successfully planted in standing water as most other wetland trees. In permanently saturated soils, many species will fail or merely survive with limited growth. With compacted soils, this problem is exacerbated by the restricted soil aeration. In saturated conditions, the opening of the planting hole in a relatively tight soil will probably not result in free soil water immediately flowing into the planting holes, and the tree can be properly placed. However, in freely permeable soils with high water tables, rapid movement of free soil water into the planting hole is very probable. Placement of a tree into a water-filled planting hole will likely result in J-rooting, regardless of the efforts of the planter. Clearly, J-rooting is not desirable, but when compared with shallow planting with exposed root collars, slight J-rooting is viewed as being far less deleterious (Stroempl 1990). On wet sites, the J-rooting criteria will frequently be ignored. If such soil conditions are likely to exist at the time of the planting, bedding the site should be considered. Haines, Allen, and Pendleton (1988) is an annotated and indexed bibliography for bottomland hardwood restoration. Besides the bibliography, this volume offers appendixes on flood tolerances by species. With wetland reforestation, the key elements are as follows:

a. Not plant in standing water.

b. No shallow root collar placement.

c. A tight, firm planting.

d. Proper plant tending.

Outside the use of tree shelters, herbivory issues are not addressed in this specification—different pay items. The protocols for the use of tree shelters can be found in Windell (1992), Windell (1993), and Bainbridge (1994). Most tree shelters are tubular. TreePee and Tree Sentry are 2-ft-tall, self-staking conical shelters that will accept a browse-netting guard. Simple browse-netting guards have been used in the Northwest for many years to protect conifer seedlings. A field trial of the use of tree shelters in wetlands is found in Maoris et al. (1995), where 100 percent of the unprotected bald cypress stock died, largely from nutria loss. Shelter protection was judged to be highly effective and essential for bald cypress

establishment in the presence of nutria. Polyvinyl chloride pipe, as an alternative material to manufactured tree shelters, was tested and proved equally effective. In this study, trees fertilized with a slow-release fertilizer showed a twofold increase in diameter growth, when compared with nonfertilized trees.

Note: Stem girdling does not necessarily result in the death of young hardwood saplings. Resprouting following girdling is very common in young oaks—the root collar is an apical meristem (personal observation). *Silvics of North America: Agricultural Handbook 654* (Burns and Honkala 1990) is a highly recommended reference and describes the vegetative reproduction capabilities of most trees native to the continental United States and Alaska with some attention to Hawaii and the tropics. This reference indicates that the ability to successfully regenerate via resprouting is very dependent on stem size with smaller size classes showing much greater ability.

Clewell and Lea (1989) offer a candid overview of wetland reforestation in the Southeast with an extensive bibliography. This work emphasizes good handling practices and documents numerous failures caused by the abuse of the planting materials. Everett (1994) is a recent compilation volume that focuses on the restoration of stressed forested ecosystems in the Northwest. Landis (1992) is another compilation volume with focus on biodiversity and restoration.

Evapotranspiration loss estimates for use in hydrologic modeling are discussed under the specification for clay liner.

Bedding for reforestation

Bedding for reforestation consists of the construction of raised planting beds and planting mounds for reforestation projects. This is best done with the use of a bedding harrow. Specifications for this item can be found in Appendix I.

A bedding harrow is a piece of forestry equipment that is commonly used on the Southeast Coastal Plain for establishing pine plantations on wet, sandy soils. The harrow consists of a heavy-duty disk, followed immediately by an hourglass-shaped roller. The use of this tool results in the creation of a mound and furrow topography with the top of the mounds being approximately 18 in. higher than the adjacent furrows. On coarse soils, the beds will tend to slough to a height of about 10-12 in. Where there is a concern for excessive flooding, the final bedding runs direct surface water towards an outlet or stream. The advantage of using a bedding harrow to create microtopograhy is that the soil is slightly compacted by the weight of the roller and is less susceptible to erosion. On West Coast restoration projects, the authors have used an agricultural disk followed by an alfalfa bed shaping/packing tool to create similar mounds.

A more naturalized microtopographic pattern can be realized via precise grading (Barry, Garlo, and Wood 1996).

Commercial bedders were not designed for wetland mitigation and are not the ideal tool. Having a 10-ft-wide roller with a 3-ft-wide level drum in the center of the roller would be more adaptable. Current rollers are about 7 ft in width, and the level drum is only about 1 ft wide.

At a minimum, the disk will mix the upper 18 in. of the soil profile. With the second pass, this mixing may include even deeper soils. The organic content of the resulting mounds will be dependent on the organic content of the mixed soil matrix, not the upper few inches of the existing soil. Acceptable moisture conditions for bedding are the same as for plowing. If the anticipated working window does not correspond with soil moisture conditions suitable for conducting plowing or bedding, the specification should be revised to include an irrigation element. Because of the disturbance to the soil profile, bedding should not be conducted in undisturbed soils.

In standard forestry, the bedding harrow pattern is developed in straight rows with drainage to end ditches. Tree seedlings are then established on the highest microtopographic positions. To allow for soil settlement and to reduce problems associated with working in seasonal high water tables, bedding operations are conducted during the fall with a subsequent late winter/spring planting. Settlement time is important because the level surface on top of the beds is only about 1 ft wide. A limitation on the use of a bedding harrow is that with wide and random patterns, any subsequent seeding is restricted to hand or aerial seeding. If working in strips of less than 200 (300) ft wide, the use of a hydroseeding operation in conjunction with the use of a bedding harrow is possible.

Besides uses in forestry, a bedding harrow can be used in developing microtopography for various types of mitigations, including abandonment following bedding, without additional planting or seeding programs. To avoid impact to adjacent bedding passes, the crawler should be matched in width with the roller. A good machine operator will be able to use a slightly larger crawler without excessively damaging the adjacent beds. If the roller is bouncing during the bedding operations, the operator is either driving too fast or more water ballast is required.

If a more directed bedding design is desired, two series of parallel S-shaped curves should result in an acceptable pattern. Within a bed, the S-shaped curves should be repeated at intervals of about 100 ft with a minimum breath of 15 or 20 ft. The first parallel curve series is developed without overlapping the adjacent beds. The second series is generated perpendicular to and on top of the first series. The second series can be spaced on wider run centers—about double the width of the roller. A few final passes are then made to direct excess water towards an outlet or channel, either natural or man-made. If excessive water levels are anticipated, the roller can be occasionally lifted for short distances during the

bedding operations. This will allow for free movement of water between adjacent beds.

For many applications, the ability to move the water off the beds efficiently will be a key to any planting success. Without this ability, one is hoping that the bed field will not become too flooded and drown any planting.

It is the author's experience that equipment operators have a difficult time with randomness. Regardless of direction, they will have a strong tendency to straight-line the beds. Field direction and a detail outlining the requirements for the runs is strongly recommended. For most projects, a detail for conducting the final bedding runs will be mandatory.

Marsh Plantings

Two different marsh planting specifications have been provided, one for freshwater marsh and a second for salt marsh. Both specifications emphasize high-quality planting materials and proper installation. The planting elements are relatively straightforward with the addition of mandatory soil testing. With marsh plantings, how and when the project is staged will be as, if not more, important than the actual planting methods. As a creation site grows larger, the problems with proper staging increases, especially of the biological elements including those external to the design. This is not necessarily true with restoration. The salt marsh discussion is relatively detailed, as the design protocols for low marsh and high marsh are different from each other. The plant guarantee and establishment segments will need careful review. Herbivory prevention is not fully addressed.

Planting freshwater emergent marsh

Abuse of plant materials is more likely to occur with freshwater emergent plantings than with any of the other planting types covered in this volume. The chief focus of this specification (see Appendix J) is to limit the potential for this abuse. The specification is weakest at preventing the use of undersized stock or improperly stored materials. The specification will not prevent abuse via planting at excessive water depths (see Pierce 1994).

The authors are not entirely comfortable with all the material aspects of this specification. Many of these concerns are voiced in Garbisch et al. (1996). In "traditional" landscaping, all plant materials must conform with American Standard for Nursery Stock (American Association of Nurseryman, Inc., Washington, DC, latest edition 1990). Under these standards, trees, shrubs, and many herbaceous plants are categorized, graded, and sized. This grading extends to many garden perennial bulbs, rhizomes, and tubers, where plants of the same species will be graded into

different categories based on the size of the stock. Plants are then specified based on grade designations that reference either the diameter or circumference of the stock. When grading stock, a circumference criterion will have obvious advantages over diameter characteristics—bulbs, corns, and tubers (BCTs) are not round. The wetland nursery industry has not matured to the point that industry stock standards have been produced. Until such standards are published, it will be awkward to specify materials based on stock size. Rootmass characteristics of acceptable containerized or peat pot stock limit the likelihood of receiving undersized stock. Nondormant planting should also reduce stock size concerns. For nondormant plantings of erect emergents, plants should be of a stem height that is taller then the depth of the water column at the time of planting. The authors have found that midspring, nondormant peat pot or container plantings to be among the best alternatives for emergents, especially with inexperienced planting contractors. Similar results can be achieved using high-quality dormant stock planted in early spring or midspring.

The specification requires the identification of a minimum stock size for dormant materials to be placed on the plan sheets. This is not so for rhizomatous stock, which has a specified minimum length of 4 in. This rhizome length may need to be increased for some members of the Nymphaceae. A statement indicating a minimum BCT diameter of 2 in. would not be realistic, as BCTs of several species rarely reach the 2-in. size—lots of small tubers and not a few large ones. Yeo (1965) reported that under cultivation for 6-months, a single plant of *Potamogeton pectinatus* produced more than 36,000 tubers, as cited in Voss (1972). Where necessary, differences in item coding will allow for the planting of different stock sizes of the same species at different locations. Sized line drawings of the underground segments of many marsh species are contained in Muenscher (1944), and it may be possible to prepare sizing specifications from these drawings, other sized drawings, and the published literature. However, reports of regional differences in BCT size and differences in nutrient availability from one habitat to another may severely limit or totally negate the usefulness of such information sources. If the size of stock is critically important and one is specifying large stock sizes, it is likely that it would be possible to negotiate satisfactory sizing requirements with a reputable wetland nursery under a contract-growing agreement, but most nurseries will not allow for the culling of the largest propagules from their inventories. If the project is clearly a "rush job," flexibility as to size of the stock may be required to ensure that the quantities specified can be delivered. Such flexibility should be contained in the specification or plan notes, or the project could be "unbiddable."

The recent research results reported in *Wetland Journal* (1994-1995) by McIninch and Garbisch indicate that stock size influences survival, stem production, and tillering of emergents with a strong interaction with increasing water depth. This research shows that emergents with larger stock sizes are likely to perform much better than smaller stock sizes when placed in more than 1 ft of water, but smaller stock sizes perform satisfactorily in shallow water. It is the author's observation that the

problem of undersized stock is much more common with emergent rhizomatous materials than other types of materials.

The specification does not address the growing medium for the peat pot, tubling, or containerized stock. Nor does the specification allow the use of peat pellets. This is intentional, so as to limit forcing the plant supplier into adopting propagation methods that he/she does not endorse. Except for mat stock, all the planting methodologies and stock types illustrated are established practices. Mat stock is a new, unproven stock type that has been developed for placing the nondormant stock into a water column. This type of planting is targeted at those species that develop a wiry, interwoven tangle of rhizomes and roots. It was included in the specification to outline procedures associated with unproven planting or propagation methods—no guarantees with unproven methods and because of its antiherbivory potential. Obtaining proper gas exchange may limit the usefulness of mat plantings. It is very similar in approach to planting submersed aquatics in weighted bags. Although the bag stock planting method is very simple, it is also highly effective in nonturbid waters (*Vallisneria* and several *Potamogeton*).

Where there is a concern for desiccation of the sprig material, the specification could be amended to include a kaolin clay root treatment, dip or spray, as described under the specification for reforestation. If using sprigs, one should review some of Knutson's publications to identify the plant characteristics necessary for sprig materials. Large, robust, single culm (stem) individuals from uncrowded stands are preferred for the sprig placement of *Spartina alterniflora*. Sprig stock from older, dense stands of *Spartina alterniflora* is smaller and of lower quality. Knutson and Woodhouse (1982) recommend planting three to five sprigs per planting hole for salt marsh restorations. This recommendation occurs throughout many of Knutson's publications.

If electing to place more than one sprig per planting hole, a very visible note must be included on the plan sheets; otherwise, there will be confusion in the bid preparation. The quantity sheet should indicate the total number of sprigs required for the project, not the number of planting holes.

In forestry, the concept of what constitutes plug stock is clear—stock that has been extracted from the growing cell. In herbaceous wetland plantings, a plug is not as clearly defined. Some workers use the term "plug" simply to mean planting stock with an associated soil mass without reference to stock dimensions. When developing planting tables using plugs, it is important that dimensions of plug and the requirement for its use be prominent. Donor plugs are often sized having a diameter of 4 to 6 in. and a depth of 6 to 8 in. (Knutson and Woodhouse 1982). Allen and Klimas (1986) report of successful transplants using plugs of between 1,000 and 3,000 cu cm. This latter volume illustrates many successful planting methods, shoreline stabilization techniques, and bioengineering practices. As written, this specification is clearly targeted at nursery

sources, but it can be easily modified to allow the use of materials from donor wetlands via slight modifications to the plug stock type.

The "tone" of a traditional landscape specification will differ depending on source of authorship. If the landscape specification has been authored by and for a large user, such as a Government agency, the specification will reference American Standard for Nursery Stock, but the material rejection discussion will be expanded and language similar to the following will be included: "any material deemed unsatisfactory, as solely determined by the engineer, shall not be planted and shall be removed from the project site by the close of the working day." Specifications derived from landscape contractor associations or nurseries will not contain such language. A landscape specification authored by a large end user is also likely to contain language similar to the following: "all stock shall be healthy and vigorous, as solely determined by the engineer." With some justification, landscape contractors and plant nurseries object to such language as "totally subjective and boilerplate" and subject to abuse by the engineer. At the same time, stories of plant installations using undersized plants or plants barely beyond the seedling stage are not uncommon. Once planted in a submerged water column, many seedlings will not have sufficient carbohydrate reserves to emerge above the waterline and will die. After a review of numerous landscape specifications from various sources and perspectives, the following dichotomy is evident. The providers of plant materials and landscape contractors would like the end user to "trust" the contractors to provide the best plant materials—"we sell and install only finest plant stock." Experienced end users would like for contractors to understand that "we never rejected high-quality plant materials." The essence of the quandary is straightforward—Who trusts whom?

The specification contains the following language: "Plants shall appear without significant deleterious leaf spots, leaf damage, leaf discolorations, chlorosis, leaf wilting or curling, disease, or evidence of deleterious insect infestation that could adversely affect the survival or performance of the plants, as solely determined by the Engineer." This passage was added with considerable reluctance because of the potential for abuse by the engineer through the rejection of high-quality materials. The key factor is the anticipated survival and performance of the plants and not their vegetative appearance. Mid-to-late season plants will experience some leaf loss, discoloration, and sign of disease. Common sense in judging the quality of the stock is necessary.

In most "traditional" landscaping, there is a plant establishment period. This plant establishment period is typically for 1 year, during which the contractor guarantees the survival of the plant material. If the "traditional" project is authorized by a large end user such as a transportation agency, the establishment period requirement has very few, if any, exemptions. If the specification is modeled after those authored by landscape industry, there may be numerous exemptions, including exemptions for floods, excessive wind damage, drought, severe freezing, abnormal rains, clay pans, saturated soils, wildlife loss, and vandalism. The value of

these latter guarantees is highly questionable. As the plant establishment requirement within this specification is limited, the specification allows the engineer to make some subjective judgments about the quality of the plant materials. The author of this specification also recognizes that some will strongly criticize the material specifications as flawed because of this subjectivity, but is not aware of an obvious solution that will satisfy the concerns of both the plant suppliers and the end users.

The specification is severe when plantings occur outside the designated planting window or when the antiherbivory measures are not installed properly—situations that are all too common. Late plantings and seedings simply may not survive because of various physiological reasons and for the reasons indicated within the specification notes. Seedlings of *Phragmites* from July cohorts had 0-percent survival at the end of the second growing season, as opposed to 90- and 68-percent survival with May and June cohorts, respectively (Weisner and Ekstam 1993). If an extended guarantee period is to be enforced because of contractor deviation from the plans and specifications, it is vital that all aspects of the material and acceptance segment of the specification continue to be enforced—i.e., the planting should be inspected for both material compliance and acceptance as per the specification. No compensation should be made for plant materials or planting labor for materials not conforming to the material characteristics until the end of any imposed guarantee period. One should not pay for late plantings or less robust plant materials than specified until the materials are fully proven.

Most late plantings will be caused by earthmoving delays or flooding. Earthmoving delays are normally the responsibility of the prime contractor and not the planting subcontractor. Unless warranted, do not allow the landscape subcontractors to be the main focus of late-planting discussions. Flooding delays must be dealt with common sense by the engineer, but allowances for flooding delays can be abused by contractors. The biological consequences associated with late plantings can be severe, and the entire project schedule may need to be reevaluated. If required, demand project modifications. Planting a year late during the specified planting window may be a better idea than planting 1 month late, but outside the window. While in this "delay" period, one must actively manage the site to provide optimal planting conditions during the next planting window. For example, one could elect to (a) flood the site as quickly as possible; (b) raise the water control structure to the maximum elevation; (c) maintain a deep-flooded condition; (d) control obnoxious weed colonization; and (e) plant when the window is optimal. Note: Prior to planting, one may want to disk to limit weed colonization, but such a decision would be project specific and would be partially dependent on the calendar period of the delay.

The layout plan and the requirements for staking should be reviewed. Other layout methods may be more appropriate for many projects, and the specification will need to be extensively revised. The layout requirement facilitates both plant placement and any subsequent monitoring. The use

of location stakes established along the nonflooded fringe of the marsh is prudent, as these stakes will be much longer lasting than those placed in the flooded marsh.

It must be emphasized that all plant materials do not behave in the same way, particularly in terms of phenology (seasonal growth patterns), propagation, or storage. Phenological considerations should weigh heavily in determining the appropriate planting windows, planting densities, and stock types. Handbooks for the commercial propagation and storage of many herbaceous wetland species do not exist, but anecdotal reports concerning propagation and storage problems are not uncommon. Among some of these findings are as follows:

a. A few species are best propagated via terminal meristem tissues with lateral meristems failing, and vice versa.

b. The vast majority of herbaceous plants can be propagated via dormant materials, but a few species are much more easily propagated while in leaf and yield poor results if propagated when dormant.

c. For a few species, greatly enhanced propagation is seen when using 2-year-old tissues versus 1-year-old tissues, and vice-versa.

Because of these apparent inconsistencies, it is best not to specify how a plant will be propagated, but limit the specification to the quality of the materials.

As with commercial propagation, species-specific storage problems are not well documented. Why Species A can be placed in cold storage and perform well the following spring, whereas Species B will perform unsatisfactorily, is more than an annoyance. With some materials, the genetic source of the materials, the storage environment, the number of chilling hours accumulated prior to being lifted and placed into storage, or the size of propagule (carbohydrate reserves) may be complicating factors in survival determinations. Extending the cold-storage time for the stock beyond those recommended by reputable suppliers may result in planting "dead" stock or stock with depleted carbohydrate reserves. It is likely that rhizomatous materials are more likely to suffer injury from extended storage than other types of stock. More conservative practitioners may want to consider prohibiting the use of cold-stored materials, but cold storage of dormant materials is a very common practice in the wetland nursery trade. Garbisch, McIninch, and Swartz (1995) discuss dormancy and chilling requirements for some marsh plants, but the reader should be aware that the term "chilling" is used in a broader sense than in the forestry literature. This distinction is important.

There are two recognized physiological processes that relate directly to plant storage—cold hardiness and dormancy. These processes are not synonymous. Dormancy can be defined as all instances in which a tissue predisposed to elongate does not elongate, but is in a state of quiescence.

For most temperate plants, partial dormancy can be lifted under favorable environmental conditions, such as warm temperatures or adequate moisture, but rest or true dormancy cannot be lifted without experiencing a period of low temperatures. In contrast to dormancy, cold hardiness is not restricted to meristematic tissues, but is a whole plant phenomenon. Cold hardiness is thought to occur in several stages. In the prehardening stage, sugars and other substances are sequestered in the protoplasm, the amount of water in the cells decreases, and the central vacuole divides into several smaller vacuoles. Next there are changes in ultrastructure; biomembrane structure and enzymes are reorganized to allow tissue to survive the removal of water and the formation of ice. As it relates to the cold storage of plant materials, the important feature here is that full cold hardiness takes a much longer period of time to achieve than true dormancy. In forestry, outplanting trials have consistently shown lower survival with premature lifted stock, even when no subzero cold-storage temperatures are involved (Johnson and Cline 1991). Why dormant plants do not fully harden under the nonfreezing storage conditions is not known, but the differences in outplanting survival cannot be ignored. Because of this situation, foresters do not lift seedlings until they have accumulated a minimum number of "chilling hours" after a specified calendar date. Payne (1992) outlines protocols for seed handling and vegetative propagation for a variety of aquatics and emergents via extensive references to Kadlec and Wentz (1974).

The geographic ranges of many aquatic plants are broad, covering wide areas of the country. For the temperate regions east of the Rocky Mountains, the ranges of most of the commercially available emergent marsh plants include the Great Plains. These same plants also occur in the freshwater tidal marshes of the Atlantic Coastal Plain with the addition of the Araceae and the Pontederiaceae. Between the Atlantic Coastal Plain and the Great Plains, these same plants are common to riverine wetlands, lake shores, light shaded depressions, and wetlands that are influenced by beaver. On the Great Plains, the winters are much drier than the summer months (reference T. C. Winter in *Northern Prairie Wetlands* (Van der Valk 1989)), and the reflooding of the marshes occurs in the spring. In the East, similar depressions would likely be filled by midwinter, if not in the fall. Here are two different climate regions and resulting hydrological patterns. Although the species composition is similar, the genetics of the populations may not be similar; plants could adapt to local conditions in dissimilar ways and with different phenologies.

Classic taxonomic texts, such as Muenscher (1944) and Fassett (1957), provide important habitat information relating to marsh plants. They are also helpful in determining whether the desired propagule should be specified as a BCT or a rhizome. The term cormous perennial can be substituted for BCT (Sculthorpe 1967). Stolons are not thought of as rhizomes because they are not underground. If the plant creeps and lacks an expanded storage organ, one is probably dealing with a rhizome or stolon. The distinction between rhizome and stolon is not important as it relates to ordering plant materials, only when planting the materials. Small

segments of a rhizome or stolon often represent poor planting stock because of the lack of carbohydrate reserves. Some plants will have both rhizomes and tubers. Muenscher and Fassett both frequently reference soil types and water depths at which plants can be found. However, statements of water-depth tolerances can be misleading, as the seasonal variability in the depth of the water column, water temperature, oxygen concentration, and/or light penetration could be the real limiting factors. Pierce (1994) is probably the best single work relating marsh plant selection to adaptive characteristics and hydrology. Thunhorst (1993) and Garbisch et al. (1996) offer additional guidance of the selection of plant materials for marsh mitigations. Voss (1972, 1985) and other floras, particularly the older regional floras, contain a wealth of information that can be useful in selecting plant materials. Many wetland nurseries offer planting guides; however, these guides are occasionally in gross error, and the selection of materials must be verified with other sources, such as Muenscher (1944), Fassett (1957), and field observation (Keddy 1983; Keddy and Ellis, 1985; Poiani and Johnson 1989). For example, the water-depth tolerance advertised for *Scirpus fluviatilis* (river bulrush) is exaggerated with no guidance relating to inundation duration. The taxonomic identities of nursery-grown stock should be verified, particularly within *Potamogeton*, *Scirpus*, and *Eleocharis*. At least some of the *Potamogeton pectinatus* offered by the industry is actually *Potamogeton foliosus*, which is not restricted to calcareous water—a "better" plant for noncalcareous conditions. The specification allows for taxonomic verification via the submittal of dried whole plants, inflorescences, or seed/fruit. Normally, this would be done only for species not common to the industry.

Within the specification, Kartesz and Kartesz is cited as the taxonomic authority. One should feel free to append notes on the plan sheets to either clarify or override this reference for some plant materials. Clarification of taxonomic identity can be very important, as some recognized treatments may "lump" or "split" certain taxa. If the regional reference "lumps," obtaining certain plant materials may be problematic without this additional guidance.

Example Note: The planting plan includes *Polygonum punctatum*. Acceptable plants shall include *Polygonum punctatum* Ell. var. *punctatum* and *Polygonum robustius* (Small) Fern., both perennial plants. *Polygonum punctatum* Ell. var. *confertiflorum* (Meisn.) Fassett is an annual plant limited to a maximum of 50 percent of the required nondormant peat pot stock. Additional annual plants beyond this 50-percent maximum shall not be accepted, and no payment for materials or installation of these plants shall be made by the Department. It is desired that the planting mix for the *Polygonum punctatum* include approximately 40-percent annual and 60-percent perennial plants. Suitable taxonomic treatments can be found in Polygonaceae (Buckwheat Family) of New York State (Richard Mitchell and J. Kenneth Dean, Bulletin No. 431, New York State Museum, 1978) or *Manual of Vascular Plants of the Northeastern United States and Adjacent Canada* (Henry Gleason and Arthur Cronquist, New York Botanical Gardens, Second Edition, 1994, not the 1963 Edition).

Eleocharis palustris var. *major* shall conform to the taxa of this name as identified and described in *A Manual of Aquatic Plants* by Norman Fassett (University of Wisconsin Press, 1957).

Arber (1920) and Hutchinson (1975) are classic texts targeted at the biological, anatomical, and physiological adaptations and characteristics of aquatics, including emergents. Whole plant line drawings are common in both volumes. Although Agnes Arber's work is over 70 years old, it is wonderfully insightful and readable. Sculthorpe (1967) advances much of Arber's work and is the best single synthesis of aquatic plant biology ever written. Longstreth (1989) presents an overview of photosynthesis in freshwater emergent and floating plants.

Payne (1992) and Pierce (1993) examine various design considerations for freshwater marshes. Payne (1992) should be considered a mandatory reference for freshwater marsh creation, restoration, and management. Of interest are their discussions of how the potential for muskrat herbivory and slope denning may influence slope-angle selection and dike width. Slopes of 4:1 or shallower along the flooded/nonflooded interface will deter slope denning by muskrats (Payne 1992). Pierce (1993) recommends that the slopes along the flooded/nonflooded interface slope be shallower than 10 horizontal to 1 vertical. If significant muskrat slope denning is anticipated and dikes are present, minimum dike widths need to be increased. It is thought that slope denning may result in increased muskrat populations, at least temporarily, with a corresponding increase in herbivory pressure. Hygnstrom, Timm, and Larson (1994) is a large volume dealing with wildlife control measures. The authors factor the potential for obnoxious weed invasion into the selection of the upland/wetland slope angle. Where potential for obnoxious weed invasion is low, slopes in excess of 100:1 are favored; 200:1 will provide a broader drawdown zone. Where the potential for obnoxious invasion is high, the author favors 4:1 slopes immediately grading into deepwater marsh with a shallower marsh in the interior—a moat design. If these steeper slopes are adopted, great care should be taken to ensure that the shoreline of the marsh and the associated slopes are properly planted, as these shallow areas may offer the best microsites for plant establishment. High-energy positions will favor gentle slopes regardless of obnoxious weed concerns. The anticipated hydrological pattern will also have to be factored into the selection of slopes. Payne (1992) reviews marsh-depth management for targeted species and guilds.

For most, if not all marsh projects, a hydrological model must be generated. This model must take into account the local climate and the site's hydrogeomorphic setting. Pierce (1993) and Garbisch (1994) outline hydrological considerations for the establishment of constructed marshes with Garbisch addressing both tidal and nontidal environments. Dunne (1995) emphasizes the importance of conducting long-term hydrologic budgets and the avoidance of "too stable" hydrologies when developing or restoring nontidal freshwater marshes, especially for those projects subject to strong herbivore pressure (Figure 5). Models based on average

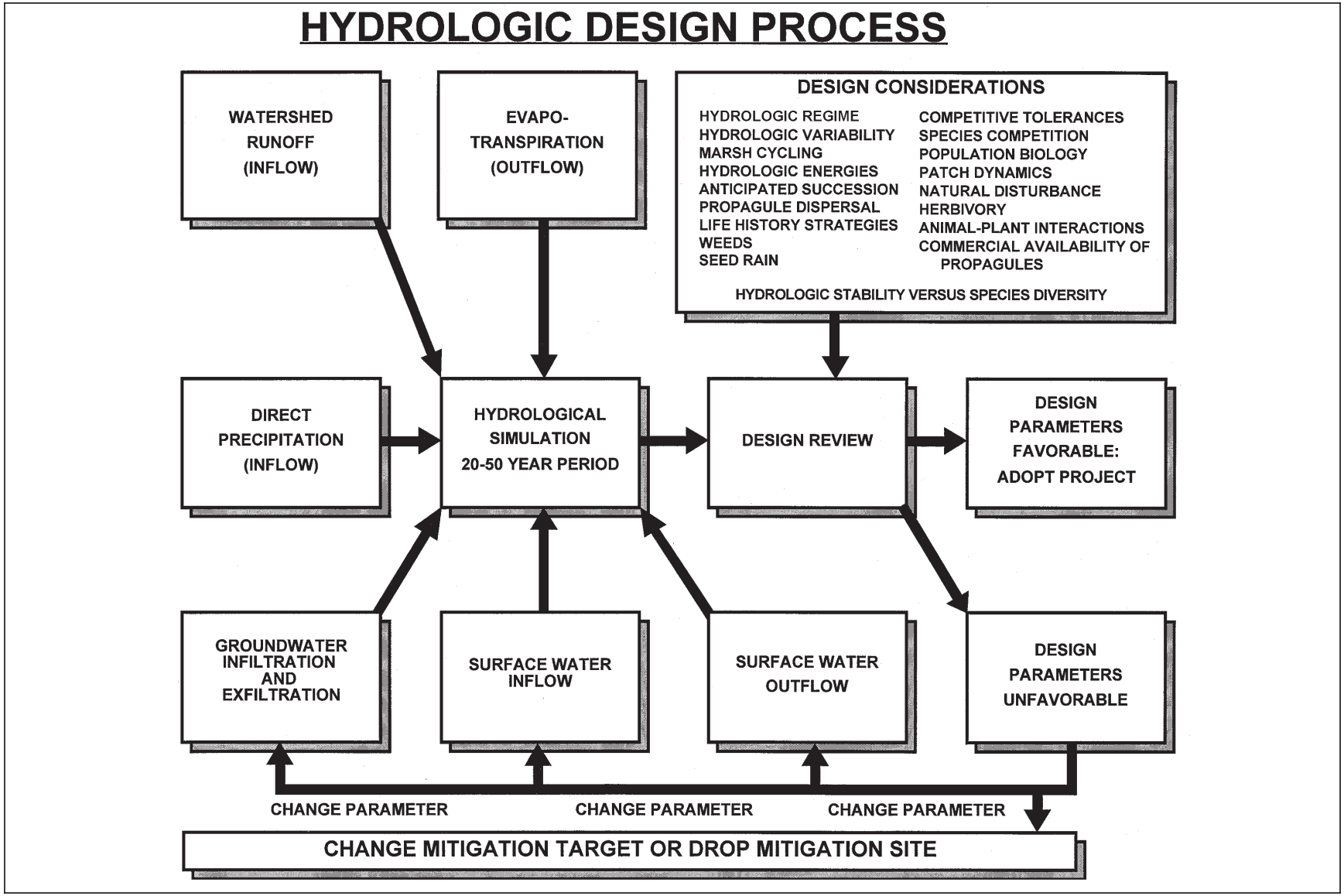

Figure 5. Hydrologic design process for freshwater wetland creation

years climatic data should be avoided, as the important biological events will occur around high- and low-precipitation years. Evapotranspiration loss estimates for use in hydrologic modeling are discussed under the specification for clay liner.

van der Valk and Davis (1978, 1980) and van der Valk (1981, 1986) address the role of successional processes in marshes, particularly as it relates to drawdown in the prairie region. In these models of marsh succession, water depth, inundation period, and herbivore pressure act as environmental sieves that direct the structure and composition of the vegetative community. Eight different life-history types are identified for emergent plants in van der Valk (1981)—annual versus perennial, seedbank persistents versus noncontributing transients, and two different germination cues. Weller (1987) discusses the concepts of marsh cycling, drawdown, and marsh management. The basis of marsh cycling and drawdown biology is found in Smith and Kadlec (1983) and Mitsch and Gosselink (1986 or 1993). Merendino et al. (1990) and Merendino and Smith (1991) detail recruitment and survival of emergents under different drawdown dates and reflooding depths in Delta Marsh, Manitoba. In these studies, maximum vegetative cover, maximum seed production, and the highest biomass production by *Scirpus* was achieved under a mid-May drawdown. *Typha* and *Lythrum* reached the highest cover under a mid-June drawdown. The mid-July drawdown was also dominated by *Typha*, but at a lower stem density. A mid-August drawdown resulted in poor recruitment, no overwintering perennial survival, and no flowering. The lack of overwintering survival was attributed to the limited length of the remaining growing season. A minimum of 45-60 days of growth is thought to be required to produce an overwintering rhizome (references in Merendino and Smith 1991). Soil temperature is thought to be a key environmental sieve in these studies.

Northern Prairie Wetlands is a contributing volume that covers a large variety of topics related to prairie wetlands—hydrology, chemistry, nutrient dynamics, vegetation, fauna, and wildlife management (edited by van der Valk, Iowa University Press, 1989). The importance of drawdown in influencing plant community structure is not limited to prairie or more arid environments, but is a feature of most emergent wetland systems, including such deepwater wetlands as the Okefenokee Swamp in Georgia (Greening and Gerritsen 1987). *Ecology of Soil Seed Banks* (Leck, Parker, and Simpson 1989) is highly recommended. Although not explicit in the chapter titles, this volume contains several chapters that focus on wetland seed banks including the management of those seed banks. Many of the biological principles outlined in this volume are valid regardless of habitat type, so one should not limit the reading to those chapters with "wetland" or "management" titles.

For recently planted marshes, a full drawdown may not be advisable until a sufficient period of strong vegetative growth and reproduction has passed and a sizable seed bank has been given time to develop. A drawdown immediately following a planting is likely to foster weed colonization due to the

lack of competition from the planted species. In many ways, the 2-year goal of a marsh planting program should be to establish viable populations of a wide array of species plus a seed bank containing whatever species were planted, including transients. Once established, the project can be allowed to enter succession with limited or no management. Any subsequent management is likely to be restricted to water level manipulations or moist-soil management. When contemplating a drawdown event, consider the previous seasons hydrological regime and the influence of that regime on the seed bank dynamics. Although desired, successful plantings do not necessarily lead to strong seed bank contribution. Collins and Wein (1995) report that a 5-year-old shoreline restoration planting is not strongly represented in an assay of the seed bank.

Typha dominance may or may not represent a desirable marsh structure. *Typha* x *glauca* (hybrid of *Typha latifolia* x *Typha angustifolia* or *Typha domingensis*) is considered to be much more aggressive and dominating than either of the parents. The ability of *Typha* to colonize a site will be dependent on many factors including hydrogeomorphic setting, climate, construction timing, distance to dispersal source, initial planting success of other species, and hydrological regime as it varies between years and over the growing season. In areas with high fall/winter precipitation, depressions with low permeable soils are probably filled with water by late fall or early winter. This hydrology pattern probably limits recruitment by those species that readily germinate in the spring including *Scirpus validus*, *Sagittaria latifolia*, and *Sparganium eurycarpum* to shore locations; and any midsummer drawdown favors recruitment of *Typha*, but only under full or near-full sun. Such driving hydrological patterns will only be observed in the planning stages when long-term hydrological budgets are developed.

Occasionally, the bid package should contain items for the control of obnoxious weeds. Chapter 13 of the Waterfowl Management Handbook, a leaflet series published by the U.S. Fish and Wildlife Service, contains management and eradication measures for a series of plants, including *Lythrum* (13.4.11), *Phragmites* (13.4.12) and *Typha* (13.4.13) and chapters on moist-soil management. The chapter on *Typha* states that cattail will not germinate underwater, but heavy germination and successful recruitment have been observed on several newly constructed mitigation sites that have been flooded for more than 6 months prior to the germination date. These sites had clear water, as typical of many new creation sites (flooded, but high-light environments due to low suspended solid and organic concentrations). Speculation is that the germination of the cattail was keyed by the timing of the final grading operations that occurred the previous summer/fall on nonflooded soils, the period coinciding with cattail seed dispersal. For one project, two side-by-side marshes were constructed of similar design. The first marsh was graded in winter, the second marsh during the next summer. These marshes are less than 50 ft apart. Both marshes were flooded soon after final grading. The next spring, the “summer” marsh exhibited a high rate of cattail germination. Few cattail germinated in the “winter” marsh. Apparently, if given the

correct environmental cue during the previous growing season (wet mud), cattail will germinate in a clear water. Note: Cattail seedlings germinating in 12 in. of water do not look like mature *Typha* plants, but resemble the flaccid floating leaves of some species of *Sparganium*.

Establishing a strong initial plant cover (shallow water depth) that casts a dense shade (asexual reproduction) while limiting or restricting drawdown events (large watershed) is a theme often taught in wetland construction classes, but one must add the timing or staging of construction. With poor initial cover, a midsummer drawdown on a sustained saturated soil is likely to lead to a heavy *Typha* establishment; but again, this may not be a problem, and may even be desirable. *Typha* is nitrogen fixing (Biesbore 1984). Because *Pontederia cordata* is a strong late-season grower and the mid-to-late season hydrological preferences for vegetative growth can overlap those of *Typha*, it is believed that *Pontederia* is among the better tall emergents to plant when there is a concern for *Typha* dominance (at least on the mid-Atlantic Coast).

Planting *Peltandra* or some other members of the arum family (Araceae) is a good way to limit herbivory losses. The presence of bitter/acrid-tasting crystals of calcium oxalate in the foliage is characteristic of this family. These plants will be rarely taken by either geese or muskrat—although they may be tossed, especially in mixed-species plantings. *Peltandra* is not a perfect solution to herbivory, as the plant has a very slow rate of colonial extension. Most members of the waterlily family (Nymphaceae) and *Saururus cernuus* (lizard's tail) do well under strong herbivore presence. *Nymphaea odorata* is not taken by geese. As with the Araceae, members of the Nymphaceae may contain considerable concentrations of calcium oxalate in their leaves (Sculthorpe 1967). However, caution is warranted, as some species in the Nymphaceae (including *Nymphaea odorata*) are very aggressive when established and may shade-out a desired submersed aquatic bed. The stems and leaves of *Saururus* contain ethereal oil glands that presumably limit herbivory by both geese and muskrat, and it is one of the few marsh species that is competitive in full shade on seasonally saturated soils. Nutria do not take *Justicia lanceolata* (willow herb), a persistent colonial herb in the Acanthaceae family (Llewellyn and Shaffer 1993). The authors have observed that the thin leaf blade of *Sagittaria latifolia* is readily taken by geese leaving a broad green leaf petiole and the flowering stalks, sufficient photosynthetic tissue for vigorous seed production. It has also been observed that *Pontederia cordata* has an indefinite growing period, at least in the Mid-Atlantic States. This allows for strong late-season growth and flowering even under heavy early season herbivory. Apparently, herbivores begin to "ignore" *Pontederia* sometime in midsummer. This switching away from *Pontederia* could be attributed to increased concentrations of unpalatable secondary compounds, a decrease in the palpability, and/or changes in herbivore preferences over the course of the growing season. Interestingly, Gary Pierce of Southern Tier Consulting has indicated that he does not observe this late-season growth pattern in *Pontederia* populations of western New York.[1] *Heteranthera reniformis* (mud plantain), also in the Pontederiaceae, is not

taken and also shows strong mid-to-late season growth. Although depicted as a short plant in most line drawings, the architecture of *Heteranthera reniformis* allows for stem tissues to float just below the water surface with long roots extending through the water column and anchoring the plants into the soil. The timing of emergence and senescence may be important factors in herbivore avoidance in some species. For example, *Alisma plantago-aquatica* often senesces in mid-August in New Jersey, weeks prior to the flights of migratory waterfowl. Important: Dirzo (1984, as cited in Nyman, Chabreck, and Kinler 1993) concludes that herbivory reduces species richness when the preferred food is not the competitive dominant, but increases diversity where the preferred food is dominant. *Typha* is the preferred food of muskrat.

The inclusion of antiherbivory measures is a wise precaution for those projects where herbivory concerns are high (Garbisch 1995, Garbisch et al. 1996). The most common antiherbivory measure for marsh establishment is waterfowl fencing, including staked brush fencing as developed in Europe—a much more effective and eye-pleasing alternative than string fencing. With string fencing, 6-in.-line intervals are recommended for the lower segments of the fence, and it is prudent to include intervals below the waterline to the expected seasonal low water. In order to be effective, the string lines must be taut and remain taut. For example, a fence with the intervals -12, -6, 0, +6, +12, +24, and +36 in. would offer some protection in marshes anticipating a strong summer drawdown. String fencing will not curtail muskrat herbivory, and the authors have observed muskrat feeding on emergents by "perching" on taut lines located at water level. Alternatively, inexpensive exclusion cages can be established to protect at least a small part of the planting with the hope of establishing populations that may spread with time. Waterfowl fencing limited to areas immediately adjacent to the shoreline can help protect those areas that are most likely to flower and fruit during the initial growing seasons. Where species introduction is the goal, limited caged plantings may be the best establishment option. All materials used in waterfowl fencing should be biodegradable, tough but degradable. It is the author's preference to use large hardwood stakes, 2 by 2 in. Besides being part of the fence, the larger stakes offer excellent perching locations. Waterfowl fencing need not be retrieved. As the fence degrades, the debris from the fence still offers considerable herbivory protection and, for a time, increased protection from muskrat. Unfortunately, the effective duration of most waterfowl fencing measures is limited to a few months and is most useful against migrants. Even if properly constructed with taut straight lines, resident geese and other resident waterfowl can become habituated to the fencing and may learn to "beat" the fence, despite the pattern and density of the fencing. Most antiherbivore measures are best considered a source of temporary respite, with the hope that the interval is of sufficient duration to allow for the development of an interwoven marsh rootmat that will resist herbivory. Once a wall of emergent vegetation is established, especially with persistent emergents, the attractiveness of an area to geese may be reduced, allowing for the permanent establishment of the plants. As such, the density for the plantings should be chosen based on the energy

of the system, the expected rate of vegetative spread, the potential for obnoxious weed invasion, and on the anticipated herbivore pressure. This is another reason for not accepting late plantings or undersized stock that will be slower to establish. If desired, antiherbivore items can be placed as "contingency items" or "if-and-when-directed items" within the bid documents. Such contingency items are used only after being authorized by the engineer; the contractor is not free to place those items at will. By placing these items as contingencies, monies have been allocated for herbivory control, but are only used when the circumstances warrant. The antiherbivore measures can be quickly and easily modified in the field as appropriate for the project, but only if the monies have been previously allocated in the bid package. Another approach to herbivore control is through direct human intervention, such as dogs.

The specification does not address the planting of free-floating aquatics (i.e., Lemnaceae) or fragment plantings of submersed aquatics (*Ceratophyllum*, *Myriophyllum*, etc.). One should be aware that there are reports of "contamination" of purchased *Ceratophyllum* (coontail) with the aggressive, non-native *Myriophyllum spicatum* L. (Eurasian Watermilfoil, taxonomic and nomenclatural confusion here; use only the latest taxonomic texts). Because of the potential for misidentification, the taxonomic identities of submersed aquatics need to be carefully checked prior to planting and suppliers warned not to ship *Myriophyllum spicatum* L., subject to order rejection. Aquatics should be thoroughly washed and sorted prior to shipment.

Unless properly planted, the large proportion of aerenchymeous tissues will cause the planted propagules of many marsh plants to eventually float. Some genera, such as *Nuphar* (yellow waterlily) and *Pontederia* (pickerel weed), are highly buoyant and can be extremely difficult to plant properly, especially in loose sands. The rhizome of *Nuphar* may reach 15 cm in diameter. When selecting planting dates, the "energy" of the system should be factored into the selection. In high-energy environments, where there is the potential for ice scouring, and on long water fetches, a fall planting may be inappropriate, as too many floaters will develop over the course of the winter. One may want to increase the planting density to compensate for expected losses in high-energy systems. However, fall or winter plantings have some inherent advantages—plants will be in the ground at the start of the growing season, plant storage and procurement problems are lessened, and spring flooding events that could interrupt the planting schedule are avoided. Besides the planting dates, the energy inherent in the system will dictate many characteristics of the planting program. In high-energy situations, planting densities should increase, and larger stock sizes may be warranted, when compared with low-energy environments. Where herbivory concerns are high, a spring planting, immediately after the waterfowl migratory season, may be prudent. This strategy allows for the avoidance of at least some potential herbivore pressure while allowing for maximum biomass development. Adopting such a planting window would mimic the existing phenological patterns of many emergent marsh species.

If properly planted, the weighting requirements for emergent plantings are not necessary, especially for spring plantings that will quickly root. Weighting has some inherent advantages for fall/winter plantings, plantings on coarse sands, and in high-energy locations, but plantings in high-energy systems are best done in the spring with consideration for requiring a mid-to-late spring planting with nondormant peat pot or containerized stock. When planting under a dewatered situation, inexperienced contractors and crews will have a strong tendency to place the materials at soil depths that are too shallow and/or to not firmly plant into the soil. Once the wetland is flooded, many of these shallowly placed plants will then float—weighting will allow at least some materials to stay on the bottom.

There are strong differences in opinion concerning whether marsh plantings should be conducted under flooded or nonflooded conditions. Planting under flooded conditions is possible, and some contractors excel at this type of planting; but it cannot be recommended for inexperienced planting crews. With experienced crews, there is a distinct advantage to planting in flooded environments in that the planting crews can plant the shoreline slopes without encountering problems associated with desiccation, plant with an easier match of the plant materials to the hydrology, and avoid creating a drawdown zone that will facilitate immediate natural colonization by weeds. Extending most marsh plantings all the way up to the design water elevation and slightly beyond to include the adjacent saturated soils is important and is best done under flooded conditions. The strongest growth will often occur in these shallowest areas and where drawdown will occur. Typically, these areas are subject to less herbivory pressure, especially if antiherbivory measures are placed.

The qualifications of the nursery providing the plant materials have not been addressed in the specification. Traditional landscaping requires that all plant materials must be from nurseries “that have been inspected and certified by State plant inspectors,” with no additional requirements. If desired, such a qualification can be easily inserted into the specification.

As written, the specification requires that the user indicate on the plans that the planting includes a fertilizing treatment—no fertilization is the default. Garbisch et al. (1996) favors fertilizing almost all marsh plantings. The decision on whether to use a fertilizer should be based on anticipated fertility levels following the planting, expected rate of vegetative spread, and the depth of the water. In many instances, especially with deepwater marsh, full fertilization will not be necessary, and additional fertilizer will simply promote an algal bloom. One should refer to the Discussion and Rationale under Topsoil Stripping and the associated references. Grace-Sierra Chemical Corporation of Milpitas, CA, manufactures fertilizers that conform to those contained in this specification under the trade names Agriform (tablets) and Osmocote (granular prills). The season of application dictates the release formula for any Osmocote selection (Garbisch et al. 1996). The understanding of these authors is that a low nitrogen, long-term release fertilizer may be developed by Grace-Sierra in the future.

Mag Amp (7-40-6) is another commercial fertilizer that has frequently been used in marsh restorations.

What is most important is that the specification is designed so that knowledgeable contractors can work effectively with the designers. If the contractor or his/her subcontractor foresees any problems with the design or specifications, he can refer to a format that has been provided that allows the contractor to identify those concerns. The contractor must provide such comments in writing within 45 days of contract award. These comments should fully identify and discuss the concerns and propose viable solutions. If the comments are sound, the comments should be adopted; but the desire to use only a single plant material vendor should not be a factor, and the diversity of the planting should not be reduced simply to comply with single vendor availability. Comments relating to the use of undersized stock should be given due consideration. Unless in obvious error, one should not allow the use of smaller stock than specified, but be open to increasing the stock size. Because certain design features or considerations may only be known to the design team and not to the contractor, the comments of a knowledgeable wetland contractor should not be considered "gospel." Design features or considerations to which the contractor may not have direct access include hydrological modeling for the wetland system, regulatory mandates, or regional concerns for weed invasion. An open dialogue between the design team and knowledgeable contractors is strongly recommended, but the ultimate decisions should rest with the design team. Comments relating to herbivory issues by experienced firms should be carefully considered; one should be open to accepting changes in the antiherbivory measures, but these comments need to be submitted early so that the paperwork associated with design changes can be made. The requirement to submit a purchase order for the plant materials immediately following the award of the contract is intended not only to give adequate time for the plant suppliers to grow the necessary stock but is a very effective mechanism for expanding the number of species available for a project by giving considerable lead time to the nurseries—it really does work.

As indicated in the Introduction, the timing of the various project elements may be as important as the elements themselves in determining the success of a project. This timing is best controlled via a construction sequence or a series of plan sheet notes and not via item specifications. Because of this limitation, these project milestones do not appear in any of the guideline specifications. Preparation of the project sequence will be dependent not only on the workability and time required to complete the various tasks, but on the biology of the site. Coordinating the soil tasks with the vegetation elements so that the vegetative elements have the best chance at developing toward the desired composition and structure should be made one of the major goals of the plan preparation—planting windows, seeding windows, dewatering/flooding windows, and windows for starting and completing the soil work. The most straightforward examples of this importance can be seen in old field succession, where the season of abandonment often dictates the direction of plant succession. Even in a

greater predictive capability, many waterfowl refuge managers can accurately forecast the succession patterns for their managed systems with different plant communities developing depending on the exact date of drawdown, but this can only be done with actively managed systems that are at least 5-10 years old. When developing the plan sequence, one must be cognizant of the period when the earthwork is to be completed and the successional window opened. Plant succession will not wait for one to plant or seed a site. For some marsh or wetland meadow creation projects, it may be best to require the excavation of the upper few inches of the soil immediately prior to a spring planting. This action removes the seed bank, reducing the potential for obnoxious weed colonization and limiting plant competition during the first growing season—the biology is determining the timing of the final grading, not gross excavation considerations. Alternatively, one could mandate a limited excavation window (i.e., November-April), followed by a spring planting. A similar strategy is associated with the flooding/dewatering issue with the biology dictating whether to plant in a flooded or dewatered condition, and when to reflood the site. As these milestones will often have a biological basis and are not construction related or present construction problems, engineers will be tempted to eliminate these biological milestones from the sequence—one should not allow this to occur.

Note: As it regards some aspects of the material descriptions, the specification borrows from course materials provided by various wetland mitigation consultants. These materials are not cited because much of this material is out of date and does not currently reflect the thinking of those same authors.

Planting salt marsh

The planting salt marsh specification (Appendix K) is targeted at planting salt marsh grasses, principally *Spartina*, but is adaptable for other grasses and nongrasses, such as *Carex lyngbeyi*, native to the Northwest. The specification differs from the freshwater marsh specification in three key areas—the requirement for salinity adaptation, the mandate to select the highest microtopographic positions when planting, and a mandatory fertilization program. Salinity requirements should be based both on measurements of tidal water salinities and on tidal sediments near the mitigation site. The survey of tidal sediment salt concentrations should include representative high-marsh locations that may exhibit higher soil salinities than low-marsh positions. The specification can easily be modified to use additional stock types, such as those found in the freshwater marsh specification.

The USDA Plant Material Research Center at Cape May, NJ, has released a cultivar of *Spartina alterniflora*, "Atlantic." This research center has developed the following protocol for acclimation of the *Spartina* to the targeted salinity level:

a. Initial acclimation at 5 parts salt/thousand.

b. Each additional day, an additional 1.5 parts salt/thousand.

Using this protocol, it will take 21 days to acclimate the plant stock from fresh water to full seawater (34.5 parts salt/thousand). Besides "Atlantic," the USDA has released several other cultivars of *Spartina alterniflora* including "Vermillion," selected for fungal resistance on the Gulf Coast, and several releases of *Spartina patens* (North Carolina and New Jersey).

For most projects, early spring probably represents the best planting period, as it avoids storm-damage losses associated with winter and fall plantings. In those parts of the country with strong seasonal precipitation patterns, this generality may not hold true. In much of California, high-marsh plantings should be conducted in the fall to take advantage of the seasonal winter rains; but if required to plant outside this fall window, any proposed irrigation measures must be cognizant of the need to maintain the appropriate salinity levels or risk weed invasion and/or subsequent osmotic stress caused by the buildup of salts in the soil or growing media. To avoid "salting" the plant materials, one should not irrigate high-marsh plantings or water any plant stock outside a controlled nursery environment with brackish or salt water; fresh water should be used.

Summer plantings of *Spartina alterniflora* or *Spartina foliosa* cannot be recommended (Daiber 1986). The longest practical growing season is desired, as tiller production is initiated after flowering in both *Spartina foliosa* (Floyd and Newcombe 1976) and *Spartina alterniflora* (Broome, Seneca, and Woodhouse 1988). Although a spring planting will probably result in the greatest survivalship, plant survival cannot be correlated with biomass production. With *Spartina alterniflora* in Galveston Bay, a February planting achieved lower survival rates, but higher total standing crop at the end of the first growing season than a comparable May planting (Webb and Dodd 1989). One should refer to the freshwater marsh specification for a discussion of late plantings.

For all coastal restoration projects, Lewis (1982) is almost a mandatory reference. This volume contains chapters targeted at various regions including the Gulf Coast, the Pacific Northwest, and southern Florida. Besides salt marsh, topics covered include coastal dunes, mangrove forests, and seagrass meadows. Contributing authors are Woodhouse, Knutson, Webb, Kruczynski, Chung, Philips, and Lewis. For salt marsh planting, this volume is not limited to *Spartina*, but includes many other genera (*Carex, Deschampsia, Juncus,* and *Distichlis).* All these chapters demonstrate hands-on expertise emphasizing design considerations, proper material handling, planting dates, salinity tolerances, and fertilizing requirements with detailed analysis of costs and man-hour commitments in some chapters. This guideline specification should be modified as required to reflect the regional concerns and plant specific needs identified in this and other works.

Daiber (1986) offers an excellent and balanced overview of salt marsh establishment with considerable emphasis on benthic colonization, organic accumulation, vegetation management, herbivory, and fertilization. This work may be the best single introduction into salt marsh establishment. Kusler and Kentula (1989) is another contributing volume that offers extensive guidance in coastal restoration. Matthews and Minello (1994) is a two-volume National Oceanic and Atmospheric Administration (NOAA) publication targeted at the restoration of *Spartina alterniflora* marshes. This latter volume contains an annotated bibliography and probably represents the most up-to-date literature compilation on *Spartina* restoration, but it is not an all inclusive bibliography. Schneller-McDonald, Ischinger, and Auble (1990) is a hard copy of the Wetland Creation/ Restoration (WCR) Database, as maintained by the National Ecology Research Center, Fort Collins, Colorado. This annotated bibliography may be the most complete reference source for wetland restoration, including salt marsh. Vernberg (1993) is a recent review of physical, geological, and chemical salt marsh processes.

Crewz and Lewis (1991) provide an overview of design considerations for both salt marsh and mangrove establishment. The primary focus of this work is on project design, not plant handling. Broome, Seneca, and Woodhouse (1988) and Broome (1989) outline most of the basic techniques for salt marsh establishment. These works are among the latest efforts outlining the proper procedures for salt marsh restoration with emphasis on plant handling considerations, and both contain good reference lists. Shisler (1989), Moy and Levin (1991), and Zedler (1993) are recommended as companion reading. There is wide agreement that with tidal marsh plantings, nitrogen availability is considered limiting (Langis, Zalejko, and Zedler 1991; Gibson, Zedler, and Langis 1994); but under a nitrogen fertilization program, available phosphorous may be limiting (Daiber 1986). As such, this specification includes a mandate for a balanced fertilizer placement and allows for subsequent broadcast treatments, but fertilizer treatments have not always been shown to increase the standing crop on low marsh (Webb and Dodd 1989; Daiber 1986). On sands, the addition of nitrogen and phosphorous will likely increase yields; however, when the substrate has a strong fraction of fines or organics, there may or may not be an increase in biomass production on low marsh. High-marsh plantings of *Spartina patens* are likely to respond vigorously to repeated fertilizer applications, but *Juncus roemerianus* may not respond because of lower nutrient need (Broome 1989). Again, the reader is strongly directed to Lewis (1982) for species specific guidance.

The initial fertilizers conform to time/temperature-release fertilizers with a large nonsoluble fraction. Agriform tablets and various Osmocote formulations comply with the material specifications (Grace-Sierra Chemical Corporation, Milpitas, CA). Maintenance fertilizer applications are generally not necessary in salt marsh projects, but when required, approximately 100 to 300 lb per acre of nitrogen and 100 lb of phosphate per acre should be applied from a soluble source at low tide in the spring (Knutson and Woodhouse 1982). Maintenance provisions in this specification call

for the placement of 200 lb of nitrogen per acre, 100 lb soluble and 100 pounds slow-release. For maintenance fertilizations, Broome (1989) recommends ammonia sulfate- or urea nitrogen-based fertilizers and the use of concentrated superphosphate, 42-46 percent P_2O_5 base oxide, chemical form ($Ca(H_2P_2O_4)_2 \cdot H_2O$). Nitrate-based fertilizers are not recommended by Broome, as they are subject to denitrification and loss under flooded conditions. Daiber (1986) indicates that in high-wave environments, annual fertilizations may be required to maintain *Spartina* plantings targeted at shoreline stabilizations.

Machine plantings of sprigs are possible using modified agricultural tools including cabbage, tobacco, and tomato planters. There is at least one forestry company offering a machine planter for use on rough ground and deep debris—Wildland Planter, R. A. Whitfield Manufacturing Company, Mableton, GA. Its use is limited by the traction and flotation characteristics of the machine and substrate conditions. Where there is a concern for desiccation of the sprig material, the specification could be amended to include a kaolin clay root treatment, dip or spray, as described under the specification for reforestation. If using sprigs, one should review some of Knutson's publications to identify the plant characteristics necessary for sprig materials. Large, robust, single culm (stem) individuals from uncrowded stands are preferred for the sprig collection of *Spartina alterniflora*. Sprig stock from older, dense stands of *Spartina alterniflora* is smaller, of lower quality and more difficult to harvest. Donor plugs are often sized having a diameter of 4- to 6-in. and a depth of 6- to 8-in. (Knutson and Woodhouse 1982). Knutson and Woodhouse (1982) recommend planting three to five sprigs per planting hole for salt marsh restorations. This recommendation occurs throughout many of Knutson's publications.

If one elects to place more than one sprig per planting hole, a visible plan note must be included on the sheets. Otherwise, there will be confusion in the bid preparation. The quantity sheet should indicate the total number of sprigs required for the project, not the number of planting holes.

For many regions of the country, the salinity conditions will also dictate whether the bid package should include monitoring for invasion by *Phragmites australis*, common reed. In higher saline environments, *Phragmites* is not competitive; but in moderate to low saline environments, it may be competitive. In some estuaries, *Phragmites* extends far into the low-marsh zone—it is not confined to high-marsh positions. For many coastal marshes now dominated by *Phragmites* or areas that are in historical salt hay farms, increasing salinity concentrations and restoring tidal flows via the removal of berms or restrictive culverts or tide gates offer an excellent opportunity for low-cost restoration (Roman, Niering, and Warren 1984; Shisler 1989; Sinicrope et al. 1990; Barrett and Niering 1993). Occasionally, such removals will result in the development of wide-open mudflats that provide valuable resting and feeding flats for a variety of shorebirds. These mudflats then revegetate via natural establishment

within a few years with elevation, salinity, and energy being the key factors in driving the development of the marsh. The value of these mudflats may be considerable, as they will be inundated for a shorter period of time than naturally occurring flats, allowing for extended wildlife use. In high-energy locations, the full and open breaching of dikes and berms may not be advisable, and such practices have resulted in the "loss" of the marsh due to excessive sediment transport including the breakdown of older peats. A structure allowing tidal exchange, but restricting storm tides and energies, provides an alternative to open breaching.

With low-marsh *Spartina alterniflora* mitigations, one key design element is the ability to convey the tidal waters off the marsh as quickly as possible during the low-tide phases and to restrict ponding. Restrictive movement of tidal water is likely to limit the lower elevation of *Spartina* colonization. The need to remove the tidal water quickly or limit ponding relates to possible physiological stress on the *Spartina*, particularly during the winter months. Unlike many freshwater marsh plants, *Spartina* does not go dormant during the winter months and is subject to winter-kill if either the O_2 or CO_2 levels in the soils are unfavorable (Garbisch 1989a; Garbisch et al. 1996). The efficient removal of tidal water allows for better O_2 diffusion into the marsh sediments and the diffusion of CO_2 from the marsh sediments into the atmosphere. Because of this need for O_2 and CO_2 diffusion, the establishment of tidal marsh vegetation on "soupy" sediments or poorly drained organic sediments can be difficult. The root mass of *Spartina alterniflora* frequently hummocks above the surrounding marsh plain promoting drainage and gas exchange. To aid gas diffusion, some mitigation designs have required a coarse sand to be placed as a planting substrate; but even with an annual fertilization program, a coarse sand may limit the biomass production (Daiber 1986). Permeable, mixed grain substrates probably provide for the greatest biomass yields. Many of the problems encountered with salt marsh establishment are identified in Crewz and Lewis (1991), Garbisch and Garbisch (1994), and Garbisch et al. (1996). In this last volume, Garbisch reports the occurrence of peat bank development in man-made marshes to such heights that the peats are now unstable and subject to severe erosion and undercutting.

Channels within salt marsh systems act to disperse tidal waters, drain the marsh surface, distribute sediments introduced from outside sources, and redistribute sediments that originate from within the marsh. The removal of surface waters is partially dependent on the slope of the marsh surface, the distance to a channel capable of conveying that water, the capacity of that channel, and frictional forces, including the vegetative component. An introduction into hydraulic design directed at salt marsh restoration is found in Haltiner and Williams (1987). With marsh creation or rehabilitation, any developed marsh surfaces must be stable under "normal" conditions even in the absence of vegetation (Garbisch 1977 as cited in Daiber 1986). There are other hydraulic and hydrological factors involved, but these other factors are typically at the landscape level and are difficult to manipulate or change. Coats, Swanson, and Williams (1989) describe the hydrological and hydraulic analyses undertaken for

the restorations of two salt marshes in California. For low-marsh mitigations, the development of a reticulating channel system, mimicking those found in natural low marshes, may be advisable to assist the movement of tidal waters, especially on poorly drained sediments. Coats et al. (1996) provide guidelines for the development of tidal channels targeted specifically at salt marsh mitigation. Garbisch (1994) and Garbisch et al. (1996) offer guidance for achieving targeted hydrologies in both tidal and nontidal wetland systems with emphasis on the use of biobenchmarks from adjacent wetland systems to establish grading patterns and elevations.

In some locales, herbivore pressure may be an important consideration that will influence many seemingly unrelated parameters, including the selection of grading elevations and the design of channel systems and other open-water/vegetation interfaces—i.e., the width, depth, and slope of any new channels should not aggravate herbivory concerns. When restoring tidal flow to diked marshes via dike removal and/or new channel construction, the same concerns and cautions are warranted, as the reintroduced tidal flows and higher energies may erode and undercut older peats.

If the project involves grading, channel excavation, or any activity that would restrict daily tidal flows, all construction staging and practices must be compatible with the salinity limits of any mitigation design. It is relatively easy to generate hypersaline conditions by restricting tidal flow and allowing water to evaporate, thereby increasing salt concentrations in the soil. The plan set must include staging guidance and prohibitions to prevent the development of excessively saline soils. The potential for the development of hypersaline conditions will determine the frequency of the soil testing. For some projects, multiple testing rounds will be appropriate, but at least one testing round should be conducted immediately prior to any seeding or planting program. Independent testing can be done by the engineer.

The duration of flooding is a key factor in determining the biomass production of a *Spartina* marsh. At the end of the first year growing season for a dredge spoil creation site in North Carolina, Woodhouse, Seneca, and Broome (1974) (as cited in Daiber 1986) obtained an aboveground yield of 2,275 kg/ha of *Spartina alterniflora* under a 3.6- to 8.9-hr/day inundation regime. This compares with aboveground yields of 280 kg/ha and 240 kg/ha for tidal regimes of 0 to 3.6 and 8.9 to 13.0 hr/day, respectively. By the end of the third growing season, the aboveground biomass yield for all three of these inundation regimes was approximately 10,000 kg/ha; but at an inundation regime of 13 to 16.6 hr per day, the aboveground biomass yield was only about half (5,460 kg/ha).

For many projects, it will be prudent to correlate biobenchmark data including soil salinities with the inundation period. The salinity of a system together with the potential for weed invasion, including *Phragmites*, will influence the design of the inundation period. In brackish situations with high potential for weed invasion, longer inundation regimes should retard *Phragmites* establishment. Where there are no available biobenchmark

data sources or as an additional hydrological check, an inundation period of between (4) 6 and 11 (13) hr/day should be suitable for most brackish marsh creation projects targeted at *Spartina alterniflora*. At locales near full-strength seawater, relatively short inundation periods can be used to promote the development of the short form of *Spartina alterniflora* with less concern for *Phragmites* establishment. *Spartina foliosa* is found in a narrower tidal range than *Spartina alterniflora*; its use is restricted to above mean tide (Knutson in Lewis 1982) and a shorter inundation period will be appropriate.

Often the results of marsh restorations projects are reported based on a hydrological reference, such as mean low water or mean high water. For example, Webb et al. (1978) reported highest growth and vegetative reproduction of *Spartina alterniflora* occurred at elevations between 6 and 12 in. below mean high water for a site in Galveston Bay, Texas. This result would then have to be translated into an inundation period with reference to local tidal amplitude. Because tidal amplitudes vary between locales, inundation periods coupled to biobenchmark data and not distances below a hydrological reference point should be used for designing grades in marsh creation.

The ability to convey water quickly onto the marsh is important for the development of *Spartina foliosa* marshes because of the uneven tidal cycle along the West Coast (semidiurnal mixed tides). If the duration between high tidal inundation events is too long, the trapped tidal water evaporates, leading to the development of salt pannes or hypersaline conditions that favor the development of marshes dominated by *Salicornia virginica* (pickelweed) (Josselyn and Buchholz 1984; Zedler 1993). Soil salinities in excess of about 45 (50) parts per thousand can limit *Spartina* establishment (Broome, Seneca, and Woodhouse 1988; Garbisch 1989a; Zedler 1984). With *Spartina foliosa,* there is disagreement in the literature relating to the salt tolerance of this species. Recent literature and personal communications suggest that *Spartina foliosa* or at least some populations of *Spartina foliosa* are more tolerant of hypersaline conditions than previously reported (Gibson, Zedler, and Langis 1994). If true, this will widen the mitigation options for *Spartina foliosa*. Prior to developing any mitigation with *Spartina foliosa* at soil salinities above 35 parts per thousand, the local salt tolerance of populations will need to be confirmed via soil testing, and the tolerance of the transplanted stock will need to be tested.

When reviewing the literature for low-marsh mitigations, special attention should be given to sediment type. In New England and much of the Mid-Atlantic States, the natural tidal marsh sediments have much higher organic contents than along the Southeast or Gulf Coast, which have a higher mineral fraction (Daiber 1986). The types of sediment may influence the design parameters as they relate to channel gradient and the slope of the marsh surface, channel configuration, and channel density. Low-marsh mitigations on highly organic sediments may require steeper marsh plain grades with shorter minimum distances to a channel to facilitate

oxygen and carbon dioxide diffusion. On low permeable soils that pond, any ponded water will evaporate and result in hypersaline conditions and possibly salt pannes. At least one company in New England specializes in supplying a substrate formulation targeted at salt marsh establishment. For some restorations, the consolidation of newly exposed peats may need to be considered in elevational determinations.

Fetch distances and the associated wave energies, shoreline geometry, and sediment size are critical design considerations in tidal mitigations. Excessive fetch distances, the development of deep debris racks, or the potential for ice scouring may prohibit the establishment of salt marshes at certain locations (Knutson et al. 1981; Knutson and Inskeep 1982; Knutson and Woodhouse 1983). The survival and development of coastal marshes require protection from erosion by high-energy waves in order to allow for sedimentation. The persistence of a marsh requires that the accretion of sediments be consistent with the elevation and inundation requirements of the vegetation and that the sedimentation rate equal or exceed sea-level rise (Vernberg 1993).

Often site selection and design will necessitate a site-specific knowledge of tidal flow regime (tidal range, time-elevation relationships, time-velocity relationshsips) and sediment regime (transport, sediment budgets, sedimentation/accretion rates, sediment properties). The integration of this information may be necessary to create or restore sites with conditions that favor long-term growth of coastal vegetation. Baseline monitoring of these conditions to ensure proper and successful designs may be needed. For example, required accretion rates can be predicted with analyses such as that of Chmura, Costanza, and Kosters (1992), who modeled marsh accretion in a Louisiana marsh. Other examples are the determination of the required tidal prism to limit the possibility of inlet closure (Coats, Swanson, and Williams 1989) or an assessment of the effect of fetch and shoreline geometry on the success of plantings (Sharp, Belcher, and Oyler, undated).

Considerable research on shoreline stabilization has been conducted by the Coastal Engineering Research Center, which became part of the U.S. Army Engineer Waterways Experiment Station (WES) in the mid-1980s, and is now known as the Coastal and Hydraulics Laboratory (CHL). This work included the development of the *Shore Protection Manual*, a three-volume manual covering guidelines and techniques for functional and structural design of shoreline protection projects. Topics covered include jetties, seawalls, bulkheads, revetments, and groins. This document is to be replaced with the *Coastal Engineering Manual*, which is currently under development by the Corps. The work of CHL is not limited to hydraulic modeling or hard engineering, but includes considerable research into vegetation stabilization of both marshes and dunes. Szuwalski and Wagner (1984) is an indexed annotated bibliography to the CHL publications and those of the Beach Erosion Board, a predecessor of the CHL. Tidal modeling and wave energy are broad research and application fields. Various different tidal hydraulic models have been developed by

universities and research institutions. FASTABS, which has been developed at WES, is among the newest two-dimensional (2-D) models with application for tidal restoration. FASTABS is capable of modeling the hydrodynamics of estuaries, bays and inlets, sediment transport, seasonal salinity variation, and input allowance for wave energies. Garbisch and Garbisch (1994) and Bartoldus, Garbisch, and Kraus (1994) contain guidelines for the development of salt marsh targeted at shoreline stabilization, and both works discuss maintenance requirements and proper project siting. These latter two volumes are not limited to adopting vegetative solutions and recognize the need for "hard" practices in high-energy locations.

Some workers have developed expertise in seeding *Spartina alterniflora*, notably Broome, Seneca, and Woodhouse, at North Carolina State University and Environmental Concern, Inc. (St. Michaels, MD). Such seeding regimes generally include wild collection of seed in the fall, wet cold storage of the seed over the winter in saline water (40 parts per thousand), and a midspring sowing with shallow incorporation of the seed into the soil (Broome, Seneca, and Woodhouse 1988). Seed is best collected from young stands adjacent to a creek or channel that have a much higher yield of seed per unit area than mature stands (Woodhouse in Lewis 1982). Last year's crop should be used in any seeding program, as the seed stores poorly beyond the first winter of storage. Seeding regimes are less expensive than planting, but are limited in that only the upper third or upper quarter of the *Spartina* zone can be successfully seeded. The seed will germinate throughout the *Spartina* zone, but erosion energy limits the zone of successful establishment. Transplants can be used over a greater variety of conditions and over greater tidal ranges. Seeding success appears to have a strong regional perspective with good results from the Mid-Atlantic States and the New England States, but poorer results from the Gulf Coast States—verbal communication that needs verification, but one should reference Webb et al. (1978) and Webb in Lewis (1982). Direct seeding with *Spartina foliosa* may not prove practical on a large scale because of erratic seed production and the reported low viability of the seed—less than 5 percent (Floyd and Newcombe 1976). Although Knutson and Woodhouse in Lewis (1982) report that substantial, viable seed crops have been gathered in San Francisco Bay, they remain cautious about the dependability of direct seeding with *Spartina foliosa*.

The use of dredge material for the construction of coastal habitats is outlined in *Dredged Material Beneficial Uses* (U.S. Army Corps of Engineers 1978, 1986). Landin, Clairain, and Newling (1989) and LaSalle, Landin, and Sims (1991) described two of these projects from the South Atlantic Coast. For some projects, mudflat creation may be a viable mitigation option (Ray et al. 1994).

High-marsh mitigation and restoration principles are different from low-marsh mitigation guidelines and in many ways are conflicting. For most high-marsh mitigations, the lowering of the groundwater table should be avoided by limiting the extent and depth of any channel system. In the Northeast, the ditching and channelization of high marshes can result in a

changing of the vegetation from a high marsh dominated by *Spartina patens* (salt hay), *Distichlis spicata*, or *Juncus gerardii* to one dominated by *Phragmites* or the shrubs *Baccharis halmifolia* or *Iva frutescens*. Because these vegetation changes are reversible,[1] plugging man-made ditch networks either by fill placement or by placement of water-control structures may offer opportunities for restoration. These latter species are typical of the highest marsh elevations and the upland/wetland border and are considered by many to be less desirable forms of vegetation. Ditching and channelization may also increase salinity levels in brackish marshes, altering the vegetation dominance. In Louisiana, channelization of high marsh may shift vegetation dominance from *Scirpus olneyi* to *Spartina patens* (Broome, Mendelssohn, and McKee 1995). One should not ditch high marsh without carefully considering the impact of the ditching.

Where the project involves the dredging of submerged soils to form salt marsh, there is the possibility for the development of low pH soils, called "cat clays." These clays represent sulfur deposits that until dredged were in anaerobic environments. When placed in aerobic environments, sulfuric acid is formed and the pH drops below 3 or 4. This condition is more deleterious with high-marsh restorations or when creating islands due to lack of daily tidal flushing. Liming may not be effective, as the formation of the sulfuric acid is being driven by the chemical constituents in the soil. Even if repeatedly limed, the benefits may only be temporary and the low pH conditions will return. It is likely that it will be physically and temporally impossible to incorporate sufficient lime into the soil to fully neutralize these acid-producing soils.

The management of salt marshes for mosquito control has been rapidly changing over the last few decades. Many Mosquito Control Commissions are adopting the tenets of what is called Open Marsh Water Management (OMWM). Daiber (1986) describes the basis of the management practices and how OMWM has evolved and changed since its use was first advocated. Many of the principal features of OMWM are directly applicable for tidal marsh mitigations, and their use is highly recommended; but as the principles of OMWM are still evolving, one should use the most current literature on the subject.

Broome, Seneca, and Woodhouse (1988), Lewis (1982), Daiber (1986), Garbisch et al. (1996), and numerous other publications contain guidelines for selecting appropriate salt marsh planting densities. For plantings targeted at shoreline stabilization, the plant spacing will be closer (Garbisch and Garbisch 1994; Garbisch et al. 1996). Knutson's work indicates a minimum practical planting bed width of 20 ft for successful erosion control with salt marsh species even in the lowest energy locations. Allen

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[1] Personal Communication, 1992, Dennis Whigham, Smithsonian Environmental Research Center, Edgewater, MD.

and Shirley (1988) provide alternative planting methodologies and bioengineering techniques (plant rolls, mats, and breakwater plantings) targeted at vegetation establishment in moderate to high-energy areas. Much of the information in the discussion and rational segment for freshwater marshes is directly applicable to salt marshes. One should refer to this discussion, especially as it relates to selecting planting densities and herbivory concerns. *Juncus roemerianus* (rush) is not taken by nutria and *Spartina patens* is not considered a preferred food for either muskrat or nutria (Chabreck et al. 1981, as cited in Nyman, Chabreck, and Kinler 1993). Garbisch, as cited in Knutson and Inskeep (1982), recommends waterfowl line placement at 6-in. intervals from sediment surface to mean high water. A more comprehensive discussion of herbivory in tidal systems is found in Daiber (1986).

Occasionally, it is necessary to stabilize brackish slopes or soils with excessive salt concentrations. Most commercially available seeds will not do well under these conditions due to osmotic stresses, and the seeding will fail. In all likelihood, the most salt-tolerant grass seed that is commercially available in bulk is weeping alkaligrass, *Puccinellia distans* "Fults," a certified seed. Like *Spartina* and the other salt marsh grasses, *Puccinellia* possess the C_4 photosynthetic pathway, which allows for considerable water conservation, reducing the osmotic stress caused by saline soils. In regions with heavy snowfall, it is frequently included as a minor component of highway seeding mixes, and it is known to form long, narrow strips along heavily salted interstate highway medians. *Puccinellia distans* is more salt tolerant than several western cultivars of *Agropyron*, *Sporobolus airoides*, or *Elymus triticoides* (Hughes, Butler, and Sanks 1975). It is caespitose, not excessively tall, and can be routinely mowed. It does not appear to be competitive outside of "salty" soils (Scott and Davison 1985). This grass and a few other members of the genus are also used in seaside golf course construction and maintenance, as are some cultivars of *Agrostis*. *Puccinellia distans* is native to Eurasia in both wet and dry situations. Along the Baltic Coast, it is one of the more important salt marsh species. It occurs periodically throughout the western United States and uncommonly in the East (excluding highway medians). Because of concerns associated with non-native species use, it should only be used after other erosion control options are dismissed. *Puccinellia maritima* is an important species in North Atlantic salt marshes. Sod of *Paspalum vaginatum* may also be useful for stabilization of saline soils.

Soils

The soil specifications center on two technical areas: (a) the development of low permeable soils and (b) the proper management of surface soils. Two different specifications are provided for the development of low permeable soils (perched) with the two specifications targeting different ranges of infiltration rates and subsequently different community types. The subsoil tillage specification is intended to provide internal soil

drainage on excessively compacted soils and is most likely to be adopted in bottomland hardwood mitigations on heavy clays. Guidelines are provided for the excavation, movement and placement of wetland topsoils, and the stripping and stockpiling of upland topsoils for use in mitigations. For sites isolated from a rich seed rain, the use of a wetland topsoil is likely to dramatically increase plant species diversity, assuming the soils are placed in a position that will allow for germination of the seed bank and there are no subsequent problems with noxious weeds. The need for organic amendments including the use of topsoil is likely to be governed by the hydrologic regime, soil texture, and the need to maintain a friable soil.

Clay liner

The most obvious use of clay liners is associated with the creation of permanently or semipermanently flooded wetland mitigations. For example, Carolina Bays are often thought to be underlined by dense clayey sediments over the coastal sands, but Lide et al. (1995) indicate that a least some systems may not be perched. The thickness of the liner and liner cover should be adjusted as required. Suitable specifications for subgrade preparation and embankment can be derived from a variety of sources including the Construction Specification Institute, Inc. (Alexandria, VA) or regional highway departments.

Warning: This specification (Appendix L) is not suitable for use in California vernal pool designs or hydrological regimes and climatic situations that will result in the cracking of the clay liner. Once placed and then cracked, there is no guarantee that the liner will reseal when again flooded. California vernal pool mitigations are best accomplished by uncovering of natural occurring claypans above a duripan and not by subgrade preparation.

There are two general options for establishing the performance criteria for the liner: permeability and infiltration. Permeability and infiltration are not synonymous. Permeability can be defined as the average velocity of water through soil under a unit hydraulic gradient. Infiltration rate is the average velocity of water through soil for a given water height at a given time from the start of the test. Infiltration tests provide fairly good results in assessing water loss if the field tests are performed with hydraulic heads representative of the design conditions.

If permeability tests are performed on undisturbed samples taken from the clay liner, it is recommended to perform tests in accordance with ASTM D5084-90: Test Method for Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.

The gradation of the liner cover material should be compatible with the clay liner. For example, the liner cover material should comply with the filter design criteria for sites where artesian conditions exist. This is done

in order to provide a stable liner cover and to prevent the excessive transport of fines from the underlying clay liner into the cover material. Clays, high plasticity silts, and coarse materials are excluded, as heavy soils will make the planting difficult, possibly retarding plant establishment. Coarse soils present problems in properly securing the plant materials. Hammer (1992) recommends a minimum soil cover depth of approximately 40 cm (16 in.).

Covering the clay liner with a layer of soil of adequate thickness is essential in order to limit desiccation cracks during strong drawdown events and root intrusion. In addition, the site groundwater fluctuations and possible effects on the constructed clay liner, such as uplift, piping, etc., should be studied. The liner cover material described in the sample specification is essentially a filter provided to prevent piping of the liner due to high water pressures exerted by groundwater during the spring months. If excessive net uplift pressure is anticipated (even though this is very unlikely), an underdrainage system for the clay liner coupled with a pressure relief system can be adopted. If the groundwater has little or no impact on the liner, then the specific gradation requirements presented for the liner cover material may be eliminated.

Where emergent plantings or seedings will occur, a friable soil should be placed on top of the liner cover and firmed to serve as a planting medium, as per topsoiling handling practices. The planting medium must not be excessively compacted, and provisions for disking and harrowing the planting soil prior to planting are prudent. The placement of this planting medium cannot be included in this specification, as only portions of the liner cover are likely to be planted or seeded in emergents. A different pay item is required for the planting medium because of differing square yard quantities. The placement of a planting medium will probably not be required for an aquatic bed—one can plant on the liner cover.

Some specifications for liner placement, particularly in landfill applications, include a maximum allowable clod size for the clay. The clod size is dependent upon the source, methods used to extract the clay, and the water content of the material. large clods are not preferred due to problems with laying the material evenly prior to compaction. If desired, a maximum clod size limit of 4 to 6 in. may be added to the specification.

Landfill applications mandate clay liners constructed in multiple lifts with a maximum single lift of 4 to 6 in. If desired, the specification can be modified to require multiple lifts. In our opinion, clay liners with a total compacted thickness of 4 to 9 in., achieved in a single lift, should be acceptable for most wetland mitigations that call for a liner. Lifts thicker than 9 in. are not recommended.

It is not recommended to install clay liners on slopes steeper than four horizontal to one vertical. For such instances, authors have used a clay core with a soil cover constructed to the desired slope—two different pay items, one for clay liner and one for clay core.

In order to establish the required permeability or the infiltration rate, a hydrologic model should be developed representing the proposed wetland system in the specific hydrogeologic setting. The thickness and the permeability of the clay liner may be introduced as the variables in developing the hydrologic model. Such a model would include estimates of precipitation, evapotranspiration, infiltration and exfiltration, and surface and groundwater inputs and outputs.

Pond construction guidelines and a discussion of the use of lining materials can be found in *Ponds - Planning, Design, Construction* (USDA, Soil Conservation Service, Agricultural Handbook Number 590).

Estimates of evapotranspiration rates can be derived from a number of empirical equations—several dozen have been developed. Methodologies and tables for the use of many of the equations are contained in Jensen (1973) and updated in Jensen, Burman, and Allen (1990). Jensen, Burman, and Allen (1990) include the 1977 Food and Agricultural Organization (FAO-24) modifications to several of the equations and an overview of the physics and physiology of evapotranspiration. These volumes are highly recommended with field testing and comparisons of 15 equations at 10 sites including locations in Australia, California, Denmark, Ohio, Idaho, Zaire, Colorado, and New Jersey. American Society of Civil Engineers (1966) represents another field review and test of many of these equations. Additional methods can be found in deMarsily (1986). Winter, Rosenberry, and Sturrock (1995) evaluate the use of 11 equations for estimating evaporation losses for a small lake in Minnesota. This study includes the Hamon equation (Hamon 1961). The Blanney-Criddle, Hamon, Hargreaves, and Thornthwaite equations are temperature-dependent estimates that can be calculated from most climate station reports, but all these equations lack a humidity variable and are not as accurate as the combination methods. The Penman equation (1963) provides a theoretical relationship to estimate the potential evapotranspiration based on the energy available, considering solar radiation, wind, humidity, and temperature. Other models have been constructed for evaluating the overall dynamic water balance of wetlands (Walton et al. 1995).

The use of Class A pan-evaporation rates to estimate the evapotranspiration rates in emergent wetlands can be found in Kadlec (1989). Kadlec's approximation targets the architecture and structure of a *Scirpus/Typha* marsh. Cooley and Idso (1980) estimated evapotranspiration from water lilies at 84 percent of open water. Rushton (1996) reports midsummer evapotranspiration rates exceeding the pan rate for a marsh near Tampa, FL. Estimates of northern peatland evapotranspiration rates and comparative open-water losses can be found in Koerselman and Beltman (1988), Lafleur (1990), and Lafleur and Roulet (1992). Dolan et al. (1984) conduct a similar comparison for a freshwater marsh in Florida. Gerla (1992) provides guidance for determining hydrological budgets and evapotranspiration estimates for intermittent wetlands of the Northern Prairie.

There is a large body of botanical work related to evapotranspiration estimates in various types of wetland communities (e.g., Bernatowicz, Leszcynski, and Tyczynska 1976; Carter 1986; Priban and Ondok 1986; Idso and Anderson 1988). The result of this body of work is quite variable, but there is a strong indication that microcosm, mesocosm, laboratory, and isolated field experiments overestimate the rate of evapotranspiration (Idso 1981; Snyder and Boyd 1987).

For three different types of lowland forests in southern New Jersey, Buell and Ballard (1972) indicated that a value of 0.45 cm water/day is appropriate for estimating evapotranspiration losses for the period from May to October. This estimate equates to evapotranspiration loss of 32.6 in. during this 6-month period and was independent of lowland forest type (hardwood or conifer dominant). The long-term average Class A pan-evaporation rate at New Brunswick, NJ, is 31.8 in. for the period May-October. An estimate for evapotranspiration loss using the Blanney-Criddle equation for this period is 32.5 in. (k = 1.0, rice), using the Thornthwaite equation, 24.5 in. Evaporation losses for the remainder of the year in New Jersey can be estimated at about an additional 5.2 in., for a yearly evapotranspiration loss estimate of proximity 37.8 in. This compares favorably with, but it is somewhat higher than, other estimates of evapotranspiration in forested wetlands including yearly estimates of 28.3 in. for an alluvial cypress swamp in southern Illinois, 36.6 in. for a segment of the Okefenokee Swamp in Georgia, and 33.8-39 in. for a swamp in central Florida (as cited in Mitsch and Gosselink 1993). These latter estimates are less than the local lake evaporation rates and support Krolikowska's (1987) conclusion that swamp evapotranspiration is generally less than lake evaporation. Chow (1964) gives an estimate of the yearly evapotranspiration loss for bottomland hardwoods and cypress as 30-40 in. per year.

The methodology for pan use can be found in Jones (1992), but pans are highly subject to improper installation and poor monitoring practices (Jensen, Burman, an Allen 1990).

Wetland subgrade treatment

For many landscape positions, the wetland subgrade treatment specification (Appendix M) should allow for the development of perched water tables that should support seasonally saturated wetland systems. The permeability or infiltration requirements are not as rigorous as those found under clay liner. If desired, the infiltration rates can be lowered to require tighter soils, but adjustments in the types of soils allowed for backfilling may have to be made. Such adjustments could reflect additional or tighter gradation requirements. For example, if soils finer than AASHTO A-4 soils are readily available, the coarser A-4 soils can be removed from the list of acceptable soils for backfilling. Care should be taken not to extend the infiltration requirements beyond what can be expected from the allowable soil types. Following the subgrade preparation, "topsoils" can

be placed to establish a proper planting medium. The infiltration test specified here can be substituted with a laboratory permeability test. Care should be taken when substituting laboratory permeability tests for infiltration tests because laboratory-measured permeability may differ as much as two orders of magnitude from the field permeability due to differences in compaction, particle distribution, and particle arrangement. An investigation on subsurface conditions, hydrology and groundwater, and a water balance study need to be performed in order to determine the required infiltration rate, depth of the proposed tight soil layer, and compaction requirements. The area of subgrade preparation should be covered adequately with a soil layer or with topsoil in order to prevent the formation of desiccation cracks.

The Burmister Soil Classification System is a field soil classification system commonly used by engineers. It differs from the NRCS Classification, as no loams are recognized. A discussion on the use of bentonite can be found in *Ponds—Planning, Design, Construction (*USDA, Soil Conservation Service, Agriculture Handbook 590). For those individuals who will allow for and believe in "self-sealing of permanently flooded mitigations," via the buildup of organics, this specification may be appropriate for that use.

Subsoil tillage

The subsoil tillage specification (Appendix N) describes the material and methods for subsoil tillage. Subsoiling is intended to break up the heavy structure of very tight soils and lower the bulk density of the soils. This breakup will aid plant establishment by facilitating oxygen diffusion into the soil, increasing root penetration and soil permeabilities, and reducing physiological stress due to saturated soils. It is commonly used in both agriculture and forestry, where the operation is called ripping. Following ripping, soils may swell and occupy more space, resulting in a vertical increase in the soil elevation. In forestry practices, the young trees are planted directly into the rip. However, this ripping occurs in the fall followed by a spring planting. This time interval allows soil particles to erode from the surrounding landscape and fill in the rip with noncompacted soils. In strict forestry applications, two shank ripping is common with a shank distance of 8 or 10 ft depending on the planting scheme. Many of the agricultural applications use much lighter rippers, such as the John Deere V-Ripper. The shanks in these agricultural rippers are of thinner steel, and the subsoiler may be equipped with coulter gangs, a type of cutting wheel, for slicing open both the plow cut and any plant stubble. Such light ripping tools could be used on abandoned agricultural land, but may be poorly suited to sites with a heavy root mat, large quantities of slash, or severely compacted soils. Subsoilers are also very common in construction and are used to break up pavement and tightly compacted soils that need to be graded or excavated.

Subsoilers are highly variable in terms of shank design, with the shanks being the penetrating arms of the subsoiler. The shanks may be straight or curved, and the depth of shank penetration varies from about 1 ft to over 5 ft for some specialized single-shank subsoilers. With heavy-duty subsoilers, the number of shanks that can be supported varies with the design and depth of tillage. Most heavy-duty subsoilers will support between five and seven shanks. Some machines will support up to one dozen shanks. These shanks are removable, so that the proper number of shanks can be used for a particular job. The depth of required penetration and the soil texture and structure will determine the number of shanks that can be effectively used. Some subsoilers have vibratory shanks to aid in the breakup of the soil structure. Most subsoilers do not have this feature. At least one company, Kaelble, manufactures a subsoiler with pair shanks. The first shank is a vibratory shank and is immediately followed by a standard shank. If the use of a vibratory shank is desired, this specification will have to be revised.

During subsoiling, the topsoil layer is not plowed under, but merely sliced through by the shanks. As the shanks are commonly spaced on 2- to 3-ft centers, the overall effectiveness of this slicing may be limited to the soil zone immediately adjacent to the shank. To further increase the effectiveness of the shank, some machines are equipped with winged points that are wider than the shank. For most restoration/mitigation efforts, subsoilers designed for forestry should prove effective. An exception to this may be in work associated with mine restoration, where deeper and more intense fracturing of the soil is required (Scout 1987). This reference also lists manufacturers of subsoilers and contains a discussion of features and limitations of their use. Most, if not all, heavy, crawler tractor manufacturers will publish reference guides for draw pound required and machine sizing for various types of work, including disking, heavy harrow, and subsoiling.

Topsoil stripping

The purpose of the topsoil stripping specification (Appendix O) is straightforward: to quarantine sufficient soil from the project site to serve as a good planting medium. However, a rich topsoil may be inappropriate in some mitigations, such as those targeted at sand communities. The depth stripped will depend on the intent of the mitigation design and the characterisitcs of the soil. Where the mitigation design calls for bedding with a harrow, the depth stripped and stockpiled should be at least 12 in. and may approach 18 in., especially if the subsoils are heavy silts or clays.

This specification has been worded such that the existing surface soils are stripped and stockpiled in the locations shown on the plans. The soil stripped need not conform to a strict requirement of a topsoil. As such, no definition of topsoil is given in the specification. If “true” topsoil is desired, the depths can be specified on the plans and, when required,

additional topsoil hauled to the project site under a different item. The method of measurement can easily be modified.

For some projects, the need to have a friable soil may be of more importance than the organic content of the soil. The depth stripped is determined by the design team, based on existing site conditions. When replaced, the material need not be used as a topsoil. If desired, the replaced soil can be disked into the subsoil to a specified depth to generate a more desirable planting medium.

Ideally, the construction sequencing as detailed on the plans should not allow for any offsite hauling of any soil until the surface soil stockpiling requirement has been completed and measured. On mitigation sites with little excess nonmitigation acreage, stockpiling the surface soils may prove very awkward for the contractor, require multiple handling, or limit construction access. As such, the construction sequence should be as detailed as possible and, where appropriate, should permit limited offsite hauling of excavated materials to allow for manageable stockpile placement. It is strongly advised that a plan note be included indicating that the stripping depths and stockpile requirements will be strictly enforced. Silt fencing protecting the stockpiling should be considered mandatory with method and payment under the appropriate item.

The necessity for topsoil in permanently flooded habitats and tidal habitats has been questioned (Allen and Kennedy 1989). In permanently flooded marsh systems, the need for organics to enhance the moisture-holding capacity of a soil is absent, and organics will likely be added to the soil quickly after establishment. In permanently flooded/saturated soils and soils that are wet for extensive periods of time, the redox potential of the soil will be greatly different when compared with the same soil in an upland position. These differences in redox potential will in turn affect pH and soil nutrient availability (Teskey and Hinckley 1977; Whitlow and Harris 1979; Pierce 1989; McKee and McKevlin 1993). For many mineral soils, flooding will result in a shift of the pH towards circumneutral values. In organic soils, the production of sulfuric acid or the action of bacteria may result in the accumulation of organic acids, lowering the pH. When assaying nutrient availability and the need for topsoil or fertilizer, the potential for changes in redox potential should be recognized, especially as it relates to the possibility for a large increase in the availability of phosphorous and iron in newly flooded wetlands. In upland mineral soils subjected to flooding, there may also be increases in the availability of nitrogen, magnesium, sulfur, manganese, cobalt, and copper in the soil. Decreases can occur in the availability of calcium and potassium (Teskey and Hinckley 1977). As many of these nutrient increases are associated with an increase in the water-soluble fractions, the true availability of the nutrients, particularly phosphorous, will then be dependent on the hydrological discharge characteristics of the wetland. These generalities are valid only for near circumneutral conditions.

The need for fertile, friable topsoil is greatest for mitigations and restorations that are not permanently flooded, semipermanently flooded, or tidally flooded. Forested mitigations that involve tree plantings should benefit from the placement of a good topsoil. A good topsoil may also be used to curtail invasion by some of the noxious weeds. *Phragmites* is highly competitive on infertile soils, tight soils, soils poor in organic matter, or abused soils. Where *Phragmites* invasion is a concern, a good topsoil should aid the development of any seeding program, thereby limiting the potential for *Phragmites* invasion.

Commercial topsoils are highly varied. Published topsoil specifications will normally include pH, sieve gradation, and minimum organic-content requirements. Frequently though not necessarily, the gradations will favor a sandy loam. Many of the more common specifications have a 2-percent minimum for organic content. Some published specifications only require a 1-percent minimum organic content. Occasionally, specifications will place a maximum value of about 10 percent, but this can be as high as 30-percent organic content or as low as 5 percent.

With any organic amendment to the soil, the overall carbon-to-nitrogen ratio of the soil should remain in the proper balance. Excessive carbon loading will reduce the nitrogen availability for plant growth, as any available nitrogen is then captured by the microbial community feeding on the abundant carbon supply. This is referred to as nitrate depression (Brady 1990). Microbial inoculation can be the primary goal of an organic amendment program.

The configuration of the stockpiling areas will influence the microbial community. When soils are stockpiled, oxygen penetration will be influenced by depth, soil texture, and the degree of soil compaction. The soil structure will be lost and soil quality will degrade. Fungal populations are particularly depleted (Harris, Birch, and Short 1993). Where there is a concern for the microflora, stockpiling footprints should be as long and linear as possible to aid oxygen diffusion and retard anaerobiosis, as dictated by the site configuration and the need to have a manageable construction sequence. With reasoned stockpile configurations, subsequent placement of the stockpiled soils is likely to result in a good mixing of the near-surface stockpiled soils with the deeper stockpiled soils and a re-inoculation of the depleted flora.

Wetland soil excavation

The wetland soil excavation specification (Appendix P) is targeted at the removal of an existing wetland soil and the proper placement of that soil. The soil will be of mixed depths, and no attempt to maintain the stratigraphy will be made. Excavation depth and placement depth need not be the same. For example, the top 18 in. of an existing wetland soil may be excavated, but placement may be at a thickness of only 4 in. Matching hydrological regimes between the donor wetland and the project site is

likely to offer the greatest potential for success. Soil placement should be firm, but not excessively compacted. If required, the specification can be modified to include a maximum soil bulk density. One should reference the specification for imprint seeding for a discussion of bulk density.

This specification assumes that the design team has fully investigated the donor wetland soils for the potential for introduction of obnoxious weeds and composition of the seed bed, and has some idea of the value of the seed bed. Moving wetland soil that has a significant obnoxious weed component or the potential for an obnoxious weed seed crop should be strongly discouraged. Brown (1995) reports the successful movement of wetland topsoils when compared with control, mowed, and plowed sites. Topsoil-treated sites had higher plant diversities, percent cover, and wildlife value than the other treatments. Mowed sites had higher values than the control sites, but were not statistically different. Plowed sites tended to become dense monotypic stands of cattail, judged to be of lower wildlife value. McKnight (1992) indicates that an early spring drawdown of transplanted species-rich wetland soil is an effective method for establishing vegetation with two to three times higher species richness than in untreated control plots.

Ecology of Soil Seed Banks, edited by Leck, Parker, and Simpson (1989), is strongly recommended to those contemplating the use of wetland soils for plant establishment. Even though not targeted at restoration and mitigation, many of the chapters have direct relevance to restoration and mitigation efforts. One should not limit the reading to the chapter on wetland seed banks. Although seed bank characteristics may follow some pattern by community type, these patterns are only evident after vigorous study and are not very intuitive, at least in the opinion of these authors. As this volume clearly demonstrates, any assumption that the seed bank will mirror the existing plant community, even when the community is mature, is often mistaken. Transporting a low-light environment wetland soil into a high-light environment may have limited value. Poiani and Johnson (1988) report favorably on the emergence method for determining seed bank composition in marshes. For the reclamation of a phosphate mine in central Florida, Erwin et al. (1985), as cited in Zentner (1994) reported much higher species richness and cover values after treatment with a salvaged wetland topsoil than with nontreated subsoils.

The center focus of this specification is the excavation of the wetland soils and the quick placement of those soils without excessive drying, exposure, or stockpiling. Excessive drying, exposure, and heating should be avoided to curtail destruction of the seed bank, premature germination of the seed bank, or premature establishment of any vegetative propagules. The specification contains no directions regarding wetland soil manipulation other than the hauling and placement. Any additional work including drawdown simulations, various stratification strategies, or mulching treatments are not presented. Such work is probably best done via other specifications or plan notes.

This specification is limited to what is hopefully best practices. The lack of "second-best" practices, the assumption of hauling, and the presence of a working window may require that the specification be modified and extended for many applications. Second-best practices, such as options to stockpile the wetland soils for later placement (include seeding and additional soil cover) or the temporary burial of the soils at a designated location, have not been included, but may be required for certain projects because of difficulties in construction staging.

For much of the country, the excavation of wetland topsoils is best done in mid-to-late fall. Late-fall excavation will allow for the winter hardening of any viable root fragments, and the donor soil will be in place at the beginning of the next growing season. Spring excavations must be approached with caution, as the sites may be "very wet," making for difficult working conditions with a resulting delay in the placement of the wetland soils. However, erosion control considerations must be factored into the decision on when to place the donor soils, possibly forcing a spring placement.

As written, the contractor selects the type of equipment to be used in the excavation with the requirement that the equipment be low ground pressure. For certain projects, it may be best to indicate on the plan sheets the type of equipment required. The tarp requirements for the haul trucks will need to be reviewed. For most applications, the in-place swing tarps should provide sufficient protection, but the included provisions give the engineer additional authority. With complaints from nearby residents and local authorities, spillage and dust can be a particularly annoying problem for the engineer.

The method of measurement given above is similar to those used in muck excavations, where payment is limited to the quantity that needs to be removed and not what is removed because of the difficulties working in mucks.

Currently, specialized equipment for the cutting, lifting, and placement of intact wetland sod is being developed. Until more information is published on proper techniques, the presentation of specifications for this type of work would be premature. However, at least one company is now offering proven equipment and technical guidance to successfully perform this work (Munro 1994a,b). With these methodologies, the placement of the sod, especially the forming of tight joints between sections and the subsequent watering, is as important as the actual lifting of the sod.

Use of fascine for soil erosion prevention

The use of fascine for soil erosion prevention specification (Appendix Q) was primarily included to provide information on fascine construction materials and not the use of the materials. Please note that all materials that will remain onsite are fully described. The proper use of

fascines and other bio-engineering techniques are outlined in the NRCS Engineering Field Handbook, Chapter 18, Soil Bioengineering for Upland Slope Protection and Erosion Reduction and other sources (including Gray, Leiser, and White 1980; Gray and Leiser 1982). *Bioengineering - Woody Plant Establishment Techniques Details for Streambank Protection and Restoration* (NRCS, November 1995, 13 pages) contains details and guidance in the use of fascines and other bioengineering techniques. Allen and Klimas (1986) illustrate a series of planting and bioengineering techniques targeted at shoreline stabilization. These publications and those developed by the regional USDA Plant Materials Specialists will have to be consulted for the appropriate details for proper placement and installation of the fascines. Prior to their use, review these details for dimensions and materials.

As with most bioengineering techniques, different practitioners will call for different sizing of the fascines, and there appears to be a trend towards using smaller diameter fascines. With longer fascines, some practitioners will call for the orientation of the growing tips of the branches in a single direction. The NRCS Engineering Handbook calls for wattles that are between 6 and 8 in. in diameter, and not 8 to 10 in. as in this specification. Proper wattle sizing is a function of the hydrologic energies within the system. In low-energy systems where the mass of the wattle may not be critical, it would not be unusual to see USDA handout materials calling for a minimum wattle size of 4 in., maximum length of about 8 ft, or a minimum branch diameter of 1 in. The use of "hollow" fascines, the interior of the fascine being dead branches or even pine 2 by 2 in. and the exterior being live whips, would appear to be a viable alternative to larger and more expensive fascines (Newsletter for the USDA-NRCS Plant Materials Program, Northeast Region, March 1994).

At the time of this writing, the *Stream Corridor Restoration Handbook* was being prepared jointly by several Federal agencies. The document is being designed as a reference for field resource managers and technical specialists with emphasis on the least intrusive solutions that are both ecologically sound and self-sustaining. The volume will include new listing and ratings for species use in bioengineering. This specification may need to be modified following guidelines contained in this new volume.

Additions to General Provisions

Within a general provision specification or a construction engineering specification, restrictions and guidelines can be placed to limit the impacts of the proposed work on existing natural resources within the boundaries of the project site as well as outside the limits of construction. Appendix A lists a number of guidelines and restrictions that may be used as additions to the general provisions in order to better protect environmentally sensitive areas during construction. The items listed are meant to serve only as an example of the types of restrictions and guidelines that

can be used to modify the items for specific projects. The use of these guidelines requires that the environmentally sensitive areas, including the wetland resources, be delineated on the plans. This would normally be done via plan labels and hatching patterns. On at least one of the plan sheets, sensitive areas should be depicted with the mandate of "No Access." A "Limit of Disturbance" is not sufficient protection.

In construction mitigations that involve extensive earthwork, considerable acreage outside of the immediate work area may be required for construction offices, equipment storage, parking, and the temporary stockpiling of soils, particularly saved topsoil. These features are not typically shown on plans, and establishing their locations is the responsibility of the contractor. Unless requirements are given under the general provisions, the contractor will establish these features in locations that best serve his/her needs with little appreciation of environmentally sensitive areas.

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Appendix A

Broadcast Seeding

NOTE: THIS SPECIFICATION IS TARGETED AT THE ESTABLISHMENT OF A DESIRED SPECIES MIX VIA HAND LABOR, MORE SO THAN FOR SOIL EROSION CONTROL APPLICATIONS. UNLESS THE SEED MIX IS KNOWN TO BE A VIABLE SPRING SOWN MIX OR THE SEEDS ARE KNOWN TO HAVE BEEN PROPERLY STRATIFIED, FALL SOWINGS SHOULD BE ADOPTED WHENEVER PRACTICABLE BECAUSE OF CONCERNS RELATED TO SATISFYING ANY STRATIFICATION REQUIREMENTS.

WITH STRATIFIED SEEDS, SEED HANDLING PROTOCOLS, PARTICULARLY AS IT RELATES TO SEED MOISTURE, WILL BE VERY DIFFERENT THAN THOSE DESCRIBED BELOW. EXCESSIVE DRYING OF STRATIFIED SEED MAY PLACE THE SEED IN DEEP DORMANCY THAT MAY BE DIFFICULT TO OVERCOME.

Description:

This work shall include, but is not limited to, site preparation, and furnishing and installing seed in accordance with Contract Plans and Specifications and/or as directed by the Engineer. This work shall also consist of maintaining seeded areas until accepted by the Engineer. The areas to be seeded and paid for under this item shall include all areas designated on the plans and as directed by the Engineer.

Materials:

(a) General: Within thirty (30) days of the award of the Contract, the Contractor shall submit a complete list of the proposed materials to be provided under this section to the Engineer for approval. This submission shall identify the seed or seed mix and include the seed sources with genetic origin of the material and identification of all varietal types. Any deviations from the seed mix specifications shall be clearly identified to the Engineer. Manufacturer's material specifications for any harrowing equipment that will be utilized for incorporating the seed into the soil shall be provided.

Upon rejection of any material, new material submissions shall be made until the proposed materials are in compliance with the specification, as solely determined by the Engineer. Any materials deemed not in compliance with the specifications by the Engineer shall not be utilized for this work. The Engineer reserves the right to reject on or after delivery any material that does not meet the specifications herein. All rejected materials and equipment shall be removed from the work site by the end of the working day. The disking and other site preparation equipment shall be of a design that can be utilized efficiently by the Contractor to meet the

requirements of the work specified herein. The equipment proposed for use by the Contractor for disking and herbicide application shall be subject to the approval of the Engineer.

NOTE: TWO OF THE FOLLOWING OPTIONS SHOULD BE DELETED: OPTION 1 IS THE HIGHER QUALITY SEED BECAUSE IT INCLUDES MINIMUM PERCENT PURITY AND MINIMUM PERCENT GERMINATION STANDARDS. ONE SHALL VERIFY SEED AGE.

OPTION 1: **(b) Seeds:** Seeds shall be supplied on the basis of bulk weight, percent purity, and percent germination. Unless authorized by the Department, the seed shall be from this year's crop (less than one (1) year old).

OPTION 2: **(b) Seeds:** Seeds shall be supplied on the basis of bulk weight. Unless authorized by the Department, the seed shall be from this year's crop.

NOTE: IF OPTION 2 IS UTILIZED, ALL REFERENCES TO GERMINATION TESTING AND PURE LIVE SEED WILL NEED TO BE REMOVED FROM THE SPECIFICATION.

OPTION 3: **(b) Seeds:** Seeds shall be supplied on the basis of Pure Live Seed (PLS). Unless authorized by the Department, the seed shall be from crops that are two (2) years old or less. These seeds shall be supplied as single species, partial seed mixes, or full seed mixes in separate bags as indicated on the plans. These separate bags shall not be mixed until authorized by the Department. As specified on the plans or contained within this specification, seed mixes shall be collected from an approved genus/species list with minimum PLS percentage standards for each of the various groupings. When specified, the seed shall conform to the minimum percent purity, minimum percent germination, and maximum weed seed percentage requirements. Pure Live Seed is defined by the formula:

$$\text{PLS} = (\text{Percent Purity of the Seed} \times \text{Germination Percentage})/100$$

All seed shall be cleaned/threshed/screened to remove the fruiting bracts, scales, floral parts, awns, perigynia, and other nonseed debris to the maximum practicable extent, as solely determined by the Department. No compensation for damage to the seed because of improper cleaning, threshing, or screening operations shall be made by the Department. The Contractor shall be solely responsible for the proper storage of the seed according to best seed storage practices.

Seeds shall be fresh, free of deleterious material and disease, and delivered to the site in the original, unopened bags showing a certified net weight, date of germination tests, supplier's name, and certified guarantee of analysis including the composition, purity and germination percentages, and percent weed seed. Seed shall be kept dry and unopened until needed for use. Damaged or faulty packages shall not be used. Seed shall conform to applicable State and Federal regulations as in effect on the date of invitation bids. At the time of delivery, the germination test shall be less than nine (9) months old. Live seed of crop plants other than those specified shall not be utilized. Unless specified otherwise, seed shall not contain in excess

of one percent (1%) of weed seed; zero percent (0%) is desirable. The Department reserves the right to conduct germination tests for each bag. The Department's germination tests shall be the final determination of percent germination. Analysis sampling and testing of the seed and seed tag labeling requirements shall be done in accordance with the _____ *(INSERT STATE REGULATIONS, OFFICE, OR CODE)* and with the Rules and Regulations for Testing Seeds adopted by the Association of Official Seed Analysts (1984).[1]

OPTIONAL PARAGRAPH: The Contractor shall furnish a certified report from an approved seed testing laboratory, not engaged in selling seed, showing a test for purity, viability and weed seed content or representative samples of the seed before it is mixed; shall witness the mixing operations; and shall immediately seal all bags of seed. The price bid shall include the cost of laboratory charges. No seed shall be delivered until the approval of samples by the Engineer; however, such approval shall not constitute final acceptance. The Engineer reserves the right to reject on or after delivery any material that does not, in his/her opinion, meet these specifications.

It is the sole responsibility of the Contractor to supply approved seed that meets the percent germination and percent purity requirements. All storage requirements including fungicide treatments and stratification considerations shall be the sole responsibility of the Contractor.

Seed mixes shall be as specified under **Construction Methods** or as shown on the plans.

(c) Genetic/Elevational Origin:

THIS SEGMENT OF THE SPECIFICATION DESCRIBES THE GEOGRAPHICAL AND HABITAT ORIGINS OF THE SOURCE MATERIALS AND WILL HAVE TO BE PROVIDED BY THE USER.

The genetic stock shall be chosen to provide typical forms of the species and include the capacity to bear fertile fruits, as approved by the Department.

(d) Legume Seed Inoculant: When legumes are included in the seeding mix, a legume inoculant shall be utilized in the seeding program. This inoculant shall be a pure live culture of nitrogen-fixing bacteria selected for maximum vitality and for the ability to transform nitrogen from the air into soluble nitrates and deposit them in the soil. All containers of inoculant shall be fresh and unopened, with the manufacturer's expiration date. Inoculant shall not be used later than the expiration date indicated on the container. The type of inoculation shall be targeted at the legumes within the mix, as indicated on the inoculant packaging, as determined by the Engineer. The Contractor may elect to ask the Engineer to supply a list of appropriate inoculants to the Contractor. If an appropriate inoculant is not identified on the plans or by the Engineer, the Contractor shall not be responsible for ensuring that the inoculant is appropriate for the legume selection.

[1] References cited in this appendix are listed in the References at the end of the main text.

(e) Lightweight Harrow: The harrow conducting the seed incorporation shall be a lightweight chain harrow with a drawbar. A heavier harrow may be required for seed bed preparation. A tine harrow attached to a drawbar shall be an acceptable substitute, provided the design of the tines allows them to be turned upward during the dragging operations. If the Contractor can demonstrate to the satisfaction of the Engineer that a modified section of chain-link fence measuring three (3) feet wide by six (6) feet long and attached to a drawbar can be utilized in conducting the dragging work, as herein specified, the Engineer may allow the use of the chain-link fence. At anytime, the Engineer may withdraw permission for the use of the chain-link fence and require the use of a harrow without any additional compensation to the Contractor.

(f) Water: Water shall be freshwater that is free from toxic substances and chemicals that may be injurious to plant growth. Trucks, hoses, and other watering equipment required to transport water from a source to the seeding area shall be included as part of the work with all costs incidental to this item.

(g) Hand Tools: All hand tools, including rakes and scarifying tools, shall be of sturdy construction and manufactured of high-quality materials. These tools shall be capable of efficiently performing the required work, as solely determined by the Engineer. Any tools determined to be substandard by the Engineer shall not be utilized for this work and shall be removed from the work site by the end of the working day. At no additional cost to the Department, the Contractor shall supply new tools capable of performing the required work within twenty-four (24) hours of the rejection of any tools. Tools shall conform to the requirements of any plan notes.

(h) Miscellaneous Materials: Perlite shall be suitable for agricultural/horticultural uses with an average particle size in excess of three (3) millimeters. The perlite shall contain no germination, growth-inhibiting properties, or elements or compounds at concentrations that will be phytotoxic.

Sand shall be either fine (0.1 - 0.25 millimeter diameter), medium (0.25 - 0.5 millimeter diameter), or coarse (0.5 - 1.0 millimeter diameter) class sand, as specified. The sand shall contain no germination, growth-inhibiting properties, or elements or compounds at concentrations that will be phytotoxic.

Submittals:

(a) Plan Review: The Contractor may submit comments concerning the appropriateness of the seeding program, including the composition of the seed mixture, seeding techniques, and the blending of inert materials. These comments shall be submitted to the Department within thirty (30) days of the award of the Contract. The Department may elect to reject some or all comments.

(b) Soil Testing: Soil tests shall be made to determine the soil gradation; nitrogen (ammonia, nitrate, and Kjeldahl nitrogen), phosphorous, potassium, magnesium, calcium,

manganese, and zinc levels; and soluble salts, pH, buffer pH, and organic matter. Soil tests shall be conducted at a State agricultural laboratory or recognized commercial laboratory, subject to approval by the Engineer. The procedures and materials utilized in collecting the samples shall be as recommended by the laboratory. All laboratory results shall be forwarded to the Engineer. If the soluble salts exceed a value of 0.5 mmhos/cm (measurement of electrical conductivity in millimhos/centimeter) or the pH is lower than 5.0 or greater than 8.0, the Contractor shall immediately inform the Engineer to determine the proper action. *(NOTE: THE TESTING REQUIREMENTS SHOULD REFLECT REGIONAL CONCERNS, AND THE TESTS AND PARAMETERS GIVEN ABOVE MAY HAVE TO BE MODIFIED.)*

Each tested sample shall involve compositing six (6) to eight (8) soil locations, collected randomly, utilizing a soil probe. The soils shall be sampled to a depth of eight (8) inches. The Contractor shall perform one (1) soil test per each ten 10 acres of planting area with a minimum of three (3) tests per site. If the in-place soils are derived from different sources, each source shall be analyzed separately at the same sampling rate or at a rate determined by the Engineer.

When directed by the Department, the placement of fertilizer, lime, iron sulfate, ammonium phosphate sulphate, or other amendments shall be done according to and paid under Section XXXXXX - Soil Amendments. Unless authorized in writing by the Department or as shown on the plans, no other amendments shall be placed.

Unless specified on the plans, the laboratory conducting the soil tests shall forward recommendations for soil amendments including lime based on a target pH of 5.5 *(NOTE: VERIFY THIS VALUE)*. If other soil amendments are authorized by the Department, such amendments shall be added as recommended by the soil testing laboratory. The payment for the placement of these other amendments shall be negotiated prior to the work.

Construction Methods:

(a) General: The Contractor must examine the area and conditions under which work is to be performed. The area must be properly prepared before seeding begins. The Engineer is to be notified in writing of conditions detrimental to the proper and timely completion of the work. The Contractor shall identify those areas that are detrimental for seeding and consult with the Engineer to determine corrective actions. Seeding work is not to proceed until either the condition is corrected or a waiver is granted from the Engineer. Unless directed by the Engineer, no seeding shall occur until all the soil testing results have been reviewed by the Contractor, the Seeding Subcontractor (if applicable), and the Engineer.

All seeding operations shall be initiated and completed within the seeding window shown on the plans or as specified herein. The work shall not be started until all earthwork in the area requiring seeding has been completed. Seeding shall not be done during periods of rain, severe drought, high winds, excessive moisture, frozen grounds, or other conditions that preclude satisfactory results. All seeding is to be done in moderately dry to moist (not flooded) soil and

at a time when the wind does not exceed a velocity of ten (10) miles an hour, or as directed by the Engineer.

(b) Site Preparation: Areas to be seeded shall be maintained at approved grades. All mechanical equipment for soil preparation or seeding shall be as approved and shall pass parallel to the contours unless otherwise directed by the Engineer. The site preparation option utilized shall be as shown on the plans. If no site preparation option is shown on the plans, the Contractor shall till, smooth, and firm the seed bed, as described below. When indicated on the plans, no-till broadcast seeding shall occur with minimal or no additional site preparation. For some projects, broadcast seeding shall occur over an established turf and vegetation without additional site preparation.

Areas to be tilled shall be tilled to a minimum depth of four (4) inches by disking or plowing and smoothed by harrowing or dragging. For all areas, if the grading has just been completed and the soil is loose and friable, not eroded or crusted, the tilling step may be omitted if so approved by the Engineer. The soil shall be left in this scarified condition and shall not be smooth-rolled. The Contractor shall be responsible for performing all work necessary to achieve and maintain an acceptable seed bed prior to seeding as directed by the Engineer at no additional cost to the Department. *OPTIONAL:* Rocks, debris and all other objects that would be detrimental to mowing shall be removed and disposed of as approved.

(c) Seed/Inoculant Handling: During all operations including Contractor storage, seeds and seed bags shall be kept covered, shaded and out of direct sunlight. Seeds shall not be stored or temporarily stored in locations or vehicles where the temperature will be in excess of 90 ^{o}F. Legume inoculant shall be refrigerated until immediately prior to use. At no time shall the inoculant be exposed to direct sun or temperatures in excess of 70 ^{o}F. Inoculation of the seed shall occur immediately prior to commencing the seeding operation. If approved by the Engineer, inoculation may occur within a window twenty-four (24) hours prior to the seeding with the requirement that the seed be temporarily stored at a temperature of less than 75 ^{o}F. For all seeding protocols, inoculant shall be utilized at twice the rate indicated on the packaging.

(d) Seeding: Seeding operations shall be initiated and completed within the seeding dates indicated for each of the mixes. The Contractor shall notify the Engineer at least forty-eight (48) hours in advance of the time he/she intends to begin sowing seed and shall not proceed with such work until permission to do so has been obtained. When delays in operations carry the work beyond the dates specified in the schedule or when conditions of high winds, excessive moisture, or ice are such that satisfactory results are not likely to be obtained at any stage of the work, the Engineer shall stop the work. The work shall be resumed with the Engineer's approval when the desired results are likely to be obtained or when approved corrective measures and procedures are adopted.

OPTIONAL SENTENCE: Seeding shall occur on moist soils. *OPTIONAL SENTENCE:* If required for good establishment as determined by the Contractor or if directed by the Engineer,

the area shall be watered prior to the seeding operation at the rate of 25,000 gallons of water per acre, with all costs for this watering incidental to the item.

After receiving the approval of the Engineer for the seed, the seed mix shall be thoroughly and completely blended with inert materials until a homogeneous mixture is achieved, subject to approval of the Engineer. The mixing of the seed mix with the inert material shall be by volume.

(1) Seeding, Type ___ shall be as follows:

INSERT SEED MIX:

(1) One part seed mix
(2) One-half part perlite
(3) One-half part coarse sand

Seeding Window: *INSERT DATES*

(2) Seeding, Type ___ shall be as follows:

INSERT SEED MIX:

(1) One part seed mix
(2) Three parts medium sand

Seeding Window: *INSERT DATES*

Where legume inoculants are required, the seed and inoculant shall be mixed immediately prior to the incorporation of the inert materials.

Following mixing of the seed with the inert materials, the seed/inert material mixture shall then be uniformly and evenly broadcast over the designated areas at a density that shall achieve a minimum of twenty (20) pure live seeds per square foot, as solely determined by the Engineer. Broadcasting may be done by hand-casting, hand-held spreader, gravity drop seeder, cyclone spreader, sling seeding, or another type of equipment or method, as approved by the Engineer. Following the seeding, the seed shall be incorporated into the soil to a minimum depth of one-quarter inch (¼") and a maximum depth of one-half inch (½"), or as shown on the plans. This incorporation may occur through hand-raking or the use of a chain harrow or tine harrow, subject to approval by the Engineer. When indicated on the plans, the areas shall be only or subsequently hand rolled to promote good seed and soil contact. To avoid soil compaction, the roller shall be an unfilled light-weight surface-corrugated water ballast roller or other equipment as shown on the plans. Areas not seeded at this density or areas where the seed has

not been incorporated into the soil to the proper depths will not be accepted, and no compensation for materials or labor for this rejected work will be made by the Department.

NOTE: SEEDING DEPTHS WILL NEED TO BE VERIFIED. THE DEPTH PROVIDED HERE MAY BE TOO DEEP FOR SMALL SEEDED SPECIES.

Following installation, seeded areas shall not be disturbed in any manner by vehicular, foot, or other traffic other than specified herein or approved by the Engineer. Particular care shall be taken to ensure complete and accurate coverage at the prescribed rates. Proper predetermined quantities of mixture in accordance with the specifications shall be used to cover specified sections of known surface area. Any area inadequately covered, as solely determined by the Engineer, shall be retreated at no additional cost to the Department.

OPTIONAL: **(e) Initial Watering:** Unless directed by the Engineer, thorough watering shall occur two (2) weeks and four (4) weeks after seed installation. Each of these waterings shall occur at the rate of 25,000 gallons per acre, with all costs for this watering incidental to the item. The Contractor shall avoid creating rills and furrows as a result of watering. The Contractor shall be responsible for repairing and reseeding any rills or furrows caused by overwatering at the Contractor's own expense. Any additional waterings required prior to achieving final acceptance shall be the sole responsibility of the Contractor, and no additional compensation shall be made by the Department.

NOTE: THE NUMBER OF INCIDENTAL WATERINGS MAY NEED TO BE MODIFIED. WATERING OF SEEDED AREAS CAN BE HANDLED IN A VARIETY OF WAYS. SOME ORGANIZATIONS REQUIRE WATERING UNTIL THE STAND IS FULLY ESTABLISHED AND ACCEPTED, WITH ALL COSTS INCIDENTAL TO THE BID PRICE. OTHERS EXTEND THE NUMBER OF INCIDENTAL WATERING APPLICATIONS TO THREE OR FOUR. HAVING A SEPARATE BID ITEM FOR WATERING, TO BE INITIATED BY THE ENGINEER, IS NOT UNCOMMON, AND ITS INCLUSION MAY BE PRUDENT FOR MANY PROJECTS.

(f) Acceptance of Seeding Work: Seeded areas shall be maintained by the Contractor until the work has been completed and accepted. Maintenance shall consist of the repair of areas damaged by erosion, wind, fire, and unauthorized access. The soil in such damaged areas shall be restored to the specified condition and specified grade. These areas shall be reseeded to the satisfaction of the Engineer.

NOTE: THE ACCEPTANCE CRITERIA MUST BE CAREFULLY REVIEWED AND EDITED. FOR SOME APPLICATIONS, A STAND ESTABLISHMENT REQUIREMENT MAY BE APPROPRIATE. FOR OTHER APPLICATIONS, IT MAY BE EQUALLY INAPPROPRIATE WITH ACCEPTANCE BASED SOLELY ON THE QUALITY OF THE SEED AND THE QUALITY OF THE INSTALLATION. ONE OF THE OPTIONS WILL HAVE TO BE DELETED FROM THE SPECIFICATION.

OPTION 1: Acceptance of the seed installation shall not occur until at least four (4) weeks following completion of the seeding operation and until all related soil erosion control items have been installed and accepted, including soil erosion control blankets and mulching, when specified. Acceptance of the seed installation by the Engineer shall be based on proper site preparation and installation, and satisfactory completion of required watering and grass stand development. When a satisfactory stand of seeded vegetation, as determined solely by the Engineer, is not established, the deficient areas shall be reseeded, as directed by the Engineer, without additional compensation until a satisfactory stand of seeded vegetation is established.

OPTION 2: Acceptance of the seed installation shall not occur until at least four (4) weeks following completion of the seeding operation and until all related soil erosion control items have been installed, accepted, including soil erosion control blankets and mulching, when specified. Acceptance of the seed installation by the Engineer shall be based on proper site preparation and installation, and satisfactory completion of required watering, if any.

(g) Damaged Areas: All areas outside of specified limits where the vegetative growth has been injuriously disturbed or destroyed by the Contractor, as solely determined by the Engineer, shall be restored and seeded in accordance with these specifications by the Contractor at his/her own expense.

Method of Measurement:

The unit of measurement for payment for Broadcast Seeding, _____ shall be the total number of square yards of surface area actually prepared, seeded, and accepted, in accordance with the plans and specifications or as directed by the Engineer. Measurements shall be made on the ground surface of accepted individual seeded areas.

Basis of Payment:

Payment shall be made at the Contractor's unit bid price per square yard for Broadcast Seeding, _____ and shall include full compensation for furnishing and placing all materials including, but not limited to, seed and the cost of all labor, tools, and equipment, and any incidentals necessary to complete this work in accordance with the plans, specifications, and directions of the Engineer.

Appendix B

Imprint Seeding

NOTE: THIS SPECIFICATION ALLOWS FOR THE ESTABLISHMENT OF A DIVERSE MICROTOPOGRAPHY WHILE CONDUCTING A RELATIVELY SIMPLE SEEDING PROGRAM. IT WOULD PROBABLY BE BEST TO READ THE DISCUSSION AND RATIONALE PRIOR TO THE SPECIFICATION. UNLESS THE SEED MIX IS KNOWN TO BE A VIABLE SPRING SOWN MIX, FALL IMPRINTING WINDOWS SHOULD BE ADOPTED WHENEVER PRACTICABLE BECAUSE OF CONCERNS RELATED TO SATISFYING STRATIFICATION REQUIREMENTS.

WITH STRATIFIED SEEDS, SEED HANDLING PROTOCOLS, PARTICULARLY AS THEY RELATE TO SEED MOISTURE, WILL BE VERY DIFFERENT THAN THOSE DESCRIBED BELOW. EXCESSIVE DRYING OF STRATIFIED SEED MAY PLACE THE SEED IN DEEP DORMANCY THAT MAY BE DIFFICULT TO OVERCOME.

Description:

This work shall include, but is not limited to, site preparation and furnishing and installing seed in accordance with Contract Plans and Specifications and/or as directed by the Engineer. This work shall also consist of maintaining seeded areas until accepted by the Engineer. The areas to be seeded and paid for under this item shall include all areas designated on the plans and as directed by the Engineer.

Materials:

(a) General: The Contractor may elect to utilize equipment that will perform several of the required operations simultaneously. Within thirty (30) days of the award of the Contract, the Contractor shall submit a complete list of the proposed materials to be provided under this section to the Engineer for approval. This submission shall identify the seed or seed mix and include the seed sources with genetic origin of the material and identification of all varietal types, and the imprinting tool as required herein. Any deviations from the seed mix specifications shall be clearly identified to the Engineer.

Upon rejection of any material, new material submissions shall be made until the proposed materials are in compliance with the specification, as solely determined by the Engineer. Any materials deemed not in compliance with the specifications by the Engineer shall not be utilized for this work. The Engineer reserves the right to reject on or after delivery any material that does not meet the specifications herein. All rejected materials and equipment shall be removed from the work site by the end of the working day. The disking and other site preparation equipment shall be of a design that can be utilized efficiently by the Contractor to meet the requirements of the work specified herein. All equipment proposed for use by the Contractor shall be subject to the approval of the Engineer.

(b) Imprinting Tool: The submission material on the tool shall include manufacturer, machine weight, drum length and diameter, drum details as they relate to imprint designs, impression dimensions and spacing, and diagrams of the expected imprint impressions corresponding to the detail figures on the plans, which include both a cross section and a surface view of a 20×20 foot imprinted treated area. The imprinting tool shall be designed for variable ballast weighting. The tool shall be capable of achieving a maximum of twelve (12) pounds per square inch stationary contact pressure on loose-soft soils as measured when the imprint design penetrates the soil to one-half the imprint design depth, and a minimum of forty-eight (48) pounds per square inch stationary contact pressure on dense-compacted soils, depending on the ballast loading. This contact pressure requirement may be satisfied by manufacturer literature or correspondence. The submission of photographs of treated areas is encouraged. The preliminary acceptance of the imprinting equipment shall be based on compliance with the imprinting details shown on the plans and other factors as herein specified. The Department may reject the use of any imprinting tool that does not comply with the details, as solely determined by the Department. The Department may give preliminary approval for an imprinter that does not satisfy the material or detail requirements if, in the opinion of the Department, the imprinter will perform the work to the Department's satisfaction.

The imprinting roller used in the work shall be specially designed for seeding applications. Sheepfoot rollers shall not be acceptable. The imprinting roller shall be capable of achieving the desired imprinting pattern as shown in the details or as approved by the Department. Preliminary approval of an imprinting roller shall not be interpreted as acceptance of the work or equipment. The Contractor shall be solely responsible for ensuring that the imprint roller will be able to satisfy the Construction Methods and Acceptance requirements, as specified herein.

Unless authorized by the Engineer, a crawler-tracked tractor shall be utilized for the imprinting operations. The tractor shall conform to the imprinting roller manufacturer's recommendations as to minimum size, power, and drawbar pounds pull with reference to soil texture and soil conditions. Unless authorized by the Engineer, the tractor width shall not exceed the width of the imprinting roller. If the imprinter can be water-filled, as designed by the manufacturer, this feature of the roller shall be operational. Other methods of ballast production shall be acceptable, subject to approval by the Engineer. The amount of ballast that shall be utilized will be dependent of the site conditions and must be adjustable. The tractor shall have the hydraulic lines and characteristics necessary for proper operation of the imprinter as designed and recommended by the imprinter manufacturer. It shall be the Contractor's responsibility to ensure that all imprinting equipment possesses sufficient power and is of appropriate design and weight distribution to complete the imprinting operations. At the direction of the Engineer, low-pressure tractors, as advertised by the manufacturer and as approved by the Engineer, shall be utilized for this work without any additional compensation to the Contractor. When requested by the Engineer, the Contractor shall supply manufacturer's literature advertising the equipment as low-ground pressure.

NOTE: ONE OF THE FOLLOWING OPTIONS SHOULD BE DELETED. OPTION 1 IS HIGHER QUALITY SEED BECAUSE IT INCLUDES MINIMUM PERCENT PURITY AND MINIMUM PERCENT GERMINATION CHARACTERISTICS. ONE SHALL VERIFY SEED AGE REQUIREMENT.

OPTION 1: **(c) Seeds:** Seeds shall be certified seeds. Seeds shall be supplied on the basis of bulk weight, percent purity and percent germination. Unless authorized by the Department, the seed shall be this year's crop (less than one (1) year old).

OPTION 2: **(c) Seeds**: Seeds shall be supplied on the basis of Pure Live Seed (PLS). Unless authorized by the Department, the seed shall be from crops that are two (2) years old or less. These seeds shall be supplied as single species, partial seed mixes, or full seed mixes in separate bags as indicated on the plans. These separate bags shall not be mixed until authorized by the Department.

As specified on the plans or contained within this specification, seed mixes shall be collected from an approved genus/species list with minimum PLS percentage standards for each of the various groupings. When specified, the seed shall conform to the minimum percent purity, minimum percent germination, and maximum weed seed percentage requirements. Pure Live Seed is defined by the formula:

$$\text{PLS} = (\text{Percent Purity of the Seed} \times \text{Germination Percentage})/100$$

All seed shall be cleaned/threshed/screened to remove the fruiting bracts, scales, floral parts, awns, perigynia, and other nonseed debris to the maximum extent practicable, as solely determined by the Department. No compensation for damage to the seed because of improper cleaning, threshing, or screening operations shall be made by the Department. The Contractor shall be solely responsible for the proper storage of the seed according to best seed storage practices.

Seeds shall be fresh, free of deleterious material and disease, and delivered to the site in the original, unopened bags showing a certified net weight, date of germination tests, supplier's name and certified guarantee of analysis, including the composition, purity, and germination percentages, and percent weed seed. Seed shall be kept dry and unopened until needed for use. Damaged or faulty packages shall not be used. Seed shall conform to applicable State and Federal regulations as in effect on the date of invitation bids. At the time of delivery, the germination test shall be less than nine (9) months old. Live seed of crop plants other than those specified shall not be utilized. Unless specified otherwise, seed shall not contain in excess of one percent (1%) of weed seed; zero percent (0%) is desirable. The Department reserves the right to conduct germination tests for each bag. The Department's germination tests shall be the final determination of percent germination. Analysis sampling and testing of the seed and seed tag labeling requirements shall be done in accordance with the _____ *(INSERT STATE REGULATIONS, OFFICE, OR CODE)* and with the Rules and Regulations for Testing Seeds adopted by the Association of Official Seed Analysts.

OPTIONAL PARAGRAPH: The Contractor shall furnish a certified report from an approved seed testing laboratory, not engaged in selling seed, showing a test for purity, viability and weed seed content or representative samples of the seed before it is mixed; shall witness the mixing operations; and shall immediately seal all bags of seed. The price bid shall include the cost of laboratory charges. No seed shall be delivered until the approval of samples by the Engineer; however, such approval shall not constitute final acceptance. The Engineer reserves the right to reject on or after delivery any material that does not, in his/her opinion, meet these specifications.

(1) Imprint Seeding, Type ___ shall be as follows:

INSERT SEED MIX , INERT MATERIALS, AND SEEDING WINDOW

(2) Imprint Seeding, Type _____ shall be as follows:

INSERT SEED MIX, INERT MATERIALS, AND SEEDING WINDOW

It is the sole responsibility of the Contractor to supply approved seed that meets the percent germination and percent purity requirements. All storage requirements and stratification considerations shall be the sole responsibility of the Contractor.

OPTIONAL **(d) Genetic/Elevational/Exposure Origin:**

THIS SEGMENT OF THE SPECIFICATION DESCRIBES THE GEOGRAPHICAL, ELEVATIONAL, AND HABITAT ORIGINS OF THE SOURCE MATERIALS AND WILL HAVE TO BE PROVIDED BY THE USER.

The genetic stock shall be chosen to provide typical forms of the species and include the capacity to bear fertile fruits, as approved by the Department.

(e) Legume Seed Inoculant: When legumes are included in the seeding mix, a legume inoculant shall be utilized in the seeding program. This inoculant shall be a pure live culture of nitrogen-fixing bacteria selected for maximum vitality and for the ability to transform nitrogen from the air into soluble nitrates and deposit them in the soil. All containers of inoculant shall be fresh and unopened, with the manufacturer's expiration date. Inoculant shall not be used later than the expiration date indicated on the container. The type of inoculation shall be targeted at the legumes within the mix, as indicated on the inoculant packaging, as determined by the Engineer. The Contractor may elect to ask the Engineer to supply a list of appropriate inoculants to the Contractor. If an appropriate inoculant is not identified on the plans or by the Engineer, the Contractor shall not be responsible for ensuring that the inoculant is appropriate for the legume selection.

(f) Water: Water shall be fresh water that is free from toxic substances and chemicals that may be injurious to plant growth. Trucks, hoses, and other watering equipment required

to transport water from a source to the seeding area shall be included as part of the work with all costs incidental to this item.

(d) Soil Testing: Soil tests shall be made to determine the soil gradation; nitrogen (ammonia, nitrate, and Kjeldahl nitrogen), phosphorous, potassium, magnesium, calcium, manganese, and zinc levels; and soluble salts, pH, buffer pH, and organic matter. Soil tests shall be conducted at a State agricultural laboratory or recognized commercial laboratory, subject to approval by the Engineer. The procedures and materials utilized in collecting the samples shall be as recommended by the laboratory. All laboratory results shall be forwarded to the Engineer. If the soluble salts exceed a value of 0.5 mmhos/cm (measurement of electrical conductivity in millimhos/centimeter) or the pH is lower than 5.0 or greater than 8.0, the Contractor shall immediately inform the Engineer to determine the proper action. *(NOTE: THE TESTING REQUIREMENTS SHOULD REFLECT REGIONAL CONCERNS AND THE TESTS AND PARAMETERS GIVEN ABOVE MAY HAVE TO BE MODIFIED).*

Each tested sample shall involve compositing six (6) to eight (8) soil locations, collected randomly, utilizing a soil probe. The soils shall be sampled to a depth of eight (8) inches. The Contractor shall perform one (1) soil test per each ten (10) acres of seeding area with a minimum of three (3) tests per site. If the in-place soils are derived from different sources, each source shall be analyzed separately at the same sampling rate or at a rate determined by the Engineer.

When directed by the Department, the placement of iron sulfate, ammonium phosphate sulphate, or other amendments shall be done according to and paid under Section XXXXXX - Soil Amendments. Unless authorized in writing by the Department or as shown on the plans, no other amendments shall be placed.

Unless specified on the plans, the laboratory conducting the soil tests shall forward recommendations for soil amendments including lime based on a target pH of ___ *(INSERT VALUE)*. If other soil amendments are authorized by the Department, such amendments shall be added as recommended by the soil testing laboratory. The payment for the placement of these other amendments shall be negotiated prior to the work.

Construction Methods:

(a) General: Imprint Seeding shall be performed within the areas shown on the plans and fully cover all ground within these areas. The Contractor must examine the area and conditions under which work is to be performed. Unless the area is in suitable condition, as determined solely by the Engineer, the area shall be properly prepared before seeding begins. The Engineer is to be notified in writing of conditions detrimental to the proper and timely completion of the work. The Contractor shall identify those areas that are detrimental for seeding and consult with the Engineer to determine corrective actions. Seeding work is not to proceed until either the condition is corrected or a waiver is granted from the Engineer. All seed boxes, bins, and seeding equipment shall be free of residual seed. *OPTIONAL SENTENCE WITH EDITS*: If required for good seedling establishment as determined by the

Contractor or if directed by the Engineer, the area shall be watered prior to the seeding operation at the rate of 25,000 gallons of water per acre with all costs for this watering incidental to the item.

All seeding operations shall be initiated and completed within the seeding window shown on the plans or as specified herein. The work shall not be started until all earthwork in the area requiring seeding has been completed. Seeding shall not be done during periods of rain, severe drought, high winds, excessive moisture, frozen grounds, or other conditions that preclude satisfactory results, as solely determined by the Engineer. All seeding is to be done in moderately dry to moist (not wet or excessively dry) soil and at a time when the wind does not exceed a velocity of ten (10) miles per hour, or as directed by the Engineer. Conducting imprinting operations on wet soils may result in poor development of the impressions, excessive amounts of soils adhering to the roller, which will inhibit or prevent successful development of the impressions, and in the rejection of the work without compensation to the Contractor. Conducting imprinting operations on dry soils may result in poor development of impressions and the rejection of all work without compensation to the Contractor.

Unless directed by the Engineer, no seeding shall occur until all the soil testing results have been reviewed by the Contractor, the Seeding Subcontractor (if applicable), and the Engineer.

(b) Site Preparation: Areas to be seeded shall be maintained at approved grades. All mechanical equipment for the site preparation and the seeding shall pass parallel to the contours unless otherwise directed by the Engineer. The site preparation option utilized shall be as shown on the plans. When indicated on the plans, imprint seeding shall occur with minimal or no additional site preparation. If no site preparation option is shown on the plans, the Contractor shall till and prepare the seed bed, as described as follows. (*NOTE: FOR MANY USERS THE APPROPRIATE "DEFAULT" SETTING WILL BE NO TILLAGE.)*

Areas shall be tilled to a depth of twelve (12) inches by disking or plowing, and then smoothed by harrowing. For all areas, if the grading has just been completed and the soil is loose and friable, not eroded or crusted, the tilling step may be omitted if so approved by the Engineer. The soil shall be left in this scarified condition and shall not be smooth-rolled. The Contractor shall be responsible for performing all work necessary to achieve and maintain an acceptable seed bed prior to seeding as directed by the Engineer at no additional cost to the Department. *OPTIONAL:* Rocks, debris, and all other objects that would be detrimental to mowing shall be removed and disposed, subject to approval by the Engineer.

OPTIONAL PARAGRAPH: With approval of the Engineer, the Contractor may utilize a subsoiler/ripping tool in lieu of tilling. This subsoiler/ripping tool shall have a minimum of five (5) steel shanks. The distance between adjacent shanks shall not exceed thirty (30) inches. Each steel shank shall have the minimum dimensions of one and one-half inches by seven and one-half inches by eighteen inches ($1\frac{1}{2}^2 \times 7\frac{1}{2}^2 \times 18^2$). Larger shanks are acceptable. The minimum vertical tillage depth shall be twelve (12) inches and a maximum of twenty-four (24) inches, as measured by field performance determined solely by the Engineer. Each shank shall be equipped with replaceable steel points.

(c) Seed/Inoculant Handling: During all operations including Contractor storage, seeds and seed bags shall be kept covered, shaded, and out of direct sunlight. Seeds shall not be stored or temporarily stored in locations or vehicles where the temperature will be in excess of 90 ^{o}F. Legume inoculant shall be refrigerated until immediately prior to use. At no time shall the inoculant be exposed to direct sun or temperatures in excess of 70 ^{o}F. Inoculation of the seed shall occur immediately prior to commencing the seeding operation. If approved by the Engineer, inoculation may occur within a window twenty-four (24) hours prior to the seeding with the requirement that the seed be temporarily stored at a temperature of less than 75 ^{o}F. For all seeding protocols, inoculant shall be utilized at twice the rate indicated on the packaging. Where legume inoculants are required, the seed and inoculant shall be mixed immediately prior to seed placement per the manufacturer's directions.

(d) Seeding: The seeding and imprinting operations shall be initiated and completed within the seeding dates indicated for each of the mixes or as shown on the plans. The Contractor shall notify the Engineer at least forty-eight (48) hours in advance of the time he/she intends to begin site preparation or seeding. The Contractor shall not proceed with such work until permission to do so has been obtained from the Engineer. When delays in operations carry the work beyond the dates specified in the schedule, or when conditions of high winds, excessive moisture, or ice are such that satisfactory results are not likely to be obtained at any stage of the work, the Engineer shall stop the work. The work shall be resumed with the Engineer's approval when the desired results are likely to be obtained or when approved corrective measures and procedures are adopted.

Seeding shall be done shall by broadcasting the seed over the designated areas at a density that shall achieve a minimum of *INSERT VALUE* pure live seeds per square foot, as solely determined by the Engineer. Broadcast methods include hand-casting, hand-held spreader, and cyclone spreader, as approved by the Engineer. Gravity-drop seeders may be utilized if the Contractor can demonstrate to the Engineer that the seed can be placed evenly across the entire site at the specified rate. During the seeding operation, the individual components of the seed mix shall be distributed uniformly and evenly across the acreage and changes in the mix due to loss of small-seeded species, or for any other reason, shall not be accepted. The Contractor may blend nontoxic inert materials with the seed to facilitate seed placement, subject to approval of the Engineer. Alternative methods of seeding shall be subject to approval by the Department. Particular care shall be taken to ensure complete and accurate coverage at the prescribed rates. Proper predetermined quantities of mixture in accordance with the specifications shall be used to seed the designated areas. Any area inadequately covered, as solely determined by the Engineer, shall be reseeded at no additional cost to the Department. Following installation, all surfaces seeded shall not be disturbed in any manner by vehicular, foot, or other traffic other than specified herein or approved by the Engineer.

(e) Imprinting Operations: The imprinter and tractor shall be as previously approved by the Engineer. Within twenty-four (24) hours of the seeding, imprinting operations shall be conducted over the entire seeded acreage. The imprinter roller shall pass over all ground at least once. Adjacent passes of the roller shall overlap by a minimum of six (6) inches. Imprinting equipment shall pass perpendicular to contours unless directed by the Engineer.

Unless directed by the Engineer, the imprinting roller shall be operated at a speed of between three (3) and four (4) miles per hour. When properly performed, only a single series of passes by the imprinter shall be required for this work.

Excessive soil compaction and ballast loading shall be avoided. Proper ballast shall be utilized to reach a desirable compaction level. The ballast of the operating imprinter should initially adjusted so that the imprinting teeth penetrate to a depth of one-half the imprint design depth. Greater penetration depths indicate that the imprinting roller may be too heavy and its use may result in excessive soil compaction and subsequent rejection of the work. After an examination of the resulting impressions and the results of any initial compaction testing, the ballast may then be adjusted based on the characteristics of the impressions. Once acceptable impressions are developed, as specified herein, additional ballast that would increase the level of soil compaction shall not be utilized. Ballast loading shall be changed if varying soil textures are encountered.

The imprinting operation shall result in the creation of the imprint pattern shown on the plans or as previously approved by the Department, as solely determined by the Engineer. This pattern shall be judged based on the imprint patterns formed in the soil and not the roller design. Depth of impression, shape of impression and impression, spacing shall be among the factors utilized to determine acceptance. Regardless of previous approval of equipment, it is the sole responsibility of the Contractor to ensure that the required imprint pattern is produced. Imprint impressions shall be the **full depth**, length, and width of the design detail. Seventy-five percent (75%) of the side walls of the impressions shall be smooth and firm. If more than twenty-five percent (25%) of the impressions in a given area are not at the proper depth or are not smooth and firm, that area shall be not be accepted; the area will be reseeded and imprinted at no additional cost to the Department. If soil features and patterns generated by the tractor limit the ability to produce the proper impressions, the Engineer may stop the work, require the use of a low-ground pressure tractor, and/or reject the work. Rocky areas shall be excluded from this assessment, as solely determined by the Engineer.

NOTE: ST. JOHN AND DIXON (1995)[1] RECOMMEND THAT THE IMPRINTED SOILS BE TESTED FOR MAXIMUM ALLOWABLE SOIL BULK DENSITIES. THE SPECIFICATION WILL NEED TO BE MODIFIED IN ORDER TO FOLLOW THIS RECOMMENDATION.

(f) Acceptance: Areas not seeded at the required density or areas that have not been imprinted into the soil, as specified herein, shall not be accepted, and no compensation for materials or labor for this rejected work shall be made by the Department. Seeded areas shall be maintained by the Contractor until the work has been completed and accepted. Maintenance shall consist of the repair of areas damaged by erosion, wind, fire, and unauthorized access. The soil in such damaged areas shall be restored to the specified condition and specified grade. These areas shall be reseeded and reimprinted to the satisfaction of the Engineer at no additional cost to the Department.

[1] References cited in this appendix are listed in the References at the end of the main text.

NOTE: ONE OF THE FOLLOWING OPTIONS SHOULD BE DELETED:

OPTION 1: Acceptance of the work shall not occur until at least four (4) weeks following completion of the imprinting operation. Acceptance of the work by the Engineer shall be based on proper site preparation and installation, vegetation stand development, and the satisfactory completion of any required watering. When a satisfactory stand of seeded vegetation, as determined solely by the Engineer, is not established, the deficient areas shall be reseeded and reimprinted, as directed by the Engineer, without additional compensation until a satisfactory stand of seeded vegetation is established.

OPTION 2: Acceptance of the work shall not occur until at least four (4) weeks following completion of the imprinting operation. Acceptance of the work by the Engineer shall be based on proper site preparation and installation and satisfactory completion of any required watering.

For areas rejected, the site preparation, seeding, and imprinting operations shall be repeated at no additional cost to the Department. The Engineer may require the Contractor to utilize a heavier imprinter or more ballast than was used in the initial work.

(g) Damaged Areas: All areas outside of specified limits where the vegetative growth has been injuriously disturbed or destroyed by the Contractor, as solely determined by the Engineer, shall be restored and seeded in accordance with these specifications by the Contractor at his/her own expense.

Method of Measurement:

The quantity of Imprint Seeding, Type ____ to be paid for under this section shall be the number of square yards placed and accepted to the limits shown on plans, conforming with all the requirements of these specifications, complete and accepted.

Basis of Payment:

Imprint Seeding, Type _____ shall be paid for at the contract unit price per square yard bid and accepted for Section XXXXXX - Imprint Seeding, which price and payment shall constitute full compensation for all labor, equipment, tools, water, and incidentals necessary to complete the work.

Appendix C

Cool-Season Hydroseeding

NOTE: THIS SPECIFICATION HAS A STRONG FOCUS ON SOIL EROSION CONTROL, MUCH MORE SO THAN ON THE ESTABLISHMENT OF WETLAND PLANT COMMUNITIES.

Description:

This work shall include, but is not limited to, site preparation, furnishing and installing seed, dye and application of fertilizer, lime, mulch, and synthetic binder in accordance with Contract Plans and Specifications and/or as directed by the Engineer. This work shall also consist of maintaining seeded areas until accepted by the Engineer. The areas to be seeded and paid for under this item shall include all areas designated on the plans and as directed by the Engineer.

Materials:

(a) General: Within thirty (30) days of the award of the Contract, the Contractor shall submit a complete list and the manufacturer's material specifications for the proposed materials to be provided under this section to the Engineer for approval. This submission shall include seed mix, seed source, fertilizer, lime, wood fiber mulch, and synthetic binder and seeding equipment. Upon rejection of any material, new material submissions shall be made until the proposed materials are in compliance with the specification, as solely determined by the Engineer. Any materials deemed not in compliance with the specifications by the Engineer shall not be utilized for this work. The Engineer reserves the right to reject on or after delivery any material that does not meet the specifications herein. All rejected materials and equipment shall be removed from the work site by the end of the working day. The disking equipment shall be of a design that can be utilized efficiently by the Contractor to meet the requirements of the work specified herein. The equipment proposed for use by the Contractor for disking shall be subject to the approval of the Engineer.

Seed and all other materials necessary to complete the work shall be delivered and stored in original unopened packages showing weight, analysis, and name of manufacturer, shall be kept dry, and shall not be opened until needed for use. Damaged or faulty packages shall not be used.

(b) Seeds: Seeds shall be supplied on the basis of bulk weight, percent purity, and percent germination. All seed shall be certified seed. Unless authorized by the Department, the seed shall be this year's crop (less than one (1) year old).

All seed shall be cleaned/threshed/screened to remove the fruiting bracts, scales, floral parts, awns and other nonseed debris to the maximum extent practicable, as solely determined by the Department. No compensation for damage to the seed because of improper cleaning,

threshing, or screening operations shall be made by the Department. The Contractor shall be solely responsible for the proper storage of the seed according to best seed storage practices.

Seeds shall be fresh, free of deleterious material and disease, and delivered to the site in the original, unopened bags showing a certified net weight, date of germination tests, supplier's name and certified guarantee of analysis, including the composition, purity, and germination percentages, and percent weed seed. Seed shall conform to applicable State and Federal regulations as in effect on the date of invitation bids. At the time of delivery, the germination test shall be less than nine (9) months old. Live seed of crop plants other than those specified shall not be utilized. Unless specified otherwise, seed shall not contain in excess of one percent (1%) of weed seed; zero percent (0%) is desirable. The Department reserves the right to conduct germination tests for each bag. The Department's germination tests shall be the final determination of percent germination. Analysis sampling and testing of the seed and seed tag labeling requirements shall be done in accordance with the _____ *(INSERT STATE REGULATIONS, OFFICE, OR CODE)* and with the Rules and Regulations for Testing Seeds adopted by the Association of Official Seed Analysts.

OPTIONAL PARAGRAPH: The Contractor shall furnish a certified report from an approved seed testing laboratory, not engaged in selling seed, showing a test for purity, viability, and weed seed content or representative samples of the seed before it is mixed; shall witness the mixing operations; and shall immediately seal all bags of seed. The price bid shall include the cost of laboratory charges. No seed shall be delivered until the approval of samples by the Engineer; however, such approval shall not constitute final acceptance. The Engineer reserves the right to reject on or after delivery any material that does not, in his/her opinion, meet these specifications.

It is the sole responsibility of the Contractor to supply approved seed that meets the percent germination and percent purity requirements. All storage requirements and stratification considerations shall be the sole responsibility of the Contractor.

NOTE: THE FOLLOWING SEED MIXES ARE PRESENTED ONLY AS EXAMPLES. THE PERENNIAL MIXES ARE BEST SUITED FOR THE NORTHEAST AND NORTHWEST REGIONS OF THE COUNTRY. THE SPECIES INCLUDED IN THE MIXES WERE CHOSEN BASED ON BULK AVAILABILITY OF THE SEED AND THEIR TOLERANCE TO WET SOILS. VERY LITTLE OF THIS MATERIAL IS NATIVE. IT IS STRONGLY RECOMMENDED THAT THE USER UTILIZE THE SERVICES OF THE LOCAL NATURAL RESOURCES CONSERVATION SERVICE (NRCS) PLANT MATERIAL SPECIALISTS AND THE LOCAL U.S. DEPARTMENT OF AGRICULTURE (USDA) PLANT MATERIAL RESEARCH CENTER WHEN DEVELOPING SEED MIXES. PLEASE NOTE THAT HYDROSEEDING RATES WILL BE 1.25 TO 1.5 TIMES THE RECOMMENDED DRILL RATES. THE USE OF FESTUCA ARUNDINACEA SHOULD BE RESTRICTED AS PER THE DISCUSSION AND RATIONALE.

(1) Wetland Seeding, Long-Term Perennial shall be as follows:

Seeding Period: March 1 - May 31 or August 15 - October 15

Seeding rate shall be ninety-five (95) pounds of seed per acre.

Fifty (50) pounds per acre of *Festuca arundinacea*
Ten (10) pounds per acre of *Agrostis alba*
Ten (10) pounds per acre of *Agrostis palustris*
Ten (10) pounds per acre of *Alopercus pratensis*
Ten (10) pounds per acre of *Poa trivialis*
Five (5) pounds per acre of *Trifolium hybridum*

Kind of Seed	Min. % Purity	Min. % Germination	Max. % Weed Seed
Tall Fescue (*Festuca arundinacea*)	97	90	1.0
Creeping Bentgrass (*Agrostis palustris*)	95	85	0.5
Redtop (*Agrostis alba*)	92	85	1.0
Meadow Foxtail (*Alopercus pratensis*)	90	80	0.5
Rough-stalked Bluegrass (*Poa trivialis*)	85	80	0.5
Alsike Clover (*Trifolium hybridum*)	95	90	1.0

Variety Types:

THIS INFORMATION IS VERY REGIONALIZED AND NEEDS TO BE INSERTED BY USER.

(2) Wetland Seeding, Short-Term Perennial shall be as follows:

Seeding Period: March 1 - May 31 or August 15 - October 15

Seeding rate shall be sixty-five (65) pounds of seed per acre.

Twenty (20) pounds per acre of *Agrostis alba*
Twenty (20) pounds per acre of *Alopercus pratensis*
Twenty (20) pounds per acre of *Poa trivialis*
Five (5) pounds per acre of *Trifolium repens*

Kind of Seed	Min. % Purity	Min. % Germination	Max. % Weed Seed
Redtop (*Agrostis alba*)	92	85	1.0
Meadow Foxtail (*Alopercus pratensis*)	90	80	0.5
Rough-stalked Bluegrass (*Poa trivialis*)	85	80	0.5
White Clover (*Trifolium repens*)	90	90	1.0

Variety Types:

THIS INFORMATION IS VERY REGIONALIZED AND NEEDS TO BE INSERTED BY USER.

(3) Wetland Seeding, Type Annual shall be as follows:

Seeding Period: March 1 - October 15

Seeding Rate shall be forty (40) pounds of seed per acre. Unless specified on the plans, no fertilizer treatment shall be applied with this mixture. If flooded areas are to be seeded, no mulch shall be placed. In nonflooded habitats, the wood fiber mulch shall be applied at a rate of six hundred (600) pounds per acre. No additional mulch of any kind shall be applied.

Kind of Seed	Min. % Purity	Min. % Germination	Max. % Weed Seed
Echinocloa spp.	90	85	1.00

Unless indicated on the plans, *Echinocloa* spp. is equivalent to *E. muricata*, *E. crusgalli*, or *E. walteri.*

NOTE: AS SUGGESTED BY THE PLANTING WINDOW, ECHINOCLOA CRUSGALLI IS NOT A COOL-SEASON GRASS, BUT A WARM-SEASON C4 GRASS. UNLIKE SOME WARM-SEASON GRASSES, ECHINOCLOA CAN BE VERY EASILY ESTABLISHED VIA HYDROSEEDING WITHOUT ANY TRACKING REQUIREMENTS. AS ECHINOCLOA GOES TO SEED VERY RAPIDLY EVEN ON SATURATED SOILS AND THE SEEDS ARE FAVORED BY A VARIETY OF WILDLIFE, IT IS WIDELY USED AS A COVER CROP IN WATERFOWL MANAGEMENT PROGRAMS, ESPECIALLY WITH SUMMER DRAINED IMPOUNDMENTS. THIS SPECIES IS NOT NATIVE TO NORTH AMERICA AND MAY BE CONSIDERED AN UNDESIRABLE WEED. THE USE OF NON-NATIVE SPECIES SHOULD ONLY BE ADOPTED AFTER VERY CAREFUL CONSIDERATION AS TO THE POTENTIAL FOR ADVERSE EFFECTS TO NATIVE COMMUNITIES. SOME WORKERS

WILL FULLY REJECT THE USE OF ALL NON-NATIVES, NONREGIONAL SPECIES, OR EVEN NONREGIONAL POPULATIONS OF NATIVE SPECIES. UNDER NO CIRCUMSTANCES SHOULD ONE UTILIZE A NON-NATIVE SPECIES IN A REGION OF THE COUNTRY WHERE THAT SPECIES IS NOT CONSIDERED TO BE ALREADY COMMON. IN 1994, THE AUTHORS KNOW OF NO COMMERCIAL SOURCES FOR THE NATIVE ECHINOCLOA WALTERI OR ECHINOCLOA MURICATA.

(c) Water: Water shall be fresh water that is free from toxic substances and chemicals that may be injurious to plant growth. Trucks, hoses, and other watering equipment required to transport water from a source to the seeding area shall be included as part of the work with all costs incidental to this item.

(d) Soil Testing: Soil tests shall be made to determine the soil gradation; nitrogen (ammonia, nitrate, and Kjeldahl nitrogen), phosphorous, potassium, magnesium, calcium, manganese, and zinc levels; and soluble salts, pH, buffer pH, and organic matter. Soil tests shall be conducted at a State agricultural laboratory or recognized commercial laboratory, subject to approval by the Engineer. The procedures and materials utilized in collecting the samples shall be as recommended by the laboratory. All laboratory results shall be forwarded to the Engineer. If the soluble salts exceed a value of 0.5 mmhos/cm (measurement of electrical conductivity in millimhos/centimeter) or the pH is lower than 5.0 or greater than 8.0, the Contractor shall immediately inform the Engineer to determine the proper action. *(NOTE: THE TESTING REQUIREMENTS SHOULD REFLECT REGIONAL CONCERNS AND THE TESTS AND PARAMETERS GIVEN ABOVE MAY HAVE TO BE MODIFIED).*

Each tested sample shall involve compositing six (6) to eight (8) soil locations, collected randomly, utilizing a soil probe. The soils shall be sampled to a depth of eight (8) inches. The Contractor shall perform one (1) soil test per each ten (10) acres of planting area with a minimum of three (3) tests per site. If the in-place soils are derived from different sources, each source shall be analyzed separately at the same sampling rate or at a rate determined by the Engineer.

When directed by the Department, the placement of iron sulfate, ammonium phosphate sulphate, or other amendments shall be done according to and paid under Section XXXXXX - Soil Amendments. Unless authorized in writing by the Department or as shown on the plans, no other amendments shall be placed.

Unless specified on the plans, the laboratory conducting the soil tests shall forward recommendations for soil amendments including lime based on a target pH of 5.5 *(NOTE: VERIFY THIS VALUE)*. If other soil amendments are authorized by the Department, such amendments shall be added as recommended by the soil testing laboratory. The payment for the placement of these other amendments shall be negotiated prior to the work.

(e) Fertilizer: The recommendations of a soil fertility test for nitrogen, phosphorous, and potassium based on a 100 bushel corn yield shall be used to determine the application rate

for these nutrients. Soil testing shall follow the guidelines described above. A maximum of fifty (50) pounds of nitrogen per acre shall be applied.

In lieu of a soil test, a commercial fertilizer shall be used having a composition by weight of

10-20-20

Nitrogen, N, ten percent (10%), 50% by weight of the nitrogen content available from ureaform (slow release)

Available Phosphoric Acid, P_2O_5, twenty percent (20%)

Water Soluble Potash, K_2O, twenty percent (20%)

The guarantee analysis of the fertilizer shall have a minimum of fifty (50) percent of the total nitrogen derived from ureaform, furnishing a minimum of twenty-five (25) percent cold water insoluble nitrogen at twenty-five degrees (25 ^oF), a minimum activity index of forty (40) percent, and a minimum of three and one-half (3.5) percent urea nitrogen.

Fertilizers shall be packed in the manufacturer's standard containers weighing not over 100 pounds each. The name of the material, the net weight of the contents, and the manufacturer's name and guaranteed analysis shall appear on each container. The manufacturer's label of certification indicating compliance with these specifications shall form the basis of acceptance. The Engineer reserves the right to reject any material that has become caked or otherwise damaged. If the fertilizer is not used immediately after delivery, it shall be stored in a dry place in such a manner that its effectiveness will not be impaired.

NOTE: THE USER MAY WISH TO MODIFY THE FERTILIZER SELECTION, AS THERE ARE A NUMBER OF OTHER FORMULATIONS AND MATERIALS THAT MAY SATISFY THE REQUIREMENTS OF THE WORK. FOR SOME SENSITIVE AQUATIC AREAS, THE USE OF A LOW NITROGEN OR PHOSPHOROUS FERTILIZER MAY BE WARRANTED.

(f) Limestone, Pulverized: Pulverized limestone shall be composed of not less than eighty-five (85) percent calcium and magnesium carbonates, equivalent to not less than 40 percent calcium and magnesium oxide. Burnt or hydrated lime shall not be utilized. Each delivery of pulverized limestone shall be accompanied by a delivery slip indicating its weight and certified analysis of its chemical composition and gradation, including calcium and magnesium oxide equivalents, which shall be furnished at the time of delivery.

(g) Wood Fiber Mulch: The mulch used with the seed mixture shall be a wood fiber mulch. The wood fiber mulch shall consist of specially prepared wood processed into a uniform fibrous physical state. The wood fiber mulch shall be manufactured by the steam defibrating process or a processes of equal quality, as solely determined by the Department. The use of paper cellulose fiber mulches shall be prohibited. Unless shown on the plans, wood fiber mulch shall be free of dyes. If dyes are specified, the use of a manufacturer's green-dyed mulch shall satisfy the requirements for the materials and use of dyes as specified hereinafter.
The wood fiber, including dye, shall contain no germination, growth-inhibiting properties, or elements or compounds at concentrations that will be phytotoxic. The material shall be manufactured and processed in such a manner that the wood fiber will remain in uniform

suspension in water under agitation and will blend with other additives to form a homogeneous slurry. The wood fiber shall perform satisfactorily in hydraulic seeding equipment without clogging or damaging the system.

Wood fiber must conform to the following physical requirements: maximum fiber length less than twelve millimeters (12 mm) with at least sixty (60) percent of the fibers greater than eight and one-half millimeters (8.5 mm) in length and seventy-five (75) percent exceeding three and one-half millimeters (3.5 mm) in length; diameter approximately one millimeter (1 mm); pH range of 4.0 to 8.5; ash content of 1.6 percent maximum; and water holding capacity of 1,000 percent minimum.

The material shall be delivered in packages of uniform weight that shall bear the name of the manufacturer, the net weight, and the supplemental statement of the net weight content in the form of certification.

WARNING: THIS IS A LONG-LENGTH FIBER MULCH CHOSEN FOR SOIL EROSION CONTROL. ITS USE WILL RESTRICT THE NUMBER OF SUPPLIERS. THE USER MAY WANT TO RELAX PORTIONS OF THE MATERIAL SPECIFICATION AFTER THE IDENTIFICATION OF SUITABLE MATERIALS. THE USER WILL HAVE TO VERIFY THE AVAILABILITY OF NONDYED WOOD FIBER MULCH IN YOUR REGION.

(h) Mulch Binders: The mulch binder utilized shall be manufactured for hydroseeding application, as solely determined by the Engineer. Unless directed on the plans or by the Engineer, the binder shall be a polyvinyl acetate emulsion resin containing 60% (± 5%) total solids by weight. Mulch binders shall be miscible with all normally available water when diluted to any proportions. After an adequate drying period of two (2) to six (6) hours, the mulch binder shall no longer be soluble or dispersible in water, but shall be physiologically harmless and shall not have phytotoxic or crop-damaging properties. A binder containing an asphalt base in any proportion shall not be used. Guar gum tackifiers shall not be allowed.

(i) Legume Seed Inoculant: When legumes are included in the seeding mix, a legume inoculant shall be utilized in the seeding program. This inoculant shall be a pure live culture of nitrogen-fixing bacteria selected for maximum vitality and for the ability to transform nitrogen from the air into soluble nitrates and deposit them in the soil. All containers of inoculant shall be fresh and unopened, with the manufacturer's expiration date. Inoculant shall not be used later than the expiration date indicated on the container. The type of inoculation shall be targeted at the legumes within the mix, as indicated on the inoculant packaging, as determined by the Engineer. The Contractor may elect to ask the Engineer to supply a list of appropriate inoculants to the Contractor. If an appropriate inoculant is not identified on the plans or by the Engineer, the Contractor shall not be responsible for ensuring that the inoculant is appropriate for the legume selection.

(j) Dye: Unless shown on the plan sheets, dyes shall not be utilized or incorporated into the seeding slurry or as part of the mulch. When specified, a blue or green water-soluble dye shall be provided that has been specifically manufactured for use in a hydroseeder and

suitable for mixing with lime, fertilizer, seed, and wood fiber mulch at the manufacturer's suggested rate. The dye shall be miscible with all normally available water when diluted to any proportions and shall contain no germination or growth-inhibiting properties.

The materials shall be delivered in packages of uniform weight that shall bear the name of the manufacturer, the net weight, material analysis, and the supplemental statement of the net weight content in the form of certification.

(k) Hydroseeder: The hydroseeder shall have a minimum 1,500-gallon capacity with a minimum of one paddle agitator shafts extending horizontally through the tank. The number and dimensions of the paddle agitator shafts shall be in conformance with the manufacturer's recommendation for the model of hydroseeder utilized, as determined by the Engineer. The paddle shafts shall be capable of mixing and maintaining a homogeneous slurry of water, wood fiber mulch, fertilizer, seed, lime, and all other specified slurry components. To help ensure a homogenous slurry, this mechanical agitation system shall be capable of mixing in two (2) directions simultaneously or be reversible. The agitation system shall be capable of keeping all the solids in a state of complete suspension at all times during the seeding operations. The hydroseeder shall have a minimum eighty (80) horsepower engine and must be able to discharge through a hose or a spray tower at a continuous and consistent rate. Recirculating-type slurry agitation, as the primary means of mixing, shall not be acceptable. If recirculation agitation is present, the recirculation shall be limited to no more than fifty (50) gallons per minute. The Engineer may authorize the use of a smaller capacity hydroseeder if it is demonstrated that such equipment is capable of performing all operations satisfactorily. Hydroseeding equipment shall meet all Federal, State, and local codes for backflow prevention during loading operations. ***OPTIONAL SENTENCE:*** The hydroseeder shall be equipped with a fiber mulch shredder designed specifically for preshredding commercially produced wood fiber mulches.

OPTIONAL PARAGRAPH (USE WITH CAUTION): The hydroseeder shall be equipped with a positive displacement pump (progressing cavity pump) to extend the range of the seeding application, as manufactured by Moyno Industrial Products, Division of Robbins and Myers, Inc., Springfield, Ohio, or an approved equivalent. The positive displacement pump utilized shall be as recommended by the pump manufacturer for use with the specific hydroseeder being employed and shall result in extending the range of the hydroseeding distance a minimum distance of 1,000 feet with proper hose usage.

Construction Methods:

(a) General: The Contractor must examine the area and conditions under which work is to be performed. The area must be properly prepared before seeding begins. The Engineer is to be notified in writing of conditions detrimental to the proper and timely completion of the work. The Contractor shall identify those areas that are detrimental for seeding and consult with the Engineer to determine corrective actions. Seeding work is not to proceed until either the condition is corrected or a waiver is granted from the Engineer. Unless directed by the

Engineer, no seeding shall occur until all the soil testing results have been reviewed by the Contractor, the Seeding Subcontractor (if applicable), and the Engineer.

All seeding operations shall be initiated and completed within the seeding window shown on the plans or as specified herein. The work shall not be started until all earthwork in the area requiring seeding has been completed. Seeding shall not be done during periods of rain, severe drought, high winds, excessive moisture, frozen grounds, or other conditions that preclude satisfactory results. All seeding is to be done in moderately dry to moist (not flooded) soil and at a time when the wind does not exceed a velocity of ten (10) miles per hour, or as directed by the Engineer.

(b) Site Preparation: Areas to be seeded shall be maintained at approved grades. Prior to grading and tillage operations, the ground shall be cleared of construction materials, debris and other materials that might hinder proper grading, tillage, seeding or subsequent maintenance operations. All mechanical equipment for soil preparation or seeding, shall be as approved and shall pass parallel to the contours unless otherwise approved. The site preparation methodology utilized shall be as shown on the plans. If no site preparation methodology is shown, the Contractor shall develop the methodology, subject to the approval of the Engineer.

Areas shall be tilled to a depth of four (4) inches by disking or plowing and smoothed by harrowing or dragging. For all areas, if the grading has just been completed and the soil is loose and friable, not eroded or crusted, the tilling step may be omitted if so approved by the Engineer. The soil shall be left in this scarified condition and shall not be smooth-rolled. The Contractor shall be responsible for performing all work necessary to achieve and maintain an acceptable seed bed prior to seeding as directed by the Engineer at no additional cost to the Department. *OPTIONAL:* Rocks, debris, and all other objects that would be detrimental to mowing shall be removed and disposed of as approved.

(c) Seed/Inoculant Handling: During all operations including Contractor storage, seeds and seed bags shall be kept covered, shaded, and out of direct sunlight. Seeds shall not be stored or temporarily stored in locations or vehicles where the temperature will be in excess of 90 ^{o}F. Legume inoculant shall be refrigerated until immediately prior to use. At no time shall the inoculant be exposed to direct sun or temperatures in excess of 70 ^{o}F. Inoculation of the seed shall occur immediately prior to commencing the seeding operation. If approved by the Engineer, inoculation may occur within a window twenty-four (24) hours prior to the seeding with the requirement that the seed be temporarily stored at a temperature of less than 75 ^{o}F. For all seeding protocols, inoculant shall be utilized at five (5) times the rate indicated on the packaging.

(d) Seeding: Seeding operations shall be initiated and completed within the seeding dates indicated for each of the mixes. The Contractor shall notify the Engineer at least forty-eight (48) hours in advance of the time he/she intends to begin sowing seed and shall not proceed with such work until permission to do so has been obtained. When delays in operations carry the work beyond the dates specified in the schedule, or when conditions of

high winds, excessive moisture or ice are such that satisfactory results are not likely to be obtained at any stage of the work, the Engineer shall stop the work. The work shall be resumed with the Engineer's approval when the desired results are likely to be obtained or when approved corrective measures and procedures are adopted.

Seeding shall occur on moist soils. If required for good establishment as determined by the Contractor or if directed by the Engineer, the area shall be watered prior to the seeding operation at the rate of 27,000 gallons of water per acre with all costs for this watering incidental to the item. If indicated on the plans or if directed by the Engineer, no mulching shall be applied at any point in the seeding operation.

WARNING: THE MOVEMENT OF FLOOD WATERS ACROSS NEWLY SEEDED AREAS MAY RESULT IN THE FLOATING OF THE MULCH; THIS IS ESPECIALLY TRUE FOR BLOWN OR BROADCAST MULCH. ONCE FLOATED, THIS MULCH WILL BE TRANSPORTED DOWNSTREAM AND/OR BE REDEPOSITED WITHIN THE RESTORATION/MITIGATION AS A NUISANCE "TRASH" MAT. IF FLOODING CAN BE EXPECTED PRIOR TO ESTABLISHMENT, IT WOULD BE BEST TO LOWER THE HYDROMULCHING RATE TO ABOUT 650 POUNDS PER ACRE OR ENTIRELY REMOVE THE MULCHING REQUIREMENT. REDUCING THE MULCHING RATE WILL RESULT LOWERING THE MINIMUM AMOUNT OF WATER NEEDED TO HYDROSEED AN ACRE TO ABOUT 1,500 GALLONS PER ACRE.

The application of the seed through hydroseeding shall be completed using a hydroseeder as specified in **Materials** above. The seeding rate shall be the rate specified herein or as shown on the plans. On slopes less than 3 vertical : 1 horizontal, wood fiber mulch shall be applied at the rate of 2,000 pounds dry weight per acre. Where slopes are steeper than 3 vertical : 1 horizontal, the rate shall be 3,000 pounds dry weight per acre. Fertilizer shall be applied as per the results of the soil tests and recommendation procedures described herein. In lieu of soil testing, as specified herein, 500 pounds dry weight of 10-20-20 fertilizer shall be applied per acre. The synthetic binder shall be applied at a minimum rate of forty-five (45) gallons per acre or at the rate suggested by the manufacturer, whichever is greater. The synthetic binder shall be diluted in a minimum of 1,500 gallons of water per acre when applied on rain wet soil, and in a minimum of 2,500 gallons per acre when applied on dry soil. Both the application rate of the synthetic binder and the dilution water may be varied by the Contractor with the prior approval of the Engineer, in accordance with the construction site, particular soil requirements and the recommendations of the synthetic binder manufacturer. If required, dyes shall be applied at the dye manufacturer's suggested rate, subject to approval by the Engineer.

The Contractor may elect to incorporate as much as 3,000 pounds of limestone per acre into the slurry with payment materials and labor incidental to this item. Any additional liming required as determined in the soil test shall be incorporated into the soil to a depth of four (4) inches as per Section XXXXXX - Soil Amendments with payment under Section XXXXXX - Soil Amendments.

The fertilizer, lime, dye, and seed shall be added to the hydroseeder to form a seed slurry after the unit has been completely filled with water. The hydroseeding slurry shall be prepared as follows:

(1) Fill hydroseeding tank with water to the design capacity of the tank, as appropriate for the slurry. Begin full agitation.
(2) After completing Step 1, add seed, then add lime, and then add mulch binder. When required, add legume inoculant and dye. Then add one-half the tank capacity of wood fiber mulch.
(3) After completing Step 2, add fertilizer.
(4) After completing Step 3, add remaining wood fiber mulch under continuous agitation. Mix until homogenous slurry has been achieved.

A minimum of 3,000 gallons of water shall be required per acre seeded. The mixture should be continuously agitated from the time it is mixed to the time it is applied. Where areas of less than one (1) acre are involved, the seed, limestone, fertilizer, dye, wood fiber mulch, and synthetic binder shall be mixed together in the relative proportions specified, with not more than 300 pounds of these combined materials mixed with each one hundred (100) gallons of water.

The Contractor may choose to incorporate the wood fiber mulch and synthetic binder separately, as solely approved by the Engineer. If the Contractor chooses to apply the wood fiber mulch and synthetic binder separately, a dye as specified in **Materials** above shall be mixed thoroughly with the mulch and synthetic binder before application.

The seed slurry shall be applied within ninety (90) minutes after mixing to avoid damage to the seed or inoculant by fertilizer. If more than ninety (90) minutes pass before the hydroseeding operation is initiated, the Contractor shall inform the Engineer and will not commence seeding operations until the Engineer either approves or denies the use of the slurry. If the Engineer denies the use of the seed slurry, the Contractor shall not be reimbursed for cost of replacement material and labor, including disposal of the slurry.

NOTE: THE TIME LIMIT RECOMMENDATION FOR THE SEEDING SLURRY MAY NEED TO BE MODIFIED. KNOWLEDGEABLE RECOMMENDATIONS VARY WIDELY AND RANGE FROM THIRTY (30) MINUTES TO ABOUT TWENTY-FOUR (24) HOURS. THE NINETY-MINUTE WINDOW WAS CHOSEN, AS THIS IS ABOUT THE MAXIMUM CIRCULATION VOLUME THAT CAN BE RECOMMENDED WITH A RECIRCULATION RATE OF FIFTY (50) GALLONS PER MINUTE.

OPTIONAL PARAGRAPH: Immediately after hydroseeding on slopes 3:1 or steeper, the soil shall be firmed by a heavy-tracked crawler, such a heavy bulldozer. Equipment with excessively worn tracks or low-ground pressure equipment shall not be utilized, as solely determined by the Engineer. The Engineer shall be the sole judge of the suitability and required weight of the equipment to perform this work. At the direction of the Engineer, heavier equipment or equipment with less worn tracks shall be provided at no additional cost to the Department.

OPTIONAL WITH ABOVE PARAGRAPH: Firming with a tracked crawler shall be performed so that the entire area is covered in tracks. This will require that Contractor conduct offset passes with the crawler. Slopes shall be tracked in the direction parallel to the slope and not perpendicular (from the top of the slope to the bottom of the slope). Unless directed by the Engineer, firming of the soil may be done with the minimum number of passes of the crawler while at the same time satisfying the tracking requirements. However, the Engineer may require additional passes of the firming equipment at no additional cost to the Department.

Following installation, seeded areas shall not be disturbed in any manner by vehicular, foot, or other traffic other than specified herein or approved by the Engineer. Particular care shall be taken to ensure complete and accurate coverage at the prescribed rates. Proper predetermined quantities of the seeding mixture in accordance with the specifications shall be used to cover all specified or designated seeding areas. Any area inadequately covered, as solely determined by the Engineer, shall be retreated at no additional cost to the Department.

(e) Initial Watering: Unless directed by the Engineer, thorough watering shall occur two (2) weeks and four (4) weeks after seed installation. Each of these waterings shall occur at the rate of 27,000 gallons per acre with all costs for this watering incidental to the item. The Contractor shall avoid creating rills and furrows as a result of watering. The Contractor shall be responsible for repairing and reseeding any rills or furrows caused by overwatering at the Contractor's own expense. Any additional waterings required prior to achieving final acceptance shall be the sole responsibility of the Contractor, and no additional compensation shall be made by the Department.

NOTE: THE NUMBER OF INCIDENTAL WATERINGS MAY NEED TO BE MODIFIED. WATERING OF SEEDED AREAS CAN BE HANDLED IN A VARIETY OF WAYS. SOME ORGANIZATIONS REQUIRE WATERING UNTIL THE STAND IS FULLY ESTABLISHED AND ACCEPTED, WITH ALL COSTS INCIDENTAL TO THE BID PRICE. OTHERS EXTEND THE NUMBER OF INCIDENTAL WATERING APPLICATIONS TO THREE (3) OR FOUR (4). HAVING A SEPARATE BID ITEM FOR WATERING, TO BE INITIATED BY THE ENGINEER, IS NOT UNCOMMON, AND ITS INCLUSION MAY BE PRUDENT FOR MANY PROJECTS.

(f) Acceptance of Seeding Work: Seeded areas shall be maintained by the Contractor until the work has been completed and accepted. Maintenance shall consist of the repair of areas damaged by erosion, wind, fire, and unauthorized access. The soil in such damaged areas shall be restored to the specified condition and specified grade. These areas shall be reseeded to the satisfaction of the Engineer.

Acceptance of the seed installation shall not occur until at least four (4) weeks following completion of the seeding operation and all related soil erosion control items being installed and accepted, including soil erosion control blankets. Acceptance of the seed installation by the Engineer shall be based on proper site preparation, installation, and satisfactory completion of required watering and grass stand development. When a satisfactory stand of grass, as determined solely by the Engineer, is not established, the deficient areas shall be mowed,

refertilized, reseeded, and remulched, as directed by the Engineer, without additional compensation until a satisfactory stand of grasses is established.

(g) Damaged Areas: All areas outside of specified limits where the vegetative growth has been injuriously disturbed or destroyed by the Contractor, as solely determined by the Engineer, shall be restored and seeded in accordance with these specifications by the Contractor at his/her own expense.

Method of Measurement:

The unit of measurement for payment for Wetland Seeding, _____ shall be the total number of square yards of surface area actually prepared, seeded, limed, fertilized, mulched, tacked, and accepted in accordance with the plans and specifications or as directed by the Engineer. Measurements shall be made on the ground surface of accepted individual seeded areas.

Basis of Payment:

Payment shall be made at the Contractor's unit bid price per square yard for Wetland Seeding, _____ and shall include full compensation for furnishing and placing all materials, including, but not limited to, seed, lime, fertilizer, mulch and tackifier, the cost of all labor, tools, and equipment, and any incidentals necessary to complete this work in accordance with the plans, specifications, and directions of the Engineer. The Engineer shall allow for seventy-five percent (75%) payment following acceptance of the seed installation. The remaining twenty-five percent (25%) shall be paid upon final acceptance of all the required work.

Appendix D

Warm-Season Seeding (East Coast)

NOTE: THIS SPECIFICATION IS TARGETED AT THE ESTABLISHMENT OF WARM-SEASON WET MEADOWS IN THE EASTERN UNITED STATES, BUT CAN EASILY BE MODIFIED FOR OTHER USES. MUCH OF THE FOCUS OF THE SPECIFICATION IS TO PRECLUDE COOL-SEASON "WEED" ESTABLISHMENT. IT IS RECOMMENDED THAT THIS SPECIFICATION BE SIMPLIFIED BY REMOVING AS MANY OF THE UNNECESSARY CULTIVATING AND SEEDING OPTIONS AS PRACTICAL. THE SPECIFICATION ASSUMES THAT COLD STRATIFICATION OF THE SEED IS NOT REQUIRED.

Description:

This work shall include, but is not limited to, site preparation, furnishing and installing seed, application of fertilizer, and mowing of seeded areas in accordance with Contract Plans and Specifications and/or as directed by the Engineer. The areas to be seeded and paid for under this item shall include all areas designated on the plans and as directed by the Engineer.

Materials:

(a) General: Within thirty (30) days of the award of the Contract, the Contractor shall submit a complete list and the manufacturer's material specifications for the proposed materials to be provided under this section to the Engineer for approval. This submission shall include seed mix, seed source, fertilizer, seeding equipment, and mowing equipment. Upon rejection of any material, new material submissions shall be made until the proposed materials are in compliance with the specification, as solely determined by the Engineer. Any materials deemed not in compliance with the specifications by the Engineer shall not be utilized for this work. The Engineer reserves the right to reject on or after delivery any material that does not meet the specifications herein. All rejected materials and equipment shall be removed from the work site by the end of the working day. The disking and herbicide application equipment shall be of a design that can be utilized efficiently by the Contractor to meet the requirements of the work specified herein. The equipment proposed for use by the Contractor for disking and herbicide application shall be subject to the approval of the Engineer.

Seed and all other amendments necessary to complete the work shall be delivered and stored in original, unopened packages showing weight, analysis, and name of manufacturer, shall be kept dry, and shall not be opened until needed for use. Damaged or faulty packages shall not be used.

(b) Seeds: Seeds shall be supplied on the basis of Pure Live Seed (PLS). All named cultivars or selected varieties shall be certified seed. Unless authorized by the Department, the seed shall be from crops that are two (2) years old or less. These seeds shall be supplied as single species, partial seed mixes, or full seed mixes in separate bags as indicated on the plans.

These individual bags shall not be mixed until authorized by the Department. With drill operations, mixing may be deleterious to the seeding operation. *(NOTE: ONE SHOULD VERIFY SEED AGE REQUIREMENT.)*

As specified on the plans, seed mixes shall be collected from an approved genus/species list with minimum (PLS) percentage standards for each of the various groupings. When specified, the seed shall conform to the minimum percent purity, minimum percent germination, and maximum weed seed percentage requirements. Species groupings may be defined by taxonomic groupings or seed size/type for use in drill seeding operations.

Pure Live Seed is defined by the formula:

$$PLS = (\text{Percent Purity of the Seed} \times \text{Germination Percentage})/100$$

All seed shall be cleaned/threshed/screened to remove the fruiting bracts, scales, perigynia, floral parts, awns, and other nonseed debris to the maximum extent practicable and subject to approval by the Department. No compensation for damage to the seed because of improper cleaning, threshing, or screening operations shall be made by the Department. The Contractor shall be solely responsible for the proper storage of the seed according to best seed storage practices.

Seeds shall be fresh, free of deleterious material and disease, and delivered to the site in the original, unopened bags showing a certified net weight, date of germination tests, supplier's name and certified guarantee of analysis including the composition, purity, and germination percentages, and percent weed seed. Analysis sampling and testing of the seed and seed tag labeling requirements shall be done in accordance with the _____*(INSERT STATE REGULATIONS, OFFICE OR CODE*) and with the Rules and Regulations for Testing Seeds adopted by the Association of Official Seed Analysts. At the time of delivery, the germination test shall be less than nine (9) months old. Unless specified otherwise, seed shall not contain in excess of one percent (1%) of weed seed as defined in applicable State law and regulation; zero percent (0%) is desirable. The Department reserves the right to conduct germination tests for each bag. The Department's germination tests shall be the final determination of Pure Live Seed.

It is the sole responsibility of the Contractor to provide Pure Live Seed. All storage requirements, stratification, and vernalization considerations shall be the sole responsibility of the Contractor.

OPTIONAL PARAGRAPH: The Contractor shall furnish a certified report from an approved seed testing laboratory, not engaged in selling seed, showing a test for purity, viability, and weed seed content or representative samples of the seed before it is mixed; the Contractor shall witness the mixing operations; and the laboratory shall immediately seal all bags of seed. The price bid shall include the cost of laboratory charges. No seed shall be delivered until the approval of samples by the Engineer; however, such approval shall not constitute final

acceptance. The Engineer reserves the right to reject on or after delivery any material that does not, in his/her opinion, meet these specifications.

Seeds that do not meet the specifications herein or seed that has become wet, moldy, or otherwise damaged in transit or storage shall not be accepted. Seed, after delivery to the Contractor, shall be stored in such a manner as to protect it from damage or deterioration from any source. Final acceptance of seeds must be obtained before the seed is sown. Final acceptance may be subject to the results of official sampling and testing.

NOTE: THIS IS AN EXAMPLE OF A VIABLE MIX WITH VARIETAL SELECTIONS. BY ASSIGNING DIFFERENT TYPE NUMBERS OR NAMES, THIS SPECIFICATION WILL ALLOW FOR THE SIMULTANEOUS SEEDING OF THE DIFFERENT MIXES AND ALLOW FOR DIFFERENT BID PRICES FOR EACH MIX.

Warm Season Grass Seeding, Type 1 shall be as follows:

Seed Application Rate Per Acre	Percent Min. Purity	Percent Min. Germination	Min. Pounds of PLS
Switchgrass (*Panicum virgatum*)	95	80	Drill = 15 Hydroseed = 25 Broadcast = 25
Deertongue (*Panicum clandestium* = *Dicanthelium clandestium*)	95	75	Drill = 8 Hydroseed = 12 Broadcast = 12

Variety Type:

Panicum clandestium: variety "Tioga"

Panicum virgatum: variety "Cave-in-Rock"

OPTIONAL: **(c) Genetic/Elevational/Exposure Origin:**

THIS SEGMENT OF THE SPECIFICATION DESCRIBES THE GEOGRAPHICAL AND HABITAT ORIGINS OF THE SOURCE MATERIALS AND WILL HAVE TO BE PROVIDED BY THE USER.

The genetic stock shall be chosen to provide typical forms of the species and include the capacity to bear fertile fruits, as approved by the Department.

(d) Water: Water shall be fresh water that is free from toxic substances and chemicals that may be injurious to plant growth. Hoses and other watering equipment required to

transport and place water as required on the seeding area shall be included as part of the work in this section.

(e) Soil Testing: Soil tests shall be made to determine the soil gradation; nitrogen (ammonia, nitrate, and Kjeldahl nitrogen), phosphorous, potassium, magnesium, calcium, manganese, and zinc levels; and soluble salts, pH, buffer pH, and organic matter. Soil tests shall be conducted at a State agricultural laboratory or recognized commercial laboratory, subject to approval by the Engineer. The procedures and materials utilized in collecting the samples shall be as recommended by the laboratory. All laboratory results shall be forwarded to the Engineer. If the soluble salts exceed a value of 0.5 mmhos/cm (measurement of electrical conductivity in millimhos/centimeter) or the pH is lower than 5.0 or greater than 8.0, the Contractor shall immediately inform the Engineer to determine the proper action. *(NOTE: THE TESTING REQUIREMENTS SHOULD REFLECT REGIONAL CONCERNS, AND THE TESTS AND PARAMETERS GIVEN ABOVE MAY HAVE TO BE MODIFIED.)*

Each tested sample shall involve compositing six (6) to eight (8) soil locations, collected randomly over the entire seeding area, utilizing a soil probe. The soils shall be sampled to a depth of eight (8) inches. The Contractor shall perform one (1) soil test per each ten (10) acres of planting area with a minimum of three (3) tests per site. If the in-place soils are derived from different sources, each source shall be analyzed separately at the same sampling rate or at a rate determined by the Engineer.

When directed by the Department, the placement of lime, iron sulfate, ammonium phosphate sulphate, or other amendments shall be done according to and paid under Section XXXXXX - Soil Amendments. Unless authorized in writing by the Department or as shown on the plans, no other amendments shall be placed.

Unless specified on the plans, the laboratory conducting the soil tests shall forward recommendations for soil amendments based on a target pH of _____ (*INSERT APPROPRIATE VALUE*). If other soil amendments are authorized by the Department, such amendments shall be added as recommended by the soil testing laboratory. The payment for the placement of these other amendments shall be negotiated prior to the work.

(f) Fertilizer: The recommendations of a soil fertility test for phosphorous and potassium based on a 100-bushel corn yield shall be used to determine the application rate for these nutrients.

In lieu of a soil test, as waived only by the Department and only when authorized by the Department, a commercial fertilizer shall be applied in accordance with the specifications herein. This fertilizer shall have a composition by weight of an approved equivalent of:

TYPE 1: 0-20-20
Nitrogen, N, zero percent (0%)
Available Phosphoric Acid, P_2O_5, twenty percent (20%)
Water Soluble Potash, K_2O, twenty percent (20%)

TYPE 2: 10-20-20
Nitrogen, N, ten percent (10%), 50% by weight of the nitrogen content available from ureaformaldehyde (slow release)
Available Phosphoric Acid, P_2O_5, twenty percent (20%)
Water Soluble Potash, K_2O, twenty percent (20%)

The guaranteed analysis for Fertilizer Type 2 shall have a minimum of fifty percent (50%) of the total nitrogen derived from ureaform, furnishing a minimum of twenty-five percent (25%) cold water insoluble nitrogen at twenty-five degrees (25 ^oF), a minimum activity index of forty percent (40%), and a minimum of three and one-half percent (3.5%) urea nitrogen.

Fertilizers shall be packed in the manufacturer's standard packaging weighing not over 100 pounds each. The name of the material, the net weight of the contents, and the manufacturer's name and guaranteed analysis shall appear on each package. The manufacturer's label of guarantee of analysis indicating compliance with these specifications shall form the basis of acceptance. The Engineer reserves the right to reject any material that has become caked or otherwise damaged.

If the fertilizer is not used immediately after delivery, it shall be stored in a dry place in such a manner that its effectiveness will not be impaired.

NOTE: THE USER MAY WISH TO MODIFY THE FERTILIZER SELECTION, AS THERE ARE A NUMBER OF OTHER FORMULATIONS AND MATERIALS THAT SATISFY THE REQUIREMENTS OF THE WORK.

(g) Legume Seed Inoculant: When legumes are included in the seeding mix, a legume inoculant shall be utilized in the seeding program. This inoculant shall be a pure live culture of nitrogen-fixing bacteria selected for maximum vitality and for the ability to transform nitrogen from the air into soluble nitrates and deposit them in the soil. All containers of inoculant shall be fresh and unopened, with the manufacturer's expiration date. Inoculant shall not be used later than the expiration date indicated on the container. The type of inoculation shall be targeted at the legumes within the mix, as indicated on the inoculant packaging, as determined by the Engineer. The Contractor may elect to ask the Engineer to supply a list of appropriate inoculants to the Contractor. If an appropriate inoculant is not identified on the plans or by the Engineer, the Contractor shall not be responsible for ensuring that the inoculant is appropriate for the legume selection.

(h) Dye: When a hydroseeder is utilized, a blue or green water-soluble dye shall be provided that has been specifically manufactured for use in a hydroseeder and suitable for mixing with lime, fertilizer, seed and wood fiber mulch at the manufacturer's suggested rate. The dye shall be miscible with all normally available water when diluted to any proportions and shall contain no germination or growth-inhibiting properties.

The materials shall be delivered in packages of uniform weight that shall bear the name of the manufacturer, the net weight, material analysis, and the supplemental statement of the net weight content in the form of certification.

(i) Herbicide: Unless indicated on the plans, the herbicide shall be a glyphosate herbicide that has been approved for use in aquatic systems by the U.S. Environmental Protection Agency. The Contractor shall submit to the Engineer, in writing, the name of the herbicide, its manufacturer, and additional information that describes its proper use, application rates, residence time, usage precautions and restrictions, and the method and equipment proposed for its application, at least one (1) month prior to its use. The Contractor shall also submit evidence that the Contractor, or his/her designated agent, is certified/licensed/permitted by ____ *(INSERT REGULATORY AGENCY)* to handle and apply the herbicide at the work site. The Engineer reserves the right to deny the use of the herbicide at any time, including the method and equipment used for its application.

(j) Hydroseeder: The hydroseeder shall have a minimum 1,500-gallon capacity with a minimum of one paddle agitator shafts extending horizontally through the tank. The number and dimensions of the paddle agitator shafts shall be in conformance with the manufacturers recommendation for the model of hydroseeder utilized, as determined by the Engineer. The paddle shafts shall be capable of mixing and maintaining a homogeneous slurry of water, wood fiber mulch, fertilizer, seed, lime, and all other specified slurry components. To help ensure a homogenous slurry, this mechanical agitation system shall be capable of mixing in two directions simultaneously or be reversible. The agitation system shall be capable of keeping all the solids in a state of complete suspension at all times during the seeding operations. The hydroseeder shall have a minimum eighty- (80) horsepower engine and must be able to discharge through a hose or a spray tower at a continuous and consistent rate. Recirculating-type slurry agitation, as the primary means of mixing, shall not be acceptable. If recirculation agitation is present, the recirculation shall be limited to no more than fifty (50) gallons per minute. The Engineer may authorize the use of a smaller capacity hydroseeder if it is demonstrated that such equipment is capable of performing all operations satisfactorily. Hydroseeding equipment shall meet all Federal, State, and local codes for backflow prevention during loading operations. ***OPTIONAL SENTENCE:*** The hydroseeder shall be equipped with a fiber mulch shredder designed specifically for preshredding commercially produced wood fiber mulches.

OPTIONAL PARAGRAPH (USE WITH CAUTION): The hydroseeder shall be equipped with a positive displacement pump (progressing cavity pump) to extend the range of the seeding application, as manufactured by Moyno Industrial Products, Division of Robbins and Myers, Inc., Springfield, OH, or an approved equivalent. The positive displacement pump utilized shall be as recommended by the pump manufacturer for use with the specific hydroseeder being employed and shall result in extending the range of the hydroseeding distance a minimum distance of 1,000 feet with proper hose usage.

(k) Range Drill: The range drill shall be of a type specifically designed for use with warm-season grasses such that the grass seed will not clog or be damaged by the drill and will

remain thoroughly mixed when spread. The drill shall be capable of seeding both fluffy seeds and chaffy seeds and mixtures of different seed types, sizes and shapes, simultaneously. ***OPTIONAL SENTENCE:*** The drill shall be capable of supporting simultaneously three different seed box types, including fluffy seeds and chaffy seeds, as described by the drill manufacturer and as determined by the Engineer. The drill shall be fitted with depth bands and packer wheels to ensure that the seeds are placed in a firm seed bed at a depth of 0.25 to 0.5 inches, covered by a minimum of 0.25 inches of soil, and will firm the soil around the grass seed after placement.

(l) Lightweight Harrow: The harrow shall be a lightweight chain harrow with a draw bar. A heavier harrow may be required for site preparation. A tine harrow attached to a draw bar shall be an acceptable substitute, provided the design of the tines allows them to be turned upward during the dragging operations. If the Contractor can demonstrate to the satisfaction of the Engineer that a modified section of chain-link fence measuring three (3) feet wide by six (6) feet long and attached to a drawbar can be utilized in conducting the dragging work, as herein specified, the Engineer may allow the use of the chain- link fence. At any time, the Engineer may withdraw permission for the use of the chain-link fence and require the use of a harrow without any additional compensation to the Contractor.

(m) Mower: The mower shall be a flail-type shredder or mower, minimum 12-foot cutting width, equipped with a minimum of sixty (60) pairs cupped-type or side-slicer cutting blades, evenly spaced. If capable, the machine setup shall include center-cut blades. The mower shall have a minimum cutting height of three (3) inches and an allowable cutting height of at least ten (10) inches. The mower shall be capable of being attached to a three-point hitch.

Construction Methods:

(a) General: The seeding methodology shall either be hydroseeding, drill seeding, or broadcast seeding as shown on the plans. If no method of seeding is shown on the plans, the area shall be broadcast seeded. With the permission of the Engineer, hydroseeding or drill seeding shall be allowed. The method and option utilized in site preparation shall be as shown on the plans. If no site preparation option is indicated on the plans, site preparation shall be done under Option 2 - Fall Cultivation.

The Contractor must examine the area and conditions under which work is to be performed. The area must be properly prepared before seeding begins. The Engineer is to be notified in writing of conditions detrimental to the proper and timely completion of the work. The Contractor shall identify those areas that are detrimental for seeding and consult with the Engineer to determine corrective actions. Seeding work is not to proceed until the condition is either corrected or a waiver is granted from the Engineer. Unless directed by the Engineer, no seeding shall occur until all the soil testing results have been reviewed by the Contractor, the Seeding Subcontractor (if applicable), and the Engineer.

All seeding operations shall be initiated and completed within the seeding window shown on the plans or as specified herein. The work shall not be started until all earthwork in the area

requiring seeding has been completed. Seeding or soil tracking/firming shall not be done during periods of rain, severe drought, high winds, excessive moisture, frozen grounds, or other conditions that preclude satisfactory results. All seeding is to be done in moderately dry to moist (not flooded) soil and at a time when the wind does not exceed a velocity of ten (10) miles per hour, or as directed by the Engineer.

Following installation, seeded areas shall not be disturbed in any manner by vehicular, foot, or other traffic other than specified herein or approved by the Engineer. Particular care shall be taken to ensure complete and accurate coverage at the prescribed rates. Proper predetermined quantities of the seeding mixture in accordance with the specifications shall be used to cover all specified or designated seeding areas. Any area inadequately covered, as solely determined by the Engineer, shall be retreated at no additional cost to the Department.

(b) Site Preparation: Areas to be seeded shall be maintained at approved grades. All mechanical equipment for soil preparation or seeding shall be as approved and shall pass parallel to the contours unless otherwise approved. The site preparation option utilized shall be as shown on the plans.

Areas shall be tilled to a depth of six (6) inches by disking or plowing and smoothed/firmed by harrowing or dragging. For all areas, if the grading has just been completed and the soil is loose and friable, not eroded or crusted, the tilling step may be omitted if so approved by the Engineer. The soil shall be left in this scarified condition and shall not be smooth-rolled. The Contractor shall be responsible for performing all work necessary to achieve and maintain an acceptable seed bed prior to seeding as directed by the Engineer at no additional cost to the Department. Rocks, debris, and all other objects that would be detrimental to mowing shall be removed and disposed of as approved.

(1) Option 1 - Herbicides: Under this option, tillage and firming shall occur during the period between _____ (*INSERT DATES) (NOTE: MID-TO-LATE SUMMER FOR BEST CONTROL OF MANY COOL SEASON SPECIES).* Three (3) weeks after firming, the live vegetation shall be treated with an approved glyphosate herbicide with the requirement that this treatment occur during the period from _____ (*INSERT DATES, EARLY FALL).* Other than the specified dragging operations, do not further cultivate the soil. The following spring between the period _____ *(INSERT DATES),* the site shall again be treated with a glyphosate herbicide as directed by the Engineer. Seeding operations shall be initiated no earlier than ten (10) days following completion of the spring herbicide treatment and no later than twelve (12) days. All seeding operations shall be completed within fourteen (14) days following spring herbicide treatment. The Contractor shall notify the Engineer at least twenty-four (24) hours prior to each herbicide application and shall indicate the hours of application; late afternoon applications are preferred.

The method utilized to handle and apply the herbicide at the site shall conform to all applicable Federal, State, and local regulations and guidelines. The rate of herbicide application shall be in accordance with the manufacturer's recommendations for full-dose treatment, as approved by the Engineer or as shown on the plans. The herbicide shall not be applied during periods of

winds over five (5) mph, during rainy weather, or within seventy-two (72) hours of anticipated rain. Only within those areas specified on the plans, or as solely determined by the Engineer, shall the approved herbicide be applied. Following any application of the herbicide, no activities are to be conducted on the site for a minimum of seventy-two hours (72) hours or longer, as determined by the Engineer. The Contractor shall be responsible, at his/her own expense, for restoring, to the satisfaction of the Engineer, any area outside of the designated areas specified on the plans that is injured by the use of a herbicide.

NOTE: THE HERBICIDE OPTION PRESENTED IS TARGETED AT RECENTLY ABANDONED AGRICULTURAL FIELDS. DENSE PERENNIAL TURFS MAY REQUIRE A FULL YEAR OF SITE PREPARATION EITHER VIA CULTIVATION OR HERBICIDE APPLICATION. ONE SHALL REFER TO THE DISCUSSION AND RATIONALE.

(2) Option 2 - Fall Cultivation: Under this option, tillage and site preparation shall occur during the period from _____ *(INSERT DATES) (NOTE: THIS ASSUMES THAT THE SOILS WILL BE TOO WET TO WORK IN THE SPRING*). Two (2) weeks after firming, the seeding area shall be dragged to remove any existing live vegetation and emerging seedlings. The dragging operation shall be performed utilizing a lightweight harrow with drawbar as specified in **Materials** above. The lightweight harrow shall be dragged across the site no faster than four (4) mph to remove emerging plants/seedlings. The lightweight harrow shall be operated in a manner that will minimize the turning of soil, maximum tillage depth of one (1) inch. The seeding area shall be dragged during the remainder of the growing season by the specified method at no greater than two (2)-week intervals and no less than three (3)-week intervals. At the end of the growing season (*OR INSERT DATE*), as determined solely by the Engineer, the site shall be dragged regardless of plant height. This work shall conclude the fall dragging requirements.

Beginning _____ (*INSERT SPRING DATE*), the site shall again be dragged on two (2)-week intervals to remove new plant growth in the same manner as described above. Wet soil conditions may preclude the dragging operations, as confirmed by the Engineer.

The actual seeding shall not occur until at least three (3) spring dragging operations have been performed. When required, this dragging requirement shall continue on two (2)-week intervals until the specified seeding window opens and the seed is sown.

(3) Option 3 - Spring Cultivation: Under this option, tillage and site preparation shall occur during the period from _____ *(INSERT DATES)* or as indicated on the plans. (*NOTE: THIS ASSUMES THAT THE SOILS WILL NOT BE TOO WET TO WORK IN THE SPRING OR LATE SPRING*). Two (2) weeks after firming, the seeding area shall be dragged to remove any existing live vegetation and emerging seedlings. The dragging operation shall be performed utilizing a lightweight harrow with drawbar as specified in **Materials** above. The lightweight harrow shall be dragged across the site no faster than four (4) mph to remove emerging plants/seedlings, maximum tillage depth of one (1) inch. The lightweight harrow shall be operated in a manner that will minimize the turning of soil. Until

the area is sown with the specified seed, the seeding area shall be dragged during the remainder of the growing season by the specified method at no greater than two (2)-week intervals.

The actual seeding shall not occur until at least three (3) spring dragging operations have been performed. When required, this dragging requirement shall continue on two (2)-week intervals until the specified seeding window opens and the seed is sown.

(c) Seed/Inoculant Handling: During all operations including Contractor storage, seeds and seed bags shall be kept covered, shaded, and out of direct sunlight. Seeds shall not be stored or temporarily stored in locations or vehicles where the temperature will be in excess of 90 ^{o}F. Legume inoculant shall be refrigerated until immediately prior to use. At no time shall the inoculant be exposed to direct sun or temperatures in excess of 70 ^{o}F. Inoculation of the seed shall occur immediately prior to commencing the seeding operation. If approved by the Engineer, inoculation may occur within a window twenty-four (24) hours prior to the seeding with the requirement that the seed be temporarily stored at a temperature of less than 75 ^{o}F. For all seeding protocols, inoculant shall be utilized at five times the rate indicated on the packaging.

(d) Seeding: Seeding operations shall be initiated and completed within the period between _____ (*INSERT DATES*) or as indicated on the plans. *OPTIONAL SENTENCE UNDER A SPRING WINDOW:* Within this seeding window, seed operations shall be performed only if the soil temperature is greater than 55 ^{o}F. Regardless of the site preparation option or plant height, during the two (2)-day period prior to the seed placement, the seeding area shall be dragged, as specified under Option 3 - Spring Cultivation. All dragging operations are incidental to this work. No dragging operations shall occur after the seeding. The Contractor shall notify the Engineer at least forty-eight (48) hours in advance of the time he/she intends to begin sowing seed and shall not proceed with such work until permission to do so has been obtained. When delays in operations carry the work beyond the dates that are specified in the schedule or when conditions of high winds, excessive moisture, or ice are such that satisfactory results are not likely to be obtained at any stage of the work, the Engineer shall stop the work. The work shall be resumed with the Engineer's approval when the desired results are likely to be obtained or when approved corrective measures and procedures are adopted.

(1) Option 1 - Hydroseeding: The Contractor shall apply the seed and fertilizer by mixing them in an aqueous solution. The application of the seed through hydroseeding shall be completed using a hydroseeder as specified in **Materials** above. If no rate for hydroseeding is specified or shown on the plans, hydroseeding operations shall be conducted at 1.5 times the rate shown on the plans or as specified. Dye shall be added to the seed slurry according to the dye manufacturer's suggested rate or as approved by the Engineer.

The seed and dye and, if required, the legume inoculant shall be added to the hydroseeder after the unit has been completely filled with water and the agitation is fully functioning. Following this placement, fertilizer shall then be added to the tank. A minimum of 1,000 gallons of water shall be required per acre. The mixture should be continuously agitated from the time it is

mixed to the time it is applied. If fertilizer is added to the seed slurry, the seed slurry shall be applied within ninety (90) minutes after mixing to avoid damage to the seed or the inoculant by the fertilizer. If more than ninety (90) minutes pass before the hydroseeding operation is initiated, the Contractor shall inform the Engineer and will not commence seeding operations until the Engineer either approves or denies the use of the seed slurry; new inoculant shall be added at the same rate as previously utilized. If the Engineer denies the use of the slurry, the Contractor shall not be reimbursed for cost of material and labor, including disposal of the seed slurry.

NOTE: THE TIME-LIMIT RECOMMENDATION FOR THE SEEDING SLURRY MAY NEED TO BE MODIFIED. KNOWLEDGEABLE RECOMMENDATIONS VARY WIDELY AND RANGE FROM THIRTY (30) MINUTES TO ABOUT TWENTY-FOUR (24) HOURS. THE NINETY (90)-MINUTE WINDOW WAS CHOSEN AS THIS IS ABOUT THE MAXIMUM CIRCULATION VOLUME THAT CAN BE RECOMMENDED WITH A RECIRCULATION RATE OF FIFTY (50) GALLONS PER MINUTE.

Immediately after hydroseeding, the soil shall be firmed by a heavy-tracked crawler, such as a heavy bulldozer. Equipment with excessively worn tracks/growsers or low ground pressure equipment shall not be utilized, as solely determined by the Engineer. The Engineer shall be the sole judge of the suitability and required weight of the equipment to perform this work. At the direction of the Engineer, heavier equipment or equipment with less worn tracks/growsers shall be provided at no additional cost to the Department.

Firming with a tracked crawler shall be performed so that the entire area is covered in tracks. This will require that Contractor conduct offset passes with the crawler. Slopes shall be tracked in the direction parallel to the slope and not perpendicular (from the top of the slope to the bottom of the slope). Unless directed by the Engineer, firming of the soil may be done with the minimum number of passes of the crawler while at the same time satisfying the tracking requirements. If the seed bed has not been properly tracked, as solely determined by the Engineer, the Engineer may require additional passes of the firming equipment at no additional cost to the Department.

(2) Option 2 - Range Drill: The application of seed using a range drill shall be completed by using a warm-season range drill as specified in **Materials** above. Seed shall be placed in the appropriate seed box for proper sowing. The seed shall be planted at the rate specified on the plans and at a depth no less than 0.25 inches and no greater than 0.5 inches. Seed shall be planted in two directions perpendicular to each other. Half of the seed shall be planted in each direction.

(3) Option 3 - Broadcast Seeding: With the approval of the Engineer, the Contractor may elect to broadcast the seed at the specified rate. The method of broadcasting the seed shall result in all individual elements of the seed mix being evenly sown at the specified rates across the entire seeding area. Uneven seedings shall not be accepted. The method and equipment used for broadcasting the seed shall be subject to approval by the Department. At

any time during the seeding operation, the Engineer may elect to withdraw permission for broadcast use and require the Contractor to utilize the method indicated on the plans.

Following seed placement, the seeded area shall be firmed and tracked as under **Option 1 - Hydroseeding** with tracking equipment and procedures conforming to the specifications herein, as solely determined by the Engineer.

OPTIONAL: **(e) Initial Watering:** The Contractor shall thoroughly water newly seeded areas immediately upon installation at the rated of 25,000 gallons per acre, unless indicated on the plans or directed by the Engineer. A second thorough watering shall occur two (2) weeks after seed installation, unless indicated on the plans or directed by the Engineer. The Contractor shall avoid creating rills and furrows as a result of watering. The Contractor shall be responsible for repairing and reseeding any rills or furrows caused by overwatering at the Contractor's own expense.

NOTE: THE NUMBER OF INCIDENTAL WATERINGS MAY NEED TO BE MODIFIED. WATERING OF SEEDED AREAS CAN BE HANDLED IN A VARIETY OF WAYS. SOME ORGANIZATIONS REQUIRE WATERING UNTIL THE STAND IS FULLY ESTABLISHED AND ACCEPTED WITH ALL COSTS INCIDENTAL TO THE BID PRICE. OTHERS EXTEND THE NUMBER OF INCIDENTAL WATERING APPLICATIONS TO THREE OR FOUR. HAVING A SEPARATE BID ITEM FOR WATERING, TO BE INITIATED BY THE ENGINEER, IS NOT UNCOMMON, AND ITS INCLUSION MAY BE PRUDENT FOR SOME PROJECTS.

(f) Mowing: At the beginning of the second year, the seeded area shall be mowed once to a height of between eight (8) and ten (10) inches during the period from _____ *(ENTER SPRING DATES)*. This mowing shall occur prior to the green-up by the warm-season grasses. This initial spring mowing shall be accomplished with a flail mower, as specified in **Materials**. At the direction of the Engineer, additional flail mowing treatments shall be conducted across the designated areas at the height designated by the Engineer and at the agreed upon bid price for Section XXXXXX - Mowing and Maintenance.

NOTE: IF COOL SEASON WEEDS START TO DOMINATE THE SEEDING, A MOWING REGIME TO KEEP THE HEIGHT UNDER ONE (1) FOOT MAY HAVE TO BE ESTABLISHED. THEREFORE, IT MAY BE DESIRABLE TO CONDUCT MOWING, WATERING, AND RAKING OPERATIONS UNDER A DIFFERENT PAY ITEM OR UNDER A SEPARATE MAINTENANCE CONTRACT .

(g) Fertilizing: The recommendations of a soil fertility test for phosphorous and potassium based on a 100-bushel corn yield shall be used to determine the application rate for these nutrients. Soil testing shall follow the guidelines described under **Materials**.

When utilizing a hydroseeder, the fertilizer may be incorporated in the seeding slurry. For drill seeding or broadcast seeding, fertilizer shall be uniformly broadcast at the rate recommended by the soil tests prior to the seeding. Unless specified on the plans, the fertilizer shall not be

incorporated into the soil. In lieu of a soil test, as waived only by the Department and only when authorized by the Department, 400 pounds per acre of a commercial fertilizer shall be applied in accordance with the specifications herein. Unless authorized by the Department, the fertilizer used during the first year shall be Type 1 fertilizer and contain no nitrogen. Fertilizing during the second year shall occur between June 15 and July 1. In lieu of soil tests, Type 2 fertilizer shall be uniformly spread at the rate of 400 pounds per acre. A maximum of forty (40) pounds of nitrogen per acre shall be applied with this application.

(h) Acceptance of Seeding Work: Seeded areas shall be maintained by the Contractor until the work has received initial acceptance. Additional maintenance requirements may be detailed in other provisions and specifications of the Contract. Maintenance shall consist of the repair of areas damaged by erosion, wind, fire, and unauthorized access. The soil in such damaged areas shall be restored to specified condition and specified grade and shall be reseeded to the satisfaction of the Engineer.

Initial acceptance of the seed installation shall not occur until at least four (4) weeks following completion of the seeding operation. Acceptance of the seed installation by the Engineer shall be based on proper site preparation, installation, and satisfactory completion of required watering. Those areas that fail the inspection shall be reseeded at the Contractor's expense with no additional cost to the Department.

(i) Damaged Areas: All areas outside of specified limits where the vegetative growth has been injuriously disturbed or destroyed by the Contractor, as solely determined by the Engineer, shall be restored and seeded in accordance with these specifications by the Contractor at his/her own expense.

Method of Measurement:

The unit of measurement for payment for Warm-Season Grass Seeding, Type ____ shall be the total number of square yards of surface area actually prepared, seeded, fertilized, mowed, and accepted in accordance with the plans and specifications or as directed by the Engineer. Measurements will be made on the ground surface of accepted individual seeded areas.

Basis of Payment:

Payment for Warm-Season Grass Seeding, Type ___ shall be made at the Contractor's unit bid price per square yard for Warm-Season Grass Seeding, Type ____ and shall include full compensation for furnishing and placing all materials, including, but not limited to, seed and fertilizer, the cost of all labor, tools, equipment, water (if any), and any incidentals necessary to complete this work in accordance with the plans, specifications, and directions of the Engineer. The Engineer shall allow for eighty (80) percent payment following initial acceptance of the seed installation. The remaining twenty (20) percent shall be paid upon final acceptance of all the required work, including the required second year mowing.

Appendix E

Contract Growing and Seed Collection

Description:

Contract Growing and Seed Collection shall consist of furnishing the specified plants or seeds, as hereinafter specified, and the delivery of the plant or seed to a designated location or as directed by the Engineer.

Materials:

(a) Plants: Unless authorized by the Department, all stock shall be nursery grown. All plants shall conform to all sizes and measurements detailed in these specifications. With the approval of the Department, plants larger in size than specified may be utilized, but such plants shall not increase the contract price.

The growing cells and containers for the stock shall be as indicated in the specifications or as attached. Growing media shall be as detailed in these specifications or as attached. If the growing media are not specified, the Contractor shall forward the formula for the growing media to the Department for approval within 10 days of the award of the contract.

INSERT THE APPROPRIATE MATERIAL DESCRIPTIONS FROM OTHER RELEVANT SPECIFICATIONS IN THIS MANUAL AND OTHER SOURCES. PLEASE VERIFY SEED AGE REQUIREMENT.

(b) Seeds: Seeds shall be supplied on the basis of Pure Live Seed (PLS). These seeds shall be supplied as single species, partial seed mixes, or full seed mixes, as specified. Seed mixes shall be collected from an approved genus/species list with minimum PLS percentage standards for each of the various groupings. When specified, the seed shall conform to the minimum percent purity, minimum percent germination, and maximum weed seed percentage requirements. Species groupings may be defined by taxonomic groupings or seed size/type for use in drill seeding operations. Unless authorized by the Department or shown on the plans, the seed shall be this year's crop (less than one (1) year old). Until authorized in writing by the Department, individual seed source populations, species groupings, or collection locales shall be stored in separate bags or containers.

With moist or wet stored/shipped seed, the Contractor shall estimate the number and cubic volume of dry seeds per pound prior to initiating moist or wet storage. If requested, this information shall be made available to the Engineer.

Unless written authorization is obtained from the Department, the use of seeds derived from commercially available sources or second parties, as solely determined by the Department, shall be prohibited.

Pure Live Seed is defined by the following formula:

PLS = (Percent Purity of the Seed × Germination Percentage)/100

All seed shall be cleaned/threshed/screened to remove the fruiting bracts, scales, perigynia, floral parts, awns, and other nonseed debris. No compensation for damage to the seed because of improper cleaning, threshing, or screening operations shall be made by the Department. The Contractor shall be solely responsible for the proper storage of the seed according to best seed storage practices.

Analysis sampling and testing of the seed and seed tag labeling requirements shall be done in accordance with the *Insert State Regulations, Office, or Code* and with the Rules and Regulations for Testing Seeds adopted by the Association of Official Seed Analysts. A certified report from an approved seed testing laboratory for each species or species grouping shall be required. This report shall include results from tests for purity, viability, and weed seed content of representative samples. Each specified species or species grouping shall be individually tested. The results of this testing shall be forwarded to the Engineer.

Following the results of the seed tests and with the written authorization of the Department, seeds or species groupings may be combined into a mix, or the Department may require that the individual species or species grouping be delivered in individual bags. The composition of any mix shall be as specified.

Seeds shall be fresh, free of deleterious material, and delivered to the site in the original, unopened bags or sealed bins showing a certified net weight, date of germination tests, supplier's name and certified guarantee of analysis including the composition, purity, and germination percentages, and percent weed seed. In those instances where the delivered seed is a species grouping mix, the Contractor should be aware that a second germination test, as specified above, may be required to satisfy the seed labeling requirements and applicable seed labeling laws. Seed shall conform to applicable State and Federal regulations in effect on the date of invitation bids. At the time of delivery, the germination test shall be less than nine (9) months old. Live seeds of crop plants other than those specified shall not be utilized. Unless otherwise specified, seed shall not contain in excess of one percent (1%) of weed seeds; none is desirable. The Department reserves the right to conduct germination tests for each bag. The Department's germination tests shall be the final determination of Pure Live Seed, germination percentage, and purity. It is the sole responsibility of the Contractor to provide Pure Live Seed. All storage requirements including fungicide treatments and stratification considerations shall be the sole responsibility of the Contractor.

OPTIONAL SENTENCE: Unless otherwise specified or agreed to in writing, all seed shall be stored cold/dry under nonheated conditions.

NOTE: IF REQUESTING STRATIFIED SEED, THE HANDLING PROCEDURES OUTLINED HERE MAY NEED TO BE REVISED AND AUGMENTED. AS WRITTEN, THE SPECIFICATION DOES NOT MANDATE DRY STORAGE OF SEED AND BY

DEFAULT ALLOWS FOR COLD-MOIST OR COLD-WET STORED AND SHIPPED SEED. EXCESSIVE DRYING OF STRATIFIED SEED MAY PLACE THE SEED IN DEEP DORMANCY THAT MAY BE DIFFICULT TO OVERCOME. PLEASE REFERENCE THE BROADCAST SEEDING SPECIFICATION.

(c) Genetic/Elevational/Exposure Origin:

THIS SEGMENT OF THE SPECIFICATION DESCRIBES THE GEOGRAPHICAL AND HABITAT ORIGINS OF THE SOURCE MATERIALS AND WILL HAVE TO BE PROVIDED BY THE USER.. PLEASE VERIFY NURSERY LOCATION.

Plants may be grown/propagated in nurseries outside of these geographical and elevational boundaries, subject to approval by the Department, but the immediate genetic origin of the materials must meet the above geographical and habitat requirements. The genetic stock shall be chosen to provide typical forms of the species and include the capacity to bear fertile fruits, as approved by the Department.

(d) Nomenclature: For the herbaceous wetland plants, *A Synonymized Checklist of the Vascular Flora of the United States, Canada and Greenland: Volume II; The Biota of North America* (Kartesz and Kartesz, University of North Carolina Press, 1980, or later edition) shall be the authority for the plant names. The Contractor shall supply certification from the suppliers that the plants supplied are the plants specified or agreed to under substitution. No compensation shall be made for materials or the cost of installation for plant species that are not specified.

(e) Submittals: Within 10 days of the award of the contract, the successful bidder shall forward in writing a complete listing of the proposed plants and/or seeds and their genetic origins to the following address:

INSERT COMPETENT REVIEWER, OFFICE FAMILIAR WITH THE PROJECT, OR THE DESIGN GROUP.

The Department will review these submitted materials. If deficient, as solely determined by the Department, additional information shall be forwarded to the Department. Any anticipated problems with obtaining any of the specified materials shall be forwarded in writing to the Department. The cause of the problem(s) shall be discussed in full. Suggestions concerning appropriate substitutions may be included with this correspondence; however, only the Department may approve such substitutions.

Within thirty (30) days of the award of the contract, two copies of a confirmed purchase order listing the quantity and species ordered shall be forwarded to the Engineer. At the same time, a third copy of the purchase order(s) shall be forwarded to the *INSERT COMPETENT REVIEWER OR OFFICE*, at the above address. Only after written approval of the genetic origin of the source material by the Department shall the Contractor initiate the propagation or collection of the source material.

Construction Methods:

(a) General: The Contractor shall be responsible for all certificates of inspection of plant materials that may be required by Federal, State, or other authorities to accompany shipments of plants or seeds. During all phases of this work, including storage, transport, and onsite handling, the plant materials shall be carefully handled and packed to prevent injuries. During storage, transit and onsite handling, the plant materials shall be kept from freezing and kept covered, moist, cool, out of the weather, and out of the wind and sun. Plants not properly transported, packed, or handled, as solely determined by the Engineer, may be rejected by the Engineer without compensation and shall be removed from the site by the end of each workday. Plants shall be watered to maintain moist soil and/or plant conditions until accepted.

(b) Inspection: The successful bidder shall furnish complete information as to the location of all plants and seeds which he/she intends to supply. The Department reserves the right to inspect, tag (seal), and approve all plants and seeds at the source of supply. This inspection and tagging shall not in any way eliminate the right of rejection at the time of delivery. Any materials not conforming to these specifications (including undersized stock) may be rejected by the Engineer without compensation to the Contractor. Any rejected materials shall be removed from the work site by the end of each working day.

(c) Transport and Packaging: *INSERT THE REQUIRED TEXT FROM OTHER RELEVANT SPECIFICATIONS IN THIS MANUAL AND OTHER SOURCES. TRANSPORT AND PACKAGING WILL GREATLY VARY BETWEEN MATERIAL TYPES.*

Method of Measurement:

Contract Growing, Plants shall be measured by the number of each plant accepted for the various bid items.

DELETE OR REVISE ONE OF THE FOLLOWING:

Contract Growing, Seeds shall be measured by the pounds of Pure Live Seed accepted for the various bid items.

Contract Growing, Seeds shall be measured by the number of Pure Live Seeds accepted for the various bid items.

Basis of Payment:

Payment for Contract Growing, _____ shall be paid for at the unit bid price each for the various items of the bid schedule accepted, which price and payment shall constitute full compensation for furnishing all plants, seeds, labor, materials, tools, equipment, delivery costs, and incidentals necessary to complete the item. No separate payment shall be made for accessory items as herein specified as necessary or required, but all costs thereof shall be included in the unit prices bid for the Pay Item.

Appendix F

Acorn Collection

Description:

The target of this acorn collection is the oak species *Quercus* _____. Common names for this species include *INSERT LIST*. Throughout the rest of this contract, the common name "_____ oak" will be equivalent to *Quercus* _____ .

Materials and Construction Methods:

The species concept of *Quercus* _____ shall follow the technical description found in *INSERT TAXONOMIC TEXT*.

The acorns of the white oak section, *Lepidobalanus*, mature at the end of the first season. This is in contrast to the red oak section, *Erythrobalanus*, where the fruit matures during the second year. *Quercus* _____ is in the ____ oak section.

This specification is broken into two segments. The first segment is termed Initial Mapping and Preliminary Report Preparation. The second is termed Acorn Procurement.

(a) Initial Mapping and Preliminary Report Preparation: The first segment of the work consists of the initial mapping and preliminary report preparation for stands of acorn-bearing _____ oaks in *INSERT LOCATION*, with strong emphasis on locations in *INSERT LOCATION*. The mapping will be done for the year specified. The goal of the mapping shall allow for the collection of the specified number of oak acorns that are sound, viable, and suitable for use as seeds under nursery or field planting conditions. In addition, a written report indicating the quantity and quality of the expected acorn crop, acorn viability, acorn disease, and insect damage and infestation, including infestation by acorn weevils (*Curculio*), shall be prepared for approval by the Department.

This report shall also include objective recommendations of the preparer as to the merits of conducting field operations, including access considerations, to harvest the acorns. By July 15 of the specified year, four (4) copies of the report and associated mapping shall be submitted to the Department for approval. The mapping and report preparation shall be done by a Professional Forester as recognized by the Society of American Foresters, or another professional person as approved solely by the Department.

The Department will then review the mapping and recommendations of the project report and make a decision on whether to authorize the second segment of the work, Acorn Procurement. If the Department decides not to authorize Acorn Procurement, no compensation for any labor, materials, or items incidental to Acorn Procurement shall be made by the Department.

(b) Acorn Procurement: This work shall consist of activities associated with the actual gathering of the specified acorns. This work shall be completed by December 1 of the specified year. No work associated with Acorn Procurement shall be initiated until after the Department reviews the results of the Initial Mapping and Preliminary Report Preparation and the Contractor has received written authorization by the Department to proceed with Acorn Procurement. No compensation for any labor, materials, or items incidental to Acorn Procurement shall be made unless this written authorization is given by the Department.

The following are deliverable items due by September 1 of the specified year:

1. Location mapping on USGS 7.5-minute series topographic quadrangles. The mapping should identity each of the collection sites with individual designations that can be easily referenced in the accompanying report and a short site description ¾ 6 copies.

2. A detailed report on the quantity and quality of the expected acorn crop and a full discussion of the merits of conducting field harvesting operations of the designated areas. This report shall fully reference the individual collection sites presented on the USGS mapping. The report shall also include a recommendation section as it relates to whether the gathering of the acorns is a viable, practical option—6 copies.

3. In addition, the Department may require two oral presentations of the report information.

If Acorn Procurement is authorized, the collection shall be done under the direction of the same Professional Forester or person who had prepared Initial Mapping and Preliminary Report Preparation. The collection of the acorns shall be done under the following guidelines (after F. T. Bonner 1993[1]):

1. The acorns shall be collected when absolutely mature. The acorns shall not be collected before full maturation. The best maturity indices are (A) nut color change from green to brown or mottled yellow-brown in most white oaks and from green to dark brown or black in most red oaks; and (B) easy separation of acorns from their cups without pressure. Together the nut plus the cup is the acorn. In southern red oak (*Quercus falcata*) and cherrybark oak (*Quercus falcata* var. *pagodifolia*), mature acorns may have greenish tint to the pericarp. White oak (*Quercus alba*) and swamp white oak (*Quercus michauxii*) may have yellow or mottled yellow and green pericarps.

2. If collected while on the tree, the cup scar, when the nut is first removed from the cap, should be bright in color. A dark or dull color indicates that the acorn is not fully mature. However, for ground-collected nuts and acorns, the presence of a bright color cup scar is not a useful indicator of maturity, as this scar will fade after only a few days on the ground. In overcup oak (*Quercus lyrata*), it will not be possible to examine the cup scar, as the cup surrounds most of the acorn and the dissemination is nut with cap.

[1] References cited in this appendix are listed in the References at the end of the main text.

3. Larval holes are a sign of insect infestation. If present, these acorns shall be cut open to check for internal infestation by the Professional Forester. If embryonic axes are not destroyed before planting, infested acorns can still produce seedlings. Evidence of heavy infestation means that the collection shall be extended to replace damaged acorns.

4. On the same day as gathering, the acorns shall be float tested. Float testing is accomplished simply by placing the acorns in large containers of fresh water and gently mixing or swirling the acorns. Some of the acorns will sink; others will float. Acorns that sink are considered "sound." Those that float are considered to be "unsound." The float test is applicable for all species of oaks except for *Quercus lyrata*, overcup oak. Viable, sound acorns of overcup oak will float.

5. The "sound" and "unsound" acorns shall be separated. All floating debris, litter, and insects shall be removed and discarded. The "sound" acorns shall be drained and dried of excess surface moisture and placed clean of soil and debris in four (4)- to ten (10)-millimeter polyethylene bags with no more than fifteen (15) pounds of acorns in a single bag. These polyethylene bags shall then be placed in perforated fiberboard containers or other containers approved by the Department. As gas exchange will occur during storage, the polyethylene bags and the fiberboard containers shall be loosely closed and not sealed airtight. The acorns must be able to "breathe." These acorns shall be clearly labeled as "Sound on First Day of Collection." Additional labeling shall indicate species, collection location, collection date, and ownership by the Department.

[Note: For white oaks, a thinner bag of approximately two (2) millimeters may be appropriate because of higher respiration rates.]

6. *OPTIONAL ELEMENT:* The "unsound" acorns shall be examined for the reason of their "unsoundness." If the Professional Forester or other authorized professional determines that moisture loss is the reason that a considerable portion of the acorns failed the initial float test, the "unsound" acorns shall be left floating for a period of twenty-four (24) hours to allow for the rehydration of the acorns. After the twenty-four (24)-hour period is over, those acorns that sank shall be reassessed for viability by the Professional Forester. If the Forester believes that these "sinkers" are viable, and with the approval of the Department, the acorns shall be processed in the same manner as the "sound" acorns, with the strong mandate that these acorns not be mixed with the "sound" acorns and that these acorns be labeled as "Floated on Initial Test, Sinkers after 24 Hours," with the additional labeling as above. However, at the sole discretion of the Department, the Department may reject these acorns without any compensation by the Department to the Contractor. If rejected, these acorns shall be removed from the collection site by the close of the working day. If rejected, these acorns shall not be shipped. Disposal of the rejected acorns will be the responsibility of the Contractor.

7. The viability of acorns is strongly influenced by the moisture content of the acorns. At full maturity, the acorns of the white oak section have a moisture content of about fifty percent (50%). After the moisture content drops below forty-five percent (45%), there will be a

decrease in the germination percentage. If the moisture content is reduced to thirty-five percent (35%) for white oaks, all acorns will become nonviable.

At full maturity, the acorns of the red oak section have a moisture content of about forty percent (40%). After the moisture content drops below thirty-five percent (35%), there will be a decrease in the germination percentage. If the moisture content is reduced to twenty-five percent (25%) for red oaks, all acorns will become nonviable.

Because of this concern for loss of moisture content, the acorns shall not be placed in warm, dry locations. At all times, the handling of the acorns shall be done in locations, and in such a way, that the acorns retain their moisture content and that the handling does not lead to desiccation of the acorns. The acorns shall not be exposed to the direct sun or temperatures above 65 °F. If required, acorns shall be sprayed with water and then drained. Unless shipped immediately after packing, the acorns shall be placed in cold storage at temperatures between 35 °F and 40 °F (1 and 3 °C). The place and manner of storage, including the way the containers are packed and stacked, shall allow for good gas exchange. If stored for more than one (1) week, all containers shall be checked weekly and any excess moisture found in the containers drained. However, the acorns shall not be exposed to freezing temperatures.

Acorns of the white oak section can be stored for only one (1) winter period (three (3) to four (4) months). White oak acorns stored for longer periods will not be viable. Acorns of the red oak section can be stored for as many as 3-5 years. However, with this prolonged storage, the germination percentage may be reduced by half.

8. Within three (3) days of gathering the acorns, the contractor shall ship the acorns to a seed-handling firm or nursery, as directed by the Department. This shipment shall arrive at the destination within three (3) calendar days. The method of shipment shall not cause any loss in the viability of the acorns. The shipment shall be done in such a manner that the acorns retain their moisture content and that the shipping does not lead to desiccation of the acorns. The acorns shall not be exposed to direct sun, wind, or temperatures above 65 °F or below 33 °F. The manner of shipment, including the way the containers are packed and stacked, shall allow for good gas exchange. If the acorns are damaged or lost during shipment, no compensation for the damaged or lost acorns shall be made by the Department. The method of shipment shall be subject to approval by the Department. The Contractor is solely responsible for ensuring that the acorns are shipped as directed.

9. Determination of the acceptance of the acorns for payment shall not be made by the Department until all acorns have been delivered and inspected at the designated seed-handling firm or nursery.

10. The Professional Forester or other approved professional shall prepare a detailed report concerning the field operations. This report will discuss the field operations, including observations on the quantity and quality of the crop, and any recommendations for future work. Six (6) copies of this report will be furnished to the Department.

Method of Measurement and Basis of Payment:

The Pay Items for this contract will be distributed among the following items as submitted in the contract bid:

(1) Initial Mapping and Preliminary Report Preparation shall be made at the Lump Sum price bid for this work. The price bid shall include the cost of furnishing all labor, equipment, reports, mapping, and other materials necessary to complete the work satisfactorily.

(2) Acorn Procurement shall be measured in pounds of viable acorns as accepted by the Department. The payment for this work shall be made at the contract unit price per pound of viable acorns, as accepted, shipped, and specified in the contract, which price and payment shall constitute full compensation for furnishing all labor, equipment, materials, tools, shipping costs, reports, mapping, and incidentals necessary to complete the work.

Appendix G

Professional Forester

Description:

This work shall consist of providing technical support for reforestation projects conducted by the Department. This work may include, but is not limited to, scheduling material shipments, material acceptance, material transport and handling, supervision of cold storage operations, construction of field stockpile sites, tree tending, planting tool and planting bag inspection, supervision of planting crews, plant water supply, acceptance of the plantings, and acceptance of tree protection, when specified, under Section XXXXXX - Forestry Planting or Section XXXXXX - Reforestation.

All work shall be done according to best forestry practices, as solely determined by the Department. All work is subject to approval and direction by the Engineer.

Definitions:

A Forester shall be defined as an individual who has at a minimum a bachelor's degree in forestry from an approved institution and program as recognized by the Society of American Foresters. All Foresters shall be subject to approval by the Department.

The Chief Forester shall be defined as the principal forester as identified in the contract bid and as approved by the Department.

Materials:

All tarps, equipment, tools, materials, and incidentals necessary to complete this item shall be subject to approval by the Engineer. Substandard items, as solely determined by the Engineer, shall be removed from the site by the close of the working day. Specialized equipment may be required, as specified on the plans or in the bid documents.

Transport of materials will likely require the use of four (4)-wheel-drive vehicles equipped with appropriate off-road tires and capped transport beds. If directed by the Engineer, such vehicles shall be utilized without additional compensation by the Department. Smaller all-terrain vehicles may be useful for onsite transport. Regardless, the Contractor shall have a sufficient number of vehicles of the capability to transport the materials and efficiently supply the planting crews with trees, as solely determined by the Engineer.

Thermal-reflective tarps (heat shields) shall have one side of the tarp manufactured of a white-faced material and one side with a highly reflective metallic finish. The minimum size for the tarps shall be nine (9) feet by fifteen (15) feet. At no additional charge to the Department, the

Department may require the use of thermal-reflective tarps specifically designed or advertised for forestry use. Tightly woven or coated tarps may be used for the construction of wind barriers.

A sufficient quantity of nominal two (2)- by four (4)-inch lumber and/or polyvinyl choride (PVC) piping shall be provided for the construction of the field stockpiling sites required for efficient planting operations.

Water required for the plant stock and to maintain the proper moisture levels in the planting bags shall be fresh water free from toxic substances and chemicals injurious to vegetation. All water sources are subject to approval by the Engineer. Brackish water shall not be used.

Except for the actual planting tools, planting bags, and tubling carriers, all tools necessary for the reforestation project shall be supplied by the Contractor. If wire cutters are required for the opening of the shipping containers, these cutters shall be supplied by the Contractor.

Construction Methods:

(a) General: All work shall be performed in such a manner as to result in an efficient planting program and efficient support of the planting crews. The Contractor is responsible for providing all transport and vehicles required to complete all work required under this item.

The Chief Forester may direct a crew to work under his/her supervision. If the number of Foresters under the direction of the Chief Forester is not sufficient to direct the planting operations as specified, as solely determined by the Engineer, additional qualified individuals shall be hired by the Contractor at no additional cost to the Department.

A key responsibility of the Contractor shall be the proper tending of the planting stock throughout all phases of the reforestation program and the watering of the stock when required. During all work including plant transport, offsite or onsite storage, and on-site plant handling, the plant material shall be carefully handled to prevent injuries to and desiccation of the materials. The plants shall be kept from freezing, kept covered, kept moist, kept cool, and kept out of the wind and sun.

(b) Submittals: If the Contractor possesses a record of successful forest plantings that have received final approval by the U.S. Army Corps of Engineers, U.S. Forest Service, or a State forest service, comments concerning the appropriateness of the various plantings, composition of the planting blocks, planting techniques, and antiherbivory measures are welcomed and encouraged. These comments and suggestions shall be submitted to the Department within thirty (30) days of the award of the Contract. The Department may elect to reject some or all comments.

Within thirty (30) days of the award of the contract, the Contractor shall submit to the Department the names and qualifications of the personnel who will conduct the work. This submittal shall identify the proposed Chief Forester. This information shall include the

necessary information to verify Forester status and shall include institution, title of degree, years experience as a forester, and resume of professional experience. With the approval of the Department, additional staff may be added at a later date.

A minimum of ninety (90) days prior to the initiation of the planting operations, the Contractor shall supply the Engineer with a map indicating the location of each of the proposed field stockpiling sites (field caches). The base map shall be provided by the Engineer. The number and locations of the field stockpiling sites shall be developed in such a manner as to promote an efficient planting operation. This field stockpiling site plan shall be subject to approval by the Department, and whenever directed by the Department or Engineer, additional stockpiling areas shall be constructed by the Contractor at the locations selected by the Engineer at no additional cost to the Department. Prior to this submittal, the Chief Forester shall have visited and become familiarized with the planting site.

No later than forty-five (45) days prior opening of the planting window, the Contractor shall submit a preliminary shipping schedule for all plant materials to the Department. With this schedule, a letter from each plant source indicating concurrence with the preliminary schedule shall be attached. When appropriate for the project, this shipping schedule may include staggered shipments. The capacity and capabilities of the cold storage facility and the number and size of the planting crews shall be factored into the development of the delivery schedule. This schedule is preliminary and subject to change based on weather, site conditions, and the progress of the work. During the actual planting operations, the Contractor shall schedule with the various plant material sources all plant shipping for the project. The actual plant shipping shall not result in a delay of any planting operation.

(c) Vehicular Traffic: Vehicular traffic shall be subject to restrictions as specified on the plans or as directed by the Engineer. On a bedded or ripped site, the movement of vehicles shall be performed in such a manner as to limit, to the maximum practical extent, damage to the beds or rips. At any time, the Engineer may prohibit vehicular access to the planting areas.

(d) Cold-Storage Facility: When required for a project, this work shall include, but is not limited to, supervising the off-loading of the plant materials at regional cold-storage facilities in *INSERT LOCATION*, directing the stockpiling of those materials and the subsequent transport of the trees to or from the planting sites, monitoring environmental conditions at the cold-storage facility, and the cleaning of the cold-storage facility immediately following the completion of the plantings. The Chief Forester shall ensure that materials are stored properly, according to best forestry practices, as solely determined by the Department, and to the directions and specifications of the Department. Unless directed by the Department, trees shall not be stored in stacks of more than two pallets high, and the stockpiling shall be done in such a manner as to maintain good air circulation around all sides of the pallets.

At the regional cold-storage facility, the Contractor shall be solely responsible for the loading and unloading of plant stock that is being moved to or from the planting site into approved vehicles and the safe transport of the stock as specified herein. All plant transit vehicles, procedures, packing methods, and materials shall be subject to approval by the Engineer.

During transport to or from the cold-storage facility, the planting materials shall be kept covered, kept cool, kept moist, kept from freezing, and kept out of the wind and sun. Unless directed in writing by the Engineer, transport vehicles shall be capped trucks or trailers with good means of ventilation. Plant transport vehicles shall not be open-bed vehicles, and the transport compartments shall not be heated. When transporting materials to or from the cold storage facility, shipping containers shall not be stacked more than two high. At least twelve (12) inches of air space between the top of the shipping containers and vehicle cover shall be maintained when packing the plants. The containers shall then be covered with secured thermal-reflective tarps (WHITE SIDE UP), and nothing else shall be placed on top of the shipping containers. If any shipping container is damaged, the damaged opening shall be immediately taped. The Chief Forester shall be informed of such repairs to shipping containers at the earliest practicable time.

Each morning, the Chief Forester shall arrange for sufficient stock to be transported to the site for that morning's plantings. Later in the day, the Chief Forester shall arrange for additional shipments from the cold storage facility sufficient to complete the afternoon's planting. With the written approval of the Department, the Chief Forester may transport sufficient stock in the morning to serve the whole day's planting needs. However, the Department or Engineer may reject or withdraw approval of such a request. At no time shall the number of plants at the site exceed that day's planting allowance for that site. At the end of the work day and without exception, all planting materials not installed shall be returned immediately to the cold-storage facility, utilizing the same handling procedures.

The Contractor shall monitor the temperature and humidity levels within the cold-storage facility twice daily and forward this information to the Engineer on a weekly basis. If the temperature or humidity levels are outside the specified guidelines, the information shall be forwarded on a daily basis. Each monitoring shall include at least one (1) air temperature measurement and three (3) separate readings of plant stock temperatures, as measured inside widely spaced shipping containers with probe soil thermometers. The placement of the probe soil thermometers shall be done in such a manner as not to promote desiccation of the plant materials. Thermometer entrance/exit holes shall be tightly sealed at the time of both placement and removal of the thermometer.

The Contractor shall clean the cold-storage facility immediately following the completion of the planting program. Cleaning is defined as returning the facility to the same condition of cleanliness as existed at the start of the project, as solely determined by the Department. This work shall include the pickup and disposal of any project garbage or packing materials, and washing the floor to remove any clay or root slurry treatments that may have been deposited on the floor.

If the planting materials are shipped on steel pallets or another type stacking system, the Contractor shall breakdown and stack the pallets at the cold-storage facility, as directed by the Department.

(e) Plant Inspection: Immediately after delivery of the plant stock to the cold-storage facility, a representative inspection of the plant materials shall be conducted to determine conformance with the plant material specifications as contained in Section XXXXXX - Furnishing Saplings, Section XXXXXX - Reforestation, and/or Section XXXXXX - Forestry Planting. This preliminary inspection shall in no way harm the plant materials, lead to desiccation of the plant materials, or reduce the effectiveness of the shipping materials. During inspection, the exposure of the planting materials shall be minimized to fifteen (15) seconds, and all shipping containers shall be kept closed to the maximum practical extent. All shipping containers shall be resealed and, when appropriate, restapled or restrapped. If directed by the Department, this preliminary inspection at the cold-storage facility may be canceled or occur only in the presence of the Engineer.

During the transfer of the plants from the shipping containers to the planting bags, Foresters shall perform representative inspections of the planting materials for conformance with the plant material specifications. These inspections shall not result in exposure of the planting materials for more than fifteen (15) seconds, and all shipping containers shall be kept closed to the maximum practical extent.

(f) Field Stockpiling Sites: At the planting site, the transport vehicles shall be parked in a shaded location and away from the wind. The shipping containers shall then be gently off-loaded and stockpiled in a location free of standing water, as previously approved by the Department. Ideally, this location shall provide natural shade and protection from wind. Shipping containers shall be gently placed in the correct stockpiling positions.

At the planting site, the Contractor shall direct the unloading and loading of the plant stock, and the stockpiling of the trees at the approved stockpiling areas. While at the planting site, the actual unloading, loading, and stockpiling of the plant stock shall be performed by the planting crew under Section XXXXXX - Forestry Planting. The Contractor is solely responsible for directing the distribution of the trees to the field stockpiling sites.

Prior to stockpiling, spacer boards shall be placed on the ground to support the stockpiling. These spacer boards may be two (2)- by four (4)-inch lumber, PVC pipe, or another material, as approved by the Department. The entire stockpiling area shall then be subsequently shaded with thermal- reflective tarps (WHITE SIDE UP). Shipping containers shall not be stacked more than two high and stacking practices shall allow for good air circulation between the containers. Shipping containers shall not be thrown to the ground, into a stockpiling area, or between workers. Construction and maintenance of these field stockpiling areas shall be the sole responsibility of the Contractor.

If wind speeds exceed ten (10) miles per hour, a wind barrier shall be erected immediately adjacent to the stockpiling area. Whenever appropriate, the wind barrier shall be relocated or repositioned to protect the quality of the stock. The wind barrier shall be constructed utilizing tightly woven or coated tarps, or as approved by the Engineer. The materials and methods used in the construction of the wind barrier shall be subject to approval by the Engineer. With the approval of the Engineer, the Contractor may elect to utilize the transport vehicle as a

temporary storage area, subject to the above restrictions and guidelines, including the placement of thermal-reflective tarps.

Shade moves with time. It is the sole responsibility of the Contractor to ensure that, once materials are stockpiled in the field stockpiling sites, the plant materials remain shaded as the day progresses.

(g) Plant Material Handling: At all times, the shipping containers and the trees shall be handled gently and in a manner that will not injure, harm, or desiccate the plant materials. Shipping containers shall be opened by cutting the binding strap, pulling the binding tab, or another approved method, as determine by the Department. Opening the shipping container with a planting tool, a knife puncturing the shipping container, or any other method not specifically approved by the Department shall be prohibited. All damaged shipping containers shall be immediately repaired and resealed.

The Contractor shall supervise the transfer of plants from the shipping container to the planting bags or tubling carriers. This transfer of plants shall occur at the stockpiling areas. Except when actively transferring planting materials from the shipping container to the planting bag or tubling carrier, the shipping container shall remain tightly closed and always out of direct sunlight, supported by spacer boards, and shaded with a thermal-reflective tarp (WHITE SIDE UP). Unless all stock will be immediately transferred to planting bags, only one shipping container of a single species shall be opened at any field stockpiling site during planting operations.

Root pruning is not desirable and can only be initiated at the specific direction of the Chief Forester. When root pruning is required, all pruning activities shall occur at the approved field stockpiling areas with a Forester present to direct the actual pruning. No pruning activities shall occur without the presence of a Forester.

(h) Water: The Contractor shall ensure that sufficient fresh water is available for all planting operations and the watering of the stock. Until the stock is transferred into the planting bags, any required watering of the plant stock shall be the sole responsibility of the Contractor.

Unless directed by the Chief Forester, clay-coated bareroot stock shall not be watered, nor shall water be added to the clay-coated bareroot shipping containers. Tubling stock and plug stock shall be watered as necessary to maintain moist soils and root systems. If dipped in water, the stock shall not be placed in the water for more than one (1) minute. The watering shall be gentle and shall not result in the removal of soil from the stock. Do not allow water to puddle in the shipping containers, as excess water can drown root tips and promote mold on the trees.

(i) Planting Supervision: The Contractor shall ensure that the planting is installed and that all plant materials are handled and watered according to these specifications and in accordance with Section XXXXXX - Forestry Planting or Section XXXXXX - Reforestation.

During the planting operations, it shall be the Chief Forester's responsibility to ensure that the planting crews have sufficient plants to conduct the plantings efficiently.

This work shall include, but is not limited to, the following: (1) supervising the planting and the work of the planting crews; (2) communicating with the planting crew boss; (3) ensuring that the planting crew has the proper equipment; (4) ensuring that the species are planted evenly at the specified densities and on the specified planting centers; (5) ensuring that trees are planted and handled in accordance with all relative specifications; (6) inspecting the planting to ensure that the planting is in accordance with the specifications; (7) ensuring that the planting is performed according to best forestry practices, as solely determined by the Department; (8) ensuring the proper placement of the tree shelters; and (9) if required, directing any root pruning operations.

During the planting operations, the Chief Forester shall be onsite at all times, with the exception of one (1) fifteen (15)-minute period in the morning and one (1) fifteen (15)-minute period in the afternoon. At all other times, the Chief Forester shall be engaged in directly supervising the planting. When the Chief Forester is offsite, a Forester shall be onsite to supervise the planting. Where deficiencies in the planting are found, Foresters shall immediately communicate those deficiencies directly to the crew boss for corrective action. The Chief Forester has the authority to suspend from further planting any crew member who is considered unsatisfactory, as detailed in Section XXXXXX - Forest Planting or Section XXXXXX - Reforestation. During the actual distribution of the plants to the planting crew, a Forester shall be present or in the immediate vicinity of each active field cache. If plants are returned to the cold-storage facility, the Chief Forester shall inspect the cold-storage facility at the end of each planting day.

(j) Shipping Materials: Wax-impregnated boxes, tubes, tube racks, and plant trays shall not be left in the field, but shall be reassembled and stacked at a location within the project site and removed from the site at the end of each working day. If specified on the plans or directed in the bid documents or if directed by the Engineer, these materials shall be returned to the nursery. The cost for this transport or shipping shall be included in the unit bid price or the lump sum bid price for Consulting Forester.

(k) Miscellaneous Requirements: Any refuse shipping materials, trash, or crew refuse not removed by the crew shall be disposed of by the Contractor at no additional cost to the Department. The method and location of disposal are subject to approval by the Department.

Method of Measurement:

No separate measurement will be made for Professional Forester. Payment will be made at the contract lump sum price for each site.

Basis of Payment:

Professional Forester shall be paid for at the contract lump sum bid price for each individual site, which price and payment shall constitute full compensation for all labor, materials, equipment, water, and incidentals necessary to complete the item. The cost for returning shipping materials to the nursery and trash disposal shall be included in the lump sum bid price for this item.

Appendix H

Reforestation

NOTE: FOR ALMOST ALL APPLICATIONS, IT IS EXPECTED THAT THIS SPECIFICATION WILL NEED TO BE HEAVILY EDITED. IF ONE IS PLANNING TO USE A LOCAL NURSERY, ESPECIALLY A STATE NURSERY, THE MATERIAL SEGMENTS WILL NEED TO BE VERIFIED AND ONE MAY WANT TO ADOPT HANDLING REQUIREMENTS SIMILAR TO THOSE FOR "LOCAL" MATERIALS FOUND IN THE FRESHWATER MARSH SPECIFICATION.

Description:

Reforestation consists of furnishing all plants, labor, materials, equipment, transportation, storage, and the proper planting of the plant materials by approved methods, as hereinafter specified, in the locations shown on the plans or as directed by the Engineer.

Definitions:

The word "trees" is used as a general term for seedlings and saplings of both tree and shrub species.

Materials:

(a) Plant Quality and Size: All plants shall be true to type and nomenclature and typical of their species or variety. They shall have a normal habit of growth with well-developed branch systems and vigorous root systems. They shall be sound, healthy, and vigorous plants, free from visible defects, disfiguration, injury, recognizable disease of any kind, insect eggs, borers, and any infestation. All plants shall be nursery grown in a growth medium subject to approval by the Department. It will be the responsibility of the Contractor to inspect the plants before removal from the nursery where they have been grown to make sure that the plants meet these requirements.

All plants shall conform to all sizes and measurements detailed in these specifications or as indicated on the plans. Unacceptable plants shall be culled at the nursery prior to being packed. No substitutions for any materials shall be made unless agreed to in writing by the Department. With the approval of the Department, plants larger in size than specified may be utilized, but such plants shall not increase the contract price. Plants shall have a form and architecture that is easily planted for the stock specified.

EXAMPLE SPECIES

1. Pine Bareroot Specifications:

(a) For Lobolly Pine (*Pinus taeda*), a target root collar diameter of seven-thirty-seconds inch (7/32"). A minimum culling root collar diameter of six-thirty-seconds inch (6/32"). Target height of ten inches (10²), measured from root collar to terminal apical bud. Minimum culling height of eight inches (8"), measured from root collar to terminal apical bud.

(b) A vigorous compact, fibrous root system with a minimum taproot length of five and one-half inches (5½"). A target taproot length of six to seven inches (6-7"). Each seedling should have a minimum of six (6) first-order lateral (side) roots derived from the main taproot. A minimum number of between eight (8) and ten (10) first-order lateral roots is strongly preferred.

(c) Presence of secondary needles.

(d) Dormant tree with tight buds and little or no new root growth.

(e) Free of recognizable disease and mechanical damage.

(f) A continuous bark. Cambium green or yellowish in coloration.

(g) After lifting the stock from the growing beds and prior to bagging, a kaolin clay emulsion shall be applied to the entire root system of all bareroot stock. If specified on the plans or agreed to in writing by the Department, a gel emulsion may be utilized for the root treatment in lieu of the kaolin clay.

2. Hardwood and Bald Cypress Bareroot (*Taxodium distichum*) Specifications:

(a) A minimum and target root collar diameter of three-eighths inch (3/8").

(b) Minimum height of sixteen inches (16") measured from root collar to tip.

(c) Target height of twenty-four inches (24") measured from root collar to tip; a maximum height of thirty-six inches (36") measured from root collar to tip.

(d) Dormant tree with tight buds and little or no new root growth.

(e) A vigorous compact, fibrous root system with a minimum taproot length of eight inches (8") and a target length of eight to ten inches (8-10"), as measured prior to pruning.

(f) Each plant shall have a minimum of six (6) first-order lateral (side) roots derived from the main taproot. A minimum number of between eight (8) and ten (10) first-order lateral roots is strongly preferred.

(g) Unless directed otherwise by the Department, taproots and lateral roots greater than ten inches (10") in length shall be pruned or undercut at the nursery according to best forestry practices to a length of ten inches (10").

(h) An early undercut of the stock shall be allowed. However, the resulting delivered stock shall be readily plantable, and the stock shall not have “mop-head” or “paintbrush” root systems that are difficult to plant as herein specified.

(i) Free from recognizable disease and mechanical damage.

(j) A continuous bark. Cambium green or yellowish in coloration.

(k) After lifting the stock from the growing beds and prior to bagging, a kaolin clay emulsion shall be applied to the entire root system of all bareroot stock. If specified on the plans or agreed to in writing by the Department, a gel emulsion may be utilized for the root treatment in lieu of the kaolin clay.

3. Atlantic White Cedar (*Chamaecyparis thyoides*) Tubling Specifications:

(a) A target root collar diameter of three-eighths inch (3/8"). A minimum culling root collar diameter of one-quarter inch (¼").

(b) Target height of fifteen to twenty inches (15-20"). A minimum culling height of twelve inches (12") measured from root collar to tip.

(c) A vigorous compact, fibrous root system with minimum taproot length of six and one-half inches (6½") and a target taproot length of seven and one-half inches (7½"). The root system shall fully occupy the growing cell.

(d) Dormant tree with tight buds and little or no new root growth.

(e) Each plant shall have a minimum of six (6) first-order lateral (side) roots derived from the main taproot. A minimum number of between eight (8) and ten (10) first-order lateral roots is strongly preferred.

(f) The extracted root system shall conform to the shape and dimensions of the growing cells without sloughing soil or growth media, as determined during the onsite inspection. Materials not conforming to the dimensions of the cell may be rejected without compensation.

(g) The extracted root system shall have the majority of the roots in vertical orientation. If the horizontal roots are thick and flattened and the root plug stays in a thick net the shape of the original plug when the media are shaken loose, the tree shall be determined to be “pot bound” and shall be considered unacceptable stock.

(h) Free from recognizable disease and mechanical damage.

(i) A continuous bark. Cambium green or yellowish in coloration.

(j) The growing cells shall have minimum cavity depth of eight (8) inches, a minimum cavity diameter of one and one-half (1½) inches, and a minimum cavity capacity of ten (10) cubic inches. The inner surface of the cell wall shall be vertically ribbed the full length of the cell wall in a manner that promotes downward root growth and limits root spiraling (USDA, Forest Service, Agricultural Handbook 674, Volume 2). Each cell shall have a minimum of four (4) inner ribs.

4. Shrub Bareroot Specifications:

(a) A target root collar size of seven-thirty-seconds inch (7/32"). A minimum culling root collar diameter of six-thirty-seconds inch (6/32").

(b) Minimum height of twelve inches (12") measured from root collar to tip.

(c) Target height of eighteen inches (18") measured from root collar to tip; a maximum height of thirty inches (30") measured from root collar to tip.

(d) Dormant shrub with tight buds and little or no new root growth.

(e) A vigorous compact, fibrous root system with a minimum taproot length of eight inches (8") and a target length of eight to ten inches (8-10"), as measured prior to pruning.

(f) Each plant shall have a minimum of six (6) first-order lateral (side) roots derived from the main taproot. A minimum number of between eight (8) and ten (10) first-order lateral roots is strongly preferred.

(g) Unless directed otherwise by the Department, taproots and lateral roots greater than eight inches (8") in length shall be pruned or undercut at the nursery according to best forestry practices to a length of eight inches (8").

(h) An early undercut of the stock shall be allowed. However, the resulting delivered stock shall be readily plantable, and the stock shall not have “mop-head” or “paintbrush” root systems that are difficult to plant as herein specified.

(i) Free from recognizable disease and mechanical damage.

(j) A continuous bark. Cambium green or yellowish in coloration.

(k) After lifting the stock from the growing beds and prior to bagging, a kaolin clay emulsion shall be applied to the entire root system of all bareroot stock. If specified

on the plans or agreed to in writing by the Department, a gel emulsion may be utilized for the root treatment in lieu of the kaolin clay.

5. Containerized (Plug) Specifications:

(a) Stock age and type shall be as shown on the plans. Growing cell size, cell dimensions, and cell coding as shown on the plans or as specified. *(NOTE: IF DESIRED, SHOOT/ROOT RATIOS CAN BE ADDED. CONSIDERABLE CONTROL OF THE SHOOT/ROOT RATIO CAN BE OBTAINED WITH PROPER CONTAINER SELECTION).*

(b) Target root collar diameter and minimum root collar diameter as shown on the plans.

(c) Target height and minimum height measured from plug surface to apical tip as shown on the plans.

(d) Dormant tree with tight buds and little or no new root growth.

(e) A vigorous compact, fibrous root system with minimum taproot length and a target taproot length as shown on the plans.

(f) Each plant shall have a minimum of six (6) first-order lateral (side) roots derived from the main taproot. A minimum number of between eight (8) and ten (10) first-order lateral roots is strongly preferred.

(g) The extracted root system shall conform to the shape and dimensions of the growing cells without sloughing soil or growth media, as determined during the onsite inspection. Materials not conforming to the dimensions of the cell may be rejected without compensation.

(h) The extracted root system shall have the majority of the roots in vertical orientation. If the horizontal roots are thick and flattened and the root plug stays in a thick net the shape of the original plug when the media are shaken loose, the tree shall be determined to be “pot bound” and shall be considered unacceptable stock.

(i) Free from recognizable disease and mechanical damage.

(j) A continuous bark. Cambium green or yellowish in coloration.

(k) The top inch (1") of conifer stock shall possess stiff foliage and stems with firm terminal buds as a sign of proper hardening of the stock.

For all container stock (tublings and plugs), the growing methodology, arrangement, and placement of growing cells in the nursery shall be done in a manner that promotes “air

pruning" at the bottom drainage hole of the cavity (USDA, Forest Service, Agricultural Handbook 674, Volume 2). Unless specified on the plans, plug stock may be grown in individual free cells, joined cells, or in polystyrene (styrofoam) blocks. Each cell shall have a minimum cavity depth, minimum cavity capacity and minimum cavity diameter as measured at the top of the cell, as specified on the plans.

THE NEXT THREE PARAGRAPHS ILLUSTRATE HOW ADDITIONAL INFORMATION CAN BE ADDED TO A SPECIFICATION. DELETE IF NOT APPLICABLE. IT IS THE AUTHOR'S UNDERSTANDING THAT THERE MAY BE A SHIFT AWAY FROM TUBLING STOCK OF ATLANTIC WHITE CEDAR TOWARDS BARE-ROOT STOCK.

The Atlantic White Cedar shall be propagated by stem cuttings. The stem cuttings shall be obtained from juvenile plants growing in wetland environments or orchard stock derived from wetland environments. In the past, propagation via seeds has had limited success, particularly as it relates to breaking the seed dormancy requirements.

Atlantic White Cedar shall be grown and transported as tublings in propagation cells, and not as bareroot stock or extracted plugs. To ease field extraction, the tubling cells shall be free individual cells and not molded into multiple-cell units. The tubling cells shall be manufactured from either low-density or high-density polyethylene with bottom drainage. The use of styrofoam blocks or styrofoam cells shall be prohibited when culturing *Chamaecyparis* because of problems associated with fine root penetration into styrofoam walls and torn roots following extraction. The choice of propagation tubes (cells) and trays shall be subject to approval by the Department.

For Atlantic White Cedar, the growth media shall be 2 coarse perlite:1 *Sphagnum* peat moss by volume or 1 coarse perlite:1 *Sphagnum* peat moss by volume. The cuttings shall be six (6)-inch cuttings that are 10,000 ppm IBA-dipped (active indolebutyric acid). The cuttings shall be propagated with mist or polytent with bottom heat during the winter months. Cuttings shall be taken in November. Unless authorized in writing by the Department or as directed on the plans or as directed in these specifications, the propagation method shall follow the propagation guidelines for *Chamaecyparis thyoides* as found in *The Reference Manual of Woody Plant Propagation: From Seed to Tissue Culture* by Michael Dirr and Charles Heuser (Varsity Press, Inc., Athens, Georgia, 1987), and in *Manual of Woody Landscape Plants: Their Identification, Ornamental Characteristics, Culture, Propagation and Uses* by Michael Dirr (Stipes Publishing Company, Champaign, Illinois, 4th Edition, 1990). Alternatively, propagation can be made following the optimal rooting procedures outlined in Boyle and Kuser (1994).[1]

(b) Genetic/Elevational/Exposure Origin:

THIS SEGMENT OF THE SPECIFICATION DESCRIBES THE GEOGRAPHICAL AND HABITAT ORIGINS OF THE SOURCE MATERIALS AND WILL HAVE TO BE

[1] References cited in this appendix are listed in the References at the end of the main text.

PROVIDED BY THE USER. THE USE OF SEEDING ZONES AS MAPPED BY THE FOREST SERVICE TO SPECIFY STOCK IS A STANDARD FORESTRY PRACTICE. ONE SHOULD VERIFY NURSERY LOCATION.

Plants may be grown in nurseries outside of these geographical boundaries, subject to approval by the Department, but the immediate genetic origin of the materials must meet the above geographical specifications. The genetic origin shall be chosen to provide typical forms of the species and include the capacity to bear fertile fruits, as approved by the Department.

(c) Nomenclature: For all plants, *A Synonymized Checklist of the Vascular Flora of the United States, Canada and Greenland: Volume II; The Biota of North America* (Kartesz and Kartesz, University of North Carolina Press, 1980, or later edition) shall be the authority for the plant names, unless indicated on the plans. The Contractor shall supply certification from the suppliers that the plants supplied are the plants specified or agreed to under substitution. No compensation shall be made for materials or the cost of installation for plant species that are not specified.

(d) Mycorrhizae Inoculation: If indicated on the plans, plant stock shall be inoculated with mycorrhizae as specified and according to best forestry practices, as solely determined by the Department. If inoculated stock is specified, but no method of inoculation is specified, the stock shall be inoculated in bed during the growing season with a subsurface injection of a pure vegetative mycelium.

(e) Miscellaneous Materials: All shipping materials, equipment, planting tools, planting bags, tubling carriers, tarps, and incidentals necessary to complete the item shall be subject to approval by the Engineer. Substandard, defective or damaged tools and items, as solely determined by the Engineer, shall not be used and shall be removed from the site by the close of the working day. Specialized planting tools or tool configurations may be required, as specified on the plans or in the bid documents.

The kaolin clay slurry utilized shall be recognized as suitable for root protection within the forestry industry and is subject to approval by the Department. If the use of a gel root coating is requested, the type and manufacturer of the proposed gel shall be submitted to the Department with a written request for the usage of the gel. The type of gel utilized shall be subject to approval by the Department.

Thermal-reflective tarps (heat shields) shall have one side of the tarp manufactured of a white-faced material and one side with a highly reflective metallic finish. Minimum size for the thermal tarps shall be nine (9) feet by fifteen (15) feet. The Department may require the use of thermal-reflective tarps specifically designed or advertised for forestry use at no additional charge to the Department. Tightly woven or coated tarps may be used for the construction of wind barriers.

The OST bars (dibble bars) shall be a minimum of thirty-eight inches (38") inches in length. The blade shall be a minimum of three inches (3") wide with a minimum length of ten and one-quarter inches (10¼"). The thickness of the blade at the handle shall be a minimum of three-fourths inch (¾").

The KBC bars shall be a minimum of thirty-nine inches (39") in length. The blade shall be a minimum of four inches (4") wide at the middle of the blade with a minimum length of twelve inches (12"). The thickness of the blade at the handle shall be a minimum of one inch (1").

For Atlantic White Cedar and bareroot hardwood plantings, each hoedad shall have a minimum blade length of seventeen inches (17") and a minimum width of four inches (4"). If, upon inspection of the plant material by the Department, it is determined that planting with a hoedad of a minimum blade length of fifteen inches (15") is appropriate, the Contractor may utilize hoedads with 15-inch blades. Hoedads specifically designed for plug plantings shall not be utilized for the planting of bareroot hardwoods or Atlantic White Cedar.

The type, size, caliper, and length of the required cylindrical dibble or plug extractor for the planting of tubling or plug stock shall be as specified on the plans or by the Engineer. This information will be made available to the Contractor no later than sixty (60) days prior to the opening of the planting window. When a cylindrical dibble planting or a plug extraction planting is specified, as backup planting tools, the Contractor shall be required to have onsite at least the minimum number of hoedads or planting bars necessary to hand plant the stock while fully utilizing all members of the planting crew.

All planting bags shall be specifically designed for reforestation work with reflective bag liners or insulated liners. These bags shall be free of holes and in good condition. All bags shall be subject to approval by the Engineer. For hardwood and bald cypress trees, the planting bag shall be a minimum size of twelve (12) inches in diameter, eighteen (18) inches deep. For other conifers, the planting bag shall be a minimum size of twelve (12) inches in diameter, fifteen (15) inches deep or as approved by the Engineer. If specified on the plans, waterproof polyurethane-insulated planting bags shall be utilized. If tubling carriers are to be utilized by the planting crews, all tubling carriers are subject to approval by the Engineer.

Transport of materials will likely require the use of four (4)-wheel-drive vehicles equipped with appropriate off-road tires and capped transport beds. If directed by the Engineer, such vehicles shall be utilized without additional compensation by the Department. Smaller all-terrain vehicles may be useful for onsite transport. Regardless, the Contractor shall have a sufficient number of vehicles of the capability to transport the materials and efficiently supply the planting crews with trees, as solely determined by the Engineer.

Water required for the plant stock and to maintain the proper moisture levels in the planting bags shall be fresh water free from toxic substances and chemicals injurious to

vegetation. Salt or brackish water shall not be used. All water sources are subject to approval by the Department.

Perlite shall have an average particle size in excess of three (3) millimeters.

Sphagnum peat moss shall be at a minimum ninety percent (90%)-organic material with a minimum of seventy-five percent (75%) of the organic content being derived from the genus *Sphagnum*.

Burlap shall be jute burlap with a dry weight of approximately eight (8) ounces per square yard. If used in conjunction with planting bags, new jute burlap shall be soaked in water for a minimum of twenty-four (24) hours prior to use with planting bags.

Tree shelters shall be as specified on the plans or an approved equivalent. Stakes shall be nominal lumber as shown on the details or plan notes. Shelters that may be specified include the following:

(1) Blue-XÔ: Blue-X, 3120 High Street, Sacramento, CA 95815.

(2) Quadra Treegard. Treegard, 3825 Highridge Road, Madison, WI 53704.

(3) Supertube. Treessentials, Riverview Station, P.O. Box 7097, St. Paul, MN.

(4) Treehouse. American Forestry Technology, Inc., 100 North, 500 West, West Lafayette, Indiana, 47906

(5) TreePeeÔ: Baileys Forestry, 44650 Hwy 101, Box 550, Laytonville, CA 95454.

(6) Tree ProÔ: Tree Pro, 445 Lourdes Lane, Lafayette, IN 47905.

(7) Tree SentryÔ: Tree Sentry, PO Box 607, Perrysburg, OH 43552.

(f) Submittals: Within thirty (30) days of the award of the contract, the Contractor shall forward in writing a complete listing of the proposed planting materials and the genetic origins of the materials to the following address:

ONE SHALL INSERT COMPETENT REVIEWER OR OFFICE FAMILIAR WITH THE PROJECT. THIS REVIEWER NEED NOT BE THE ENGINEER. HE/SHE CAN BE PART OF THE DESIGN TEAM.

The Department will review these submitted materials. If deficient, as solely determined by the Department, additional information shall be forwarded to the Department. Any problems with obtaining any of the specified plant materials should be forwarded in writing to the *INSERT COMPETENT REVIEWER OR OFFICE*. The cause of the

acquisition problem(s) shall be discussed in full and a list of vendors contacted shall be included. The Contractor should be aware that more than one (1) vendor may be required to obtain all the necessary plant materials. Suggestions concerning appropriate substitutions may be included with this correspondence; however, only the Department may approve such substitutions.

Within sixty (60) days of the award of the contract, the Contractor shall forward confirmed purchase orders for all specified plant materials to the above address. Only after receiving written approval of the genetic origin of the source material by the Department shall the Contractor initiate the procurement of the source material.

Any proposed variance from the plant propagation guidelines shall be approved in writing by the Department prior to initiating the change(s). Upon request by the Department, the Contractor shall supply a complete methodology concerning the proposed or completed collection and propagation methods including dates of collection, collection sites, method of collection, growth media, cell sizes, rooting treatments, rooting success statistics, and propagation methods including pruning, fertilizer treatments, and recommendations concerning future propagation methods. The Contractor shall inform the plant material suppliers of these requirements prior to obtaining any purchase order agreements.

A minimum of sixty (60) days prior to the initiation of the planting operations, the Contractor shall supply the Engineer with a map indicating the location of each of the proposed field stockpiling sites (field caches). The base map shall be provided by the Engineer. The number and locations of the field stockpiling sites shall be developed in such a manner as to promote an efficient planting operation. This field stockpiling site plan shall be subject to approval by the Department, and whenever directed by the Department or Engineer, additional stockpiling areas shall be constructed by the Contractor at the locations selected by the Engineer at no additional cost to the Department.

If the Contractor possesses a record of successful forest plantings that have received final approval by the U.S. Army Corps of Engineers, U.S. Forest Service, or a State Forest Service, comments concerning the appropriateness of the various plantings, composition of the planting blocks, planting techniques and antiherbivory measures are welcomed and encouraged. These comments and suggestions shall be submitted to the Department within thirty (30) days of the award of the Contract. The Department may elect to reject some or all comments.

(g) Inspection: The Contractor shall be responsible for all certificates of inspection of plant materials that may be required by Federal, State, or other authorities to accompany shipments of plants.

The successful bidder shall furnish complete information as to the location of all plants which he/she intends to supply and use. The Department reserves the right to inspect, tag (seal), and approve all plants at the source of supply. This inspection and tagging shall not

in any way eliminate the right of rejection at the *INSERT LOCATION* cold-storage facility or at the work site including the presence of heated materials, dried trees, dried roots or growing media, excessive mold, discolored tops, dormancy release, or damaged packaging and shipping materials. Any materials not conforming to these specifications may be rejected by the Engineer without compensation to the Contractor. Any rejected materials shall be removed from the work site by the end of each working day.

(h) Plant Lifting/Culling/Packaging/Nursery Storage: Lifting, packing, and storage of plants shall be performed according to best forestry practices, as solely determined by the Department. Unless authorized by the Department, all lifting shall be preceded by lateral pruning and prelift undercutting to finalize the plant size. The lateral root pruning may occur several months prior to the actual lifting of the plants.

If a plant species is suitable for cold-storage placement, trees shall not be lifted until the trees have accumulated a minimum of 600 chilling hours, and no trees shall be lifted prior to January 1 or as specified on the plans. Whenever possible, trees shall not be lifted until the accumulation of 1,200 chilling hours, but all plants shall be lifted prior to dormancy release.

NOTE: ONE SHALL VERIFY THE NUMBER OF CHILLING HOURS FOR GEOGRAPHICAL AND ELEVATIONAL CONSIDERATIONS.

Option 1, Southeast Origin: Chilling hours shall be defined as the number of accumulated hours that the plant has experienced below 45 ^{o}F recorded after October 15, or as specified on the plans.

Option 2, Northwest Origin: Chilling hours shall be defined as the number of accumulated hours that the plant has experienced below 40 °F recorded after November 15, or as specified on the plans.

Lifting shall occur in the morning, or when the weather is cool and humid. Plants shall not be lifted from frozen soils or saturated soils. Lifted plants shall be immediately transported to the packing shed. *OPTIONAL SENTENCE:* Plants shall not be lifted when the Plant Moisture Stress (PMS) exceeds minus twenty (20) bars (a more negative value).

Unless written authorization is provided by the Department, all plants shall be machine lifted. If requested in writing, the Department may allow hand lifting. However, the hand lifting operations shall be done in such a manner as to minimize root stripping. During the lifting operations and the subsequent handling operations, exposure of the root system to air, wind, or sun shall be minimized to the maximum practical extent.

Immediately following transport to the packing shed, the trees' moisture level shall be assessed and the stock watered by misting. The packing shed shall provide a cool, humid environment to protect against plant desiccation. While being handled in the packing shed, the plant material shall be kept moist at all times. *OPTIONAL TWO SENTENCES:*

All plant materials shall be maintained at minus five (5) bars PMS or a less stressful condition. If PMS exceeds minus six (6) bars, the plants shall be misted. All plant stock shall be culled in the packing shed for conformance to the material specifications, including excessively long lateral roots, which shall be trimmed. Space heaters directed toward the packing or grading tables shall not be utilized. Bareroot trees shall be packed in sealed three (3)-ply kraft-polyethylene bags, or sealed polyethylene bags inside wax-impregnated cardboard boxes. With prior written approval of the Engineer, other shipping materials may be authorized. Unless indicated on the plans, plugs and tublings shall be shipped in sealed polyethylene bags inside supporting boxes. Tublings shall be shipped inside propagation cells. Because of concerns for excessive heating of the plant materials, the use of dark-colored packaging shall be avoided, and the use of dark-colored packaging is subject to rejection by the Department.

The trees shall be packed and marked in shipping containers in such a way as to allow quick and easy identification of the materials. Each container shall be clearly labeled with grower, species, quantity, chilling hours, lift date, packing date, cold-storage date, recommended maximum storage time, and any chemical treatment for field conditions, such as Furadan or Benlate. If more than one (1) bag is packed in a shipping container, each bag shall be marked with quantity and species. For each species, uniform packing quantities are desirable.

Except when specified and according to best forestry practices, plants may be placed into cold storage at the nursery prior to shipment. Unless directed in writing by the Engineer, species or regional populations that are poorly adapted to placement in cold storage shall not be placed in a cold-storage facility. It is the sole responsibility of the Contractor to ensure that the plants placed in cold storage are suitable for cold storage. When required for proper plant handling and outplanting survivalship or when specified, species shall be lifted at the nursery, processed, and shipped within a two-day period.

OPTION 1, SOUTHEAST ORIGIN

Cold-storage facilities shall be operated and maintained according to best forestry practices, temperature range 34-36 °F, as measured inside the shipping containers, with a minimum relative humidity of ninety percent (90%) and good ventilation. A temperature of 34 °F with a relative humidity of ninety-five percent (95%) is desired. The plant material shall not be placed in freezing temperatures. The temperature of the stock as measured inside the packaging shall not exceed 38 °F. Improper operation or maintenance of the cold-storage facility may result in the rejection of the planting material, as solely determined by the Department. Plants lifted prematurely, based on the proposed planting dates and the number of chilling hours accumulated, shall not be shipped or accepted, as solely determined by the Department. It is the sole responsibility of the Contractor to inform the nursery of this provision of the specifications.

OPTION 2, NORTHWEST ORIGIN

All cold-storage facilities shall be operated and maintained according to best forestry practices, temperature range 28-30 °F with a minimum relative humidity of ninety-five percent (95%) and good ventilation. With advance permission of the Department, operating the cold-storage facility between 34 and 36 °F shall be acceptable. Improper operation or maintenance of the cold-storage facility may result in the rejection of the planting material, as solely determined by the Department. Plants lifted prematurely, based on the proposed planting date and the number of chilling hours accumulated, shall not be shipped or accepted, as solely determined by the Department. It is the sole responsibility of the Contractor to inform the nursery of this provision of the specifications. Prior to shipment, thawing of frozen seedlings shall occur at the nursery under controlled temperature and humidity conditions, temperature range 34-36 °F with a minimum relative humidity of ninety-five percent (95%) and good ventilation. The thawing of the trees shall occur gradually so that the tops and roots are evenly thawed. Proper thawing of tubling or plug stock should take about three (3) weeks, bareroot stock about 5-7 days. However, it is the sole responsibility of the Contractor to ensure that the stock is properly thawed according to best forestry practices.

(i) Stock Transit: All plant transit procedures, packing methods, and use of materials shall be subject to approval by the Engineer. If plugs are specified, shipping and container handling of the plugs shall be done in such a manner as to limit soil loss from around the root systems to the maximum practical extent, as determined solely by the Department. Unless specified on the plans or approved in writing by the Department, open-bundled packing or shipping shall not be allowed. If open-bundled material is authorized by the Department, the Contractor shall handle the material according to best forestry practices, and the Department shall require the preparation of additional handling, shipping, and watering guidelines.

Unless directed by the Department, shipping containers (packages) shall be shipped on strapped steel or wooden pallets. Each pallet shall be numbered and marked for easy identification. A shipping slip indicating species and quantities for each pallet and total quantities shall accompany each shipment. The packing of the pallets shall be done in such a manner as to promote good ventilation around each of the individual shipping containers. Unless supported by spacers, racks, or platforms, stacking of shipping containers shall be limited to two (2) containers high per pallet. While in transit, plant materials shall be packed and protected according to best forestry practices and in such a way as to prevent the drying, heating, bruising, or possible desiccation of the plant tissues.

Unless supported by spacers, racks, or platforms, stacking of shipping pallets for bareroot stock shall be limited to two (2) pallets high, and stacking of containerized stock shall be limited to one (1) pallet high. All pallet placement and stacking shall be done in such a manner as to ensure that containers are secure in their shipping positions and to maintain good air circulation around all sides of the pallets and good ventilation throughout the storage area, as solely determined by the Engineer.

Packing of the shipping pallets shall be done in a manner that will ensure that containers are secure in their shipping positions and that there is good ventilation around all shipping pallets and containers. If the materials are not packed according to best forestry practices, as solely determined by the Department, the Department may reject all materials without compensation. During transit, the material shall be kept from freezing and kept covered, cool, moist, well-ventilated, and out of the wind and sun.

Transport of all stock shall be conducted in refrigerated trucks with proper ventilation. The beds of the trucks shall be insulated from the exhaust system. During transit, the refrigeration unit shall be in operation at all times. The temperature within the shipping compartment shall be 34-36 °F or as directed by the nursery manager in order to maintain the stock at between 34 and 36 °F. A temperature of 34 °F with a minimum relative humidity of ninety percent (90%) is desired. The product temperature of the stock as measured inside the packaging shall not exceed 36 °F. Unless taken directly to the project site, the plant material shall be delivered directly to a cold-storage facility in *INSERT REGIONAL OR LOCAL LOCATION*. The regional or local cold-storage facility is subject to approval by the Department.

If shipped directly from the nursery to the project site, the refrigeration unit and ventilation system shall be in operation at all times with onsite parking of the vehicle limited to fifty-eight (58) hours. This refrigerated compartment shall be kept closed to the maximum practicable extent. Unless directed by the Engineer, all plant materials will be planted prior to the departure of the refrigeration truck.

The *INSERT REGIONAL OR LOCAL LOCATION* cold-storage facility shall be operated and maintained according to best forestry practices, temperature range 34-36 °F, as measured inside the shipping containers (*Optional:* with a minimum relative humidity of ninety percent (90%)) and good ventilation. A temperature of 34 °F with a minimum relative humidity of ninety percent (90%) is desired. The plant material shall not be placed in freezing temperatures, and the stock temperature not exceed 36 °F. All lower course stacking shall occur on raised pallets. Unless supported by spacers or racks, stacking of shipping containers is limited to two (2) containers high. All stockpiling and stacking shall be done in such a manner as to maintain good air circulation around all sides of the pallets and good ventilation throughout the storage area, as solely determined by the Engineer. At the direction of the Engineer, the cold-storage facility will be repacked according to best forestry practices without any additional compensation to the Contractor. Improper operation, stacking or maintenance of the cold-storage facility may result in the rejection of the planting material, as solely determined by the Department.

The Contractor shall monitor the temperature and humidity levels within the cold-storage facility twice daily and forward this information to the Engineer on a weekly basis. If the temperature or humidity levels are outside the specified guidelines, the information shall be forwarded on a daily basis. Each monitoring shall include at least one (1) air temperature measurement and three (3) separate readings of plant stock temperatures, as measured inside widely spaced shipping containers with probe soil thermometers. The placement of

the probe soil thermometers shall be done in such a manner as not to promote desiccation of the plant materials. Thermometer entrance/exit holes shall be tightly sealed at the time of both placement and removal of the thermometer.

Construction Methods:

(a) General: All work and materials shall be subject to direction and approval by the Department. For this work, the Department may contract a Professional Forester to augment the staff of the Engineer and to supervise the actual planting operations, including the inspection and acceptance of the materials and the planting. When designated by the Department, this individual shall serve as the Department's project representative as it relates to this specification. This individual shall have the authority of the Engineer. The work of the Professional Forester is subject to approval by the Engineer.

A key responsibility of the Contractor is the proper tending of the planting stock throughout all phases of the reforestation program. During all work, including plant transport, offsite or onsite storage and onsite plant handling, the plant material shall be handled carefully to prevent injuries and desiccation. The plants shall be kept from freezing and kept covered, moist, cool, and out of the wind and sun. During all phases of this work, all shipping bags, shipping boxes, and plants shall be handled gently, according to best forestry practices, as solely determined by the Engineer.

(b) Planting Method and Tools: The planting method utilized shall correspond to the method specified on the plans. Unless indicated on the plans, tublings and plugs shall not be planted using OST or KBC planting bars. At the written direction of the Department, an alternative method may be substituted and may include the use of various planting tools (including shovels), power augers to develop the planting holes, specialized planting tools, or mechanized planting tools. If the Contractor wishes to use different planting tools, the Engineer may require the Contractor to submit a planting methodology for prior approval. If power augers are utilized, these augers shall possess tapered bits specifically designed for reforestation work. When power augers are utilized, the Engineer may require the use of deglazing tools to promote root growth. If power augers are authorized for use, the Contractor shall have onsite at all times at least the minimum number of hand tools necessary to hand plant the stock while fully utilizing all members of the planting crew.

(c) Planting Window: Planting shall begin as soon after *INSERT DATE*, as weather and ground conditions permit, as solely determined by the Engineer. Within five (5) days of the starting date, the Contractor shall have at least one (1) planting crew and one crew boss onsite ready to commence planting. Unless directed by the Department, all planting shall be completed by *INSERT DATE*. If specified on the plans, containerized stock may be planted from October 1 to March 1 provided the soil is not frozen or air temperatures are not freezing. Planting outside the specified planting window may only occur with the written permission of the Department. The Department may elect not to

authorize plantings outside the specified planting windows without any compensation to the Contractor including plant material or labor costs.

(d) Planting Conditions: Trees shall not be planted in frozen ground or during periods of freezing air temperatures. The Department may stop planting due to weather or any other conditions that are not favorable to tree planting. Unsatisfactory planting conditions include, but are not restricted to, temperatures above 60 ^{o}F (*NOTE: THIS TEMPERATURE CEILING SHOULD BE VERIFIED FOR LOCAL CONDITIONS)*, relative humidity below forty percent (40%), wind speed greater than ten (10) miles/hour, or available soil moisture less than fifty percent (50%). Planting may also be postponed if ground-freezing temperatures are forecasted for several days immediately following the planting. If directed by the Engineer, all planting materials shall be immediately returned to the cold-storage facility or placed in the refrigerated vehicle.

(e) Vehicular Traffic: Vehicular traffic shall be subject to restrictions as specified on the plans or as directed by the Engineer. On a bedded or ripped site, the movement of vehicles shall be performed in such a manner as to limit, to the maximum practical extent, damage to the beds or rips.

(f) Planting Sequence: The planting sequence shall be as shown on the plans or as directed by the Engineer.

(g) Planting Crew Personnel Requirements:

1. Unless specified on the plans or approved by the Department in writing, each planting crew will consist of a minimum of twelve (12) planters, a maximum of twenty (20) planters, and one (1) crew supervisor (crew boss).

2. Unless specified on the plans or approved by the Department in writing, the Contractor will provide at least one (1) qualified crew for the duration of planting. Switching to new crews or replacing one (1) crew with another will not be permitted, unless special advanced permission is given by the Department.

3. Non-English-speaking crews will have a crew supervisor who is competent in the English language.

4. Planting crew members who are not U.S. citizens shall be legally employable if the U.S. Green cards are available for examination.

5. The Contractor shall maintain liability insurance and any other insurance required by *[INSERT STATE]* law. Proof of insurance must be provided to the Department prior to commencing any planting operation.

6. The Contractor shall have a current *INSERT STATE* Business License. A copy of the license will be furnished to and kept on file with the Department before any planting activities begin.

7. Planting crew members shall be properly clothed. It is the sole responsibility of the Contractor to ensure that the planting crews have the proper work shoes. Depending on site conditions, rubberized waterproof boots with heavy soles may be required by the Department.

8. Unless directed in writing by the Department, warming fires or trash-burning fires are prohibited. If warming fires are allowed, these fires shall not occur within one hundred (100) feet of areas where seedlings are being handled.

9. If directed by the Engineer, crew members whose work is deemed unsatisfactory, as solely determined by the Engineer, shall cease all planting. These individuals may engage in other work activities, but not the actual planting. Dismissed planting crew members shall be replaced with new qualified workers within two (2) working days.

(h) Seedling/Sapling Care, Handling, Root Pruning, and Culling:

1. During transport from the cold-storage facility to the construction site or from the site to the cold-storage facility, the planting materials shall be kept from freezing and kept covered, cool, moist, and out of the wind and sun. At the time of onsite delivery, stock temperature shall not exceed 39 ^{o}F. Transport vehicles shall be capped trucks or trailers with good means of ventilation. Plant transport vehicles shall not be open-bed vehicles. The shipping compartment shall be insulated from the exhaust system of the vehicle. Unless freezing temperatures exist and unless directed by the Engineer, the transport compartment shall not be heated. When transporting materials to or from the cold-storage facility, shipping containers shall not be stacked more than two (2) high. At least twelve (12) inches of air space between the top of the shipping containers and vehicle cover shall be maintained when packing the plants. The containers shall then be covered with secured thermal-reflective tarps (WHITE SIDE UP), and nothing else shall be placed on top of the shipping containers. If any shipping container is damaged, immediately tape the damaged opening and inform the Engineer.

Each morning, the Contractor shall arrange for sufficient stock to be transported from the cold-storage facility to the site for that morning's plantings. Later in the day, the Contractor shall arrange for additional shipments from the cold-storage facility sufficient to complete the afternoon's planting. With the written approval of the Department, the Contractor may transport sufficient stock in the morning to serve the whole day's planting needs. However, the Engineer may reject or withdraw approval of such a request. At no time shall the number of plants at the site exceed that day's planting allowance for that site. At the end of the work day and without exception, all planting materials not installed

shall be returned immediately to the cold-storage facility, utilizing the same handling procedures.

2. At the work site, the transport vehicles shall be parked in a shaded location and away from the wind. The shipping containers shall then be off-loaded and stockpiled in a location free of standing water as previously approved by the Engineer. Ideally, this location shall provide natural shade and protection from wind. Prior to stockpiling, spacer boards shall be placed on the ground to support the stockpiling. These spacer boards may be two (2)- by four (4)-inch lumber, three (3)-inch-diameter polyvinyl choride pipe, or another material as approved by the Engineer. The entire stockpiling area or field cache shall then be shaded with light-colored tarp whose boundaries shall extend a minimum of three (3) feet beyond the limits of the spacer boards on all sides. Thermal-reflective tarps (WHITE SIDE UP) shall then be placed over the stockpiled materials in a manner that shall ensure that top and all sides of the shipping containers are covered by the thermal-reflective tarps. Shipping containers shall not be stacked more than two (2) high, and stacking practices shall allow for good air circulation between the containers.

If wind speeds exceed ten (10) miles/hour, a wind barrier shall be erected adjacent to the stockpiling area, subject to approval by the Department. With the approval of the Department, the Contractor may elect to utilize the transport vehicle as a temporary storage area, subject to the above restrictions and guidelines, including the placement of thermal-reflective tarps.

3. Shipping containers shall be handled gently at all times. Shipping containers shall be placed gently in the correct stockpiling positions. Shipping containers shall not be thrown to the ground, into a stockpiling area, or between workers.

Shipping containers shall be opened by cutting the binding strap, pulling the binding tab, or another approved method, as determined by the Engineer. Opening the shipping container with a planting tool, a knife puncturing the shipping container, or any other method not specifically approved by the Engineer shall be prohibited.

4. Transfer of plants from the shipping container to the planting bags or tubling carriers shall occur in the shade provided by the stockpiling areas and out of the wind to the maximum extent practicable. Except when actively transferring planting materials from the shipping container to the planting bag or tubling carrier, the shipping container shall remain tightly closed and always out of direct sunlight, supported by spacer boards, and shaded with a thermal-reflective tarp (WHITE SIDE UP). Unless all stock will be immediately transferred to planting bags, only one (1) shipping container of a single species shall be opened at any field stockpiling site during planting operations.

With bareroot stock, remove only one (1) handful of seedlings at a time from the shipping bag/box. Separate and carefully untangle this handful and immediately place it in the planting bag. Separate and untangle only enough seedlings to fill the planting bag gently to the desired volume or as directed by the Engineer. Do not separate and untangle

an entire container or an advance quantity of trees. If plug stock is specified, with the permission of the Engineer, the polyethylene shipping bags may be placed directly into the planting bag. Following transfer to the planting bag, the shipping container shall be immediately closed and placed under the protective thermal-reflective tarp. Except when actively planting or opening a shipping container, all stock shall be shaded and covered with thermal-reflective tarps.

The planting bags or tubling carriers shall not be overpacked, as determined solely by the Engineer. The number of trees that can be placed into the planting bag shall be limited to the number that can be planted in a two (2)-hour period. At any time, the Engineer may limit the number of trees that can be placed into the planting bag to a one (1)-hour planting supply. The placement or removal of trees from the planting bag or tubling carrier shall not result in bruised, torn, or otherwise damaged trees.

Unless written permission is granted by the Department, tubling stock shall not be extracted from the cell at the stockpile areas. Tublings shall be extracted from the cell only as part of the actual planting procedure.

5. Plans will typically specify that the plantings occur as mixes of several species and not as monocultures of a single species. When mixes of species are specified, the planting bags shall be packed in the approximate ratios required to naturalize/randomize the plantings as specified on the plans or as directed by the Engineer. It is the sole responsibility of the Contractor to ensure that the plantings are naturalized/randomized as specified on the plans.

Trees shall be planted in the areas designated on the plans. If an area is planted in monoculture or an inappropriate mix, as solely determined by the Engineer, at the direction of the Engineer, the planting or a segment of the planting shall be removed and the plants discarded. The area will then be replanted as specified. No compensation for the discarded plants, the cost of the installation of the discarded plants, or the cost of the removal of the discarded plants shall be made by the Department.

6. Unless specifically directed by the Engineer, no pruning, pulling, or pinching of the taproot or lateral roots shall occur in the field.

7. Field culling of seedlings shall be performed to the specifications of the Engineer. If frozen trees are found, the Engineer shall be informed immediately. Unless directed by the Engineer, these frozen trees shall not be planted and are subject to rejection without compensation for the materials.

8. Unless directed by the Engineer, clay-coated or gel-coated bareroot stock shall not be watered, nor shall water be added to the bareroot shipping containers containing coated stock. Tubling stock and plug stock shall be watered as necessary to maintain moist soils and root systems. If dipped in water, the stock shall not be placed in the water for more than one (1) minute. The watering shall be gentle and shall not result in the removal of

soil from the stock. Water shall not be allowed to puddle in the shipping containers, as excess water can drown root tips and promote mold on the trees.

9. At all times, trees in planting bags shall be kept moist. If directed by the Engineer, tree planting bags shall be lined with moist burlap cloth. Because clay-treated trees have been specified, the bareroot trees shall not be carried in moss-lined planting bags or in bags holding a water slurry.

10. Shade moves with time. It is the sole responsibility of the Contractor to ensure that, once materials are stockpiled in the field stockpiling sites, the plant materials remain shaded as the day progresses.

11. Unless directed by the Engineer, tree counting shall be prohibited. Quantities shall be determined via packing counts.

12. One shall not allow the trees to be exposed outside the shipping container or planting bag for more than two (2) minutes. Additional exposure time shall not be allowed for counting trees. At the direction of the Engineer, this exposure time may be reduced to one (1) minute.

13. One shall protect the trees from damage. One should not crush, stand, or sit on any tree or shipping container. One shall not abuse the seedlings/saplings by hitting the roots or striking the roots across an object to remove excess soil. At no time shall the clay emulsion or attached soil that covers the roots be beaten, removed, rinsed, caused to flake off, or otherwise damaged. One shall not tear the roots while handling or planting the trees.

14. When planting with an OST bar, KBC bar, cylindrical dibble, plug extractor, or power auger, only one seedling at a time shall be removed from the planting bag to avoid root drying and physical damage caused by contact with the handle of the planting bar. The tree shall be removed from the planting bag only after the planting hole or slit has been made in the ground.

15. When planting with a hoedad, planters should not carry more than three (3) trees in their hands at one time. The Engineer may specify the maximum number of trees that can be carried, based on weather conditions and work practices. At any time, the Engineer may specify that only one (1) tree can be carried in hand.

16. Once the trees have been removed from the shipping containers, the trees shall be planted immediately. Once placed in the planting bag, trees shall not be subsequently replaced back into the shipping containers. Prolonged or unnecessary exposure of trees while in planting bags shall not be allowed. Planting bags shall not be used for tree transport or for temporary storage. When not in active use, including break periods, empty planting bags shall be kept shaded.

17. Planting tools shall not be utilized to maneuver the tree or roots into any planting hole. Planting holes shall be large enough to allow easy placement of the tree at the appropriate depth without tangling, catching, or forcing upward the orientation of the root system.

18. Wax-impregnated boxes, tubes, tube racks, plant trays, shipping materials, and all crew debris shall not be left onsite, but shall be disposed of by the Contractor. Cost for this disposal shall be incidental to this item.

19. The Contractor shall maintain a sufficient supply of fresh water on site for any water needs during the planting operation.

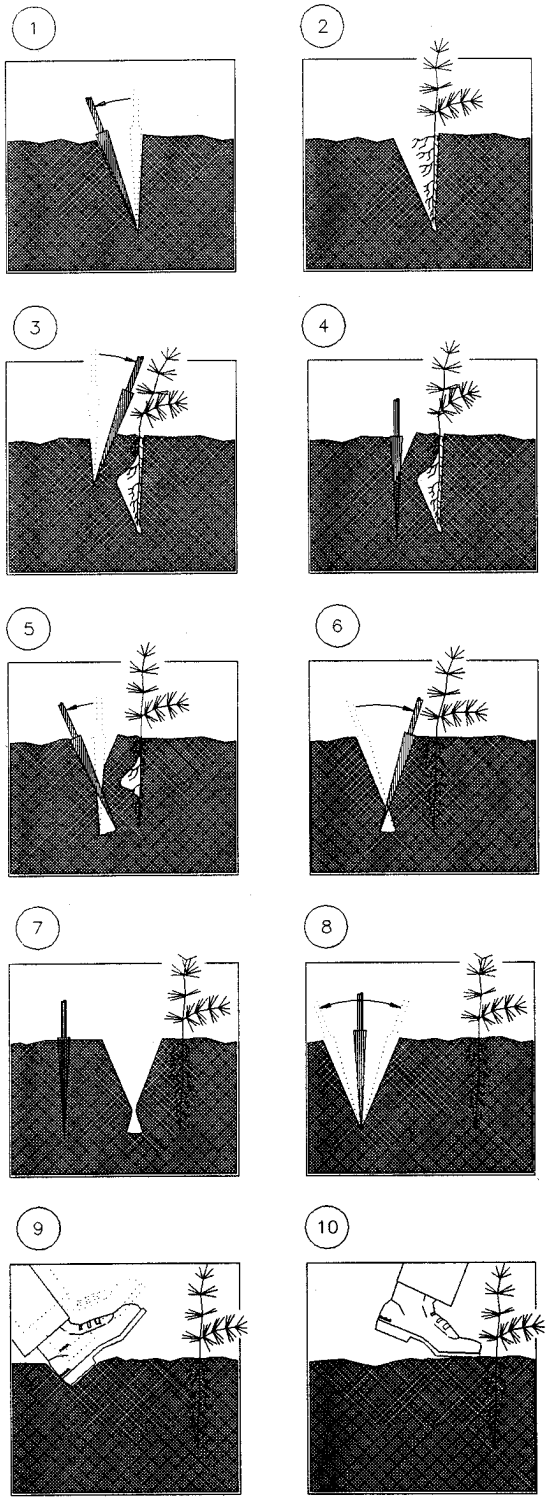
(i) Planting Spot: At the proper spacing, one shall pick a location free of debris (duff, leaves, wood, litter, grass, trash, etc.). On a bedded site, the planting locations shall be on the raised bed in the highest topographic positions. On a ripped site, the planting locations shall be in the base of the rip furrow. If no acceptable spot free of debris is available, one shall clean the debris off a planting spot to expose the mineral soil by raking the debris away with the foot, planting tool, or other means acceptable to the Engineer. Plants shall not be placed in standing water. Unless shown on the plans or directed by the Engineer, one shall place trees in the highest microtopographic positions. Planting in a waterlogged location is likely to result in J-rooting. Planting without proper removal of the debris is likely to lead to J-rooting or unwanted air pockets that will cause the roots to desiccate.

(j) Planting - OST Bar (Dibble Bar) and KBC Bar:

1. As illustrated in Figure H1, one shall insert the entire usable blade of a planting bar straight down into the soil near the center of the planting spot and open the planting hole by firmly pulling back the bar handle (the planting bar shall be used so that the blade is parallel to the planter's front side). Where soil conditions permit, no rocking of the planting bar shall occur, as solely determined by the Engineer. Where the soil is tight and the hole does not open cleanly, rock the handle back and forth until a clean hole is formed. However, excessive rocking of the bar during its insertion can result in an "hourglass hole," which will be difficult to plant or close properly because of the creation of a constriction point below which a large air pocket can form. "Hourglass hole" plantings will not be accepted. Excessive rocking can also cause the soil in the planting hole to be compacted.

The hole needs to be large enough so that the tree roots can be placed in a nearly natural position and deep enough to accept the entire root structure without the development of J-rooting, L-rooting, or binding of the roots during the planting operation.

2. Remove the planting bar from the planting hole. Remove a tree from the planting bag and immediately place the tree into the planting hole. The tree roots shall be gently placed into the planting hole so that the root collar of the seedling is one (1) or two



1. INSERT THE PLANTING BAR STRAIGHT DOWN INTO THE SOIL TO THE FULL DEPTH OF THE BLADE AND PULL BACK ON THE HANDLE TO OPEN THE PLANTING HOLE. (DO NOT ROCK THE PLANTING BAR BACK AND FORTH AS THIS CAUSES SOIL IN THE PLANTING HOLE TO BE COMPACTED, INHIBITING GROWTH.)
2. REMOVE THE PLANTING BAR AND PUSH THE TREE ROOTS DEEP INTO THE PLANTING HOLE. PULL THE TREE BACK UP TO THE CORRECT PLANTING DEPTH. GENTLY SHAKE THE TREE TREE TO ALLOW THE ROOT TO STRAIGHTEN OUT. DO NOT TWIST OR SPIN THE TREE OR LEAVE THE ROOTS J-ROOTED.
3. INSERT THE PLANTING BAR SEVERAL INCHES IN FRONT OF THE TREE AND PUSH THE BLADE HALFWAY INTO THE SOIL. TWIST AND PUSH THE HANDLE FORWARD TO CLOSE THE TOP OF THE SLIT TO HOLD THE TREE IN PLACE.
4. PUSH THE PLANTING BAR DOWN TO THE FULL DEPTH OF THE BLADE.
5. PULL BACK ON THE HANDLE TO CLOSE THE BOTTOM OF THE PLANTING HOLE.
6. PUSH FORWARD ON THE HANDLE TO FIRM SOIL ON TOP OF ROOTS AND TO CLIMINATE AIR POCKETS AROUND THE ROOT.
7. INSERT PLANTING BAR 2 INCHES FROM LAST HOLE.
8. PUSH FORWARD, THEN PULL BACKWARD TO FILL PREVIOUS HOLE.
9. REMOVE THE PLANTING BAR AND FIRM UP THE OPENING WITH THE HEEL.
10. FIRM THE SOIL AROUND THE TREE WITH THE FOOT. BE CAREFUL TO AVOID DAMAGING THE TREE.

Figure H 1. Reforestation planting procedure with KBC/OST bar (dibble bar)

(2) inches below the desired planting depth, but not far enough to damage the tree roots (Figure H2). The tree shall then be pulled gently upward until the desired planting depth is reached, as shown in the details. The tree shall be shaken slightly to loosen and spread the roots. The tree roots shall be in a nearly natural position, orientated downward and outward. The root collar shall be placed so that the collar is one (1) inch below the groundline at the planting spot.

3. One shall secure the tree in place at the proper planting depth with soil. This is done by inserting the planting bar about two (2) inches behind the tree and parallel to the planting hole, pushing the blade about halfway straight down. While holding the tree at the proper depth with the hand, the handle of the planting bar should be pushed forward, causing soil to move forward, thereby closing the planting slit and holding the tree temporarily in place.

4. The planting bar shall be pushed down to the full length of the usable blade. To close the bottom of the planting hole, one shall pull back firmly on the bar handles. This packs the soil against the tree roots at the bottom of the planting hole, tightens the soil around the bottom of the roots, and prevents air pockets. Next, the bar handle shall be pushed forward to pack the soil firmly against the entire portion of tree in the ground and to prevent any air pockets from forming around the roots. If necessary to remove the bar from the ground leaving a clean closing hole, the bar may be rocked back and forth prior to withdrawal.

5. One shall move back away from the tree about two (2) inches more and insert the planting bar into the soil the full length of the usable blade. One shall twist the planting bar to loosen soil, then firmly push forward and then back on the bar, filling the previous hole. This closing hole shall be filled by firming (stamping) with the heel and toe or by other methods approved by the Engineer. Then one shall apply firm foot pressure immediately adjacent to the tree. This is done to compact the soil, ensure proper planting, and eliminate air pockets. Firm foot pressure shall be applied in several different positions immediately adjacent to the tree. If directed by the Engineer, the placement of firm foot pressure shall occur while maintaining a gentle hold of the tree, thus promoting vertical placement of the tree.

One shall not step on, bruise, or walk through the tree, or cause the tree to lean. A check for tightness by pulling gently on the tip of the tree.

(k) Planting - Hoedad Tool:

1. As illustrated in Figure H3, one shall strike the planting spot with the blade almost vertically, with the full depth of blade into the soil, as shown in the detail. To break the soil loose at the bottom of the hole one shall pull up on the handle. Raising the handle more than a few inches shall be avoided; otherwise, the hole will fill with soil, and the tree will be shallow-rooted and unacceptable.

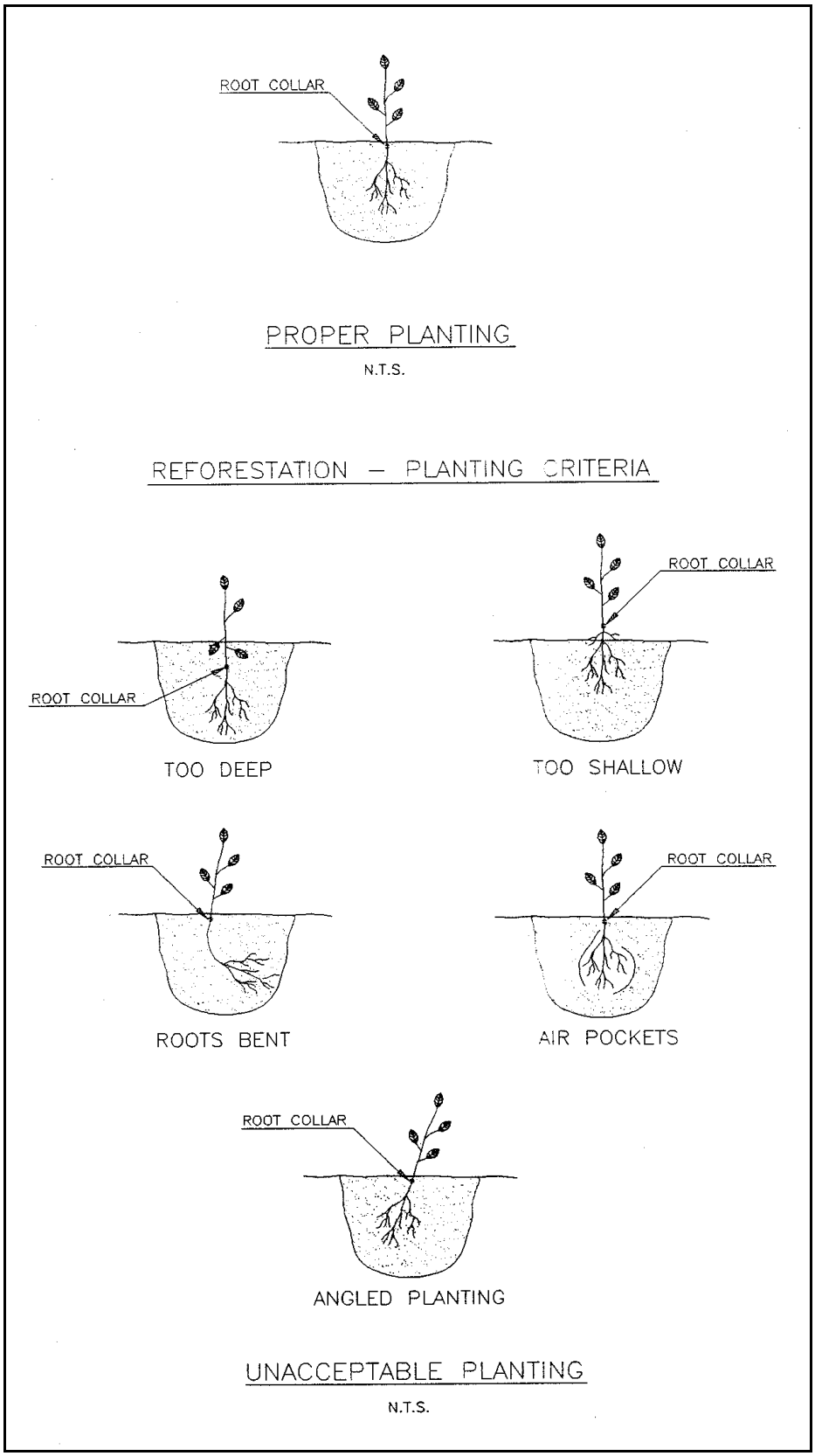
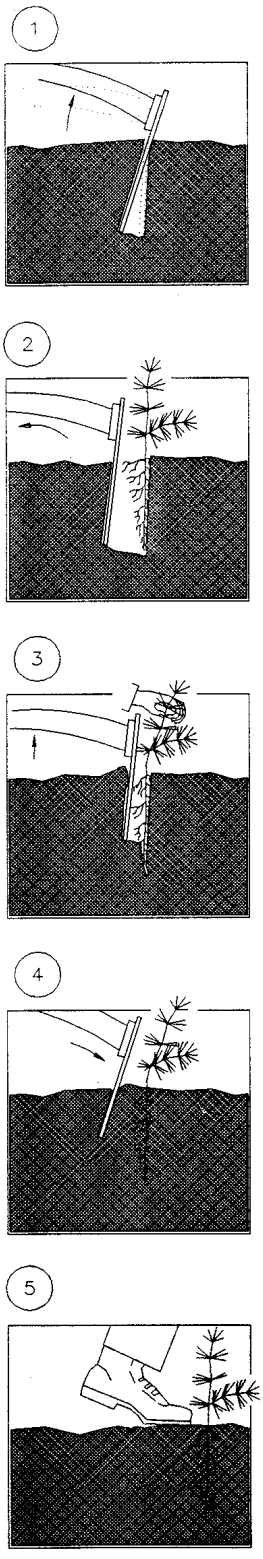


Figure H 2. Reforestation -- planting criteria



1. STRIKE BLADE ALMOST VERTICALLY, FULL DEPTH OF BLADE, INTO THE SOIL. PULL UP ON THE HANDLE TO BREAK THE SOIL LOOSE AT THE BOTTOM OF THE HOLE. CAUTION – AVOID RAISING THE HANDLE MORE THAN A FEW INCHES. OTHERWISE THE HOLE WILL FILL WITH SOIL AND THE TREE WILL BE SHALLOW ROOTED.

2. SLIDE HAND DOWN HANDLE ALMOST TO THE BLADE. PULL BACK AND DOWN ON THE HANDLE TO FORM A POCKET ON THE FAR SIDE OF THE BLADE. WITH THE OTHER HAND, IMMEDIATELY PLACE THE TREE ROOTS INTO THE POCKET TO THE FULL DEPTH OF THE HOLE.

3. HOLD TREE IN PLACE WHILE SLIDING THE HOEDAD BLADE OUT OF THE HOLE. LOOSE SOIL SHOULD FALL INTO THE HOLE, HOLDING TREE IN PLACE.

4. PULL BLADE COMPLETELY OUT OF THE HOLE AND PUSH SOIL AGAINST PLANTED TREE WITH THE TIP OF THE BLADE.

5. USE FOOT TO FIRM THE SOIL AGAINST THE TREE. DO NOT STEP ON OR BRUISE TREE WITH YOUR FOOT.

Figure H 3. Reforestation planting procedure with hoedad

2. One shall slide one hand down the handle almost to the blade. Pulling back on the handle forms a pocket on the far side of the blade. With the other hand, one shall immediately place the tree roots into the pocket to the full depth of the hole. The tree roots shall be placed gently into the planting hole so that the root collar of the seedling is one (1) or two (2) inches below the desired planting depth, but not far enough to damage the tree roots. The tree shall then be pulled gently upward until the desired planting depth is reached, as shown in the details. The tree shall be shaken slightly to loosen and spread the roots. The tree roots shall be in a nearly natural position, orientated downward and outward. The root collar shall be placed so that the collar is one (1) inch below the groundline at the planting spot.

3. One shall hold the tree in place while sliding the hoedad blade out of the hole. Loose soil should fall into the pocket, holding the tree in place.

4. One shall pull the blade completely out of the hole and push soil against the planted tree with the tip of the blade.

5. Next, firm foot pressure shall be applied immediately adjacent to the tree. This is done to compact the soil, ensure proper planting, and eliminate air pockets. Firm foot pressure shall be applied in several different positions immediately adjacent to the seedling/sapling. If directed by the Engineer, the placement of firm foot pressure shall occur while maintaining a gentle hold of the tree, thus promoting vertical placement of the tree.

One shall not step on, bruise, or walk through the tree, or cause the tree to lean. Checking for tightness is done by pulling gently on the tip of the tree.

(l) Planting Cylindrical Dibble or Plug Extractor:

1. One shall locate the planting tool in the center of the planting spot, orient the tool vertically (straight down), and apply firm pressure on the footstep so that the planting tool penetrates to the full design depth. The hole created shall be within 10° of vertical.

2. One shall remove the planting tool and examine the planting hole. The planting hole created shall be clean and conform to the shape of the dibble head or desired plug dimensions. If the planting hole does not conform to the required shape because of sloughing soil, the tool may be inserted again. If the planting hole still does not conform to the shape of the desired dimensions, the hole shall be abandoned and a new planting spot selected. If the planting hole results in a large air pocket that cannot be easily closed with foot pressure, the hole shall be abandoned and a new planting spot selected.

If the planting hole is satisfactory, one shall gently remove a tubling from the plant tray, plant carrier, or shipping container and carefully remove the tree from the plant tube. Alternatively, carefully remove a plug from the planting bag or plant carrier. Immediately place the tree in the planting hole. The tree shall be placed in the planting hole so that the

top of the tubling root collar or plug rootmass is one (1) inch below the adjacent soil elevation. The tree roots should be in a nearly natural position, oriented downward. The desired planting depth is not the depth grown in the nursery, but one (1) inch deeper.

3. While placing the tree in the planting hole, one shall not force it into the planting hole. The root system shall not be compressed, twisted, screwed, or balled-up.

4. With the foot, scrape enough soil from the surrounding area to close the planting hole fully, thus covering the soil surface of the tubling or plug to an elevation that is slightly higher than the adjacent soils, as shown on the details. A poorly closed planting hole or the exposure of the soil surface of the tubling or plug will promote desiccation of the tree and the wicking of soil moisture.

5. After the tree is placed at the appropriate depth and the soil surface of the tubling or plug is covered with soil, one shall apply firm foot pressure immediately adjacent to the tree. This is done to firm the soil, ensure proper planting, and eliminate air pockets. Firm foot pressure shall be applied in several different positions immediately adjacent to the tree. If directed by the Engineer, the placement of firm foot pressure shall occur while maintaining a gentle hold of the tree, thus promoting vertical placement of the tree. The resulting placement of the tree shall result in the top of the rootmass being one (1) inch below the soil surface with the planting hole being totally closed with firmed soil and without the presence of air pockets adjacent to or underneath the tree.

One shall not step on, bruise, or walk through the tree, or cause the tree to lean. To check for tightness one shall pull gently on the tip of the tree.

(m) Tree Shelters: When specified on the plans, tree shelters shall be installed at the designated density. The type of tree shelter shall be as shown on the plans or an approved equivalent. All work shall be done so as not to injure the trees or shrubs, bruise or cut the bark, or remove leaves or branches. Following installation of the tree shelters, the branches shall be in an upright position and no branches shall be pointing downward or toward the ground. The placement and securing of the stakes shall not result in entanglement of the trees shoots or branches with the stake ties. Installation methods for the tree shelters shall be as shown on the plans or manufacturer's instructions with the entire bottom surface of each shelter in contact with the soil. If directed by the Engineer, soil shall be mounded around the entire bottom of each shelter. If stake dimensions shown on the plans are larger than the manufacturer's recommendation, the stake dimensions shown on the plans shall be utilized. Improperly installed shelters shall be reinstalled as directed by the Engineer at no additional cost to the Department. Defective shelters, shelters damaged or weakened during transport or installation, shall not be accepted, as solely determined by the Engineer. ***EDITING REQUIRED:*** Browse guards shall (shall not) be placed as part of the shelter installation with all costs incidental to this item.

(n) Acceptance:

1. One (1) tree shall be planted in a hole large enough to accommodate the root system in a natural position.

2. The hole shall be made in mineral soil that is free from duff, litter, or trash. Holes may not be made in root piles.

3. Trees shall be planted at the depths specified. Excessively deep or excessively shallow planting shall not be accepted. Details show illustrations of unacceptable and acceptable plantings.

4. Trees shall not be damaged by planting.

5. The main taproot shall be planted straight without "U" roots, "J" roots, or "L" roots to the maximum extent practicable, as solely determined by the Engineer.

6. Lateral roots shall not be twisted, screwed, wrapped, or balled-up.

7. Trees shall stand upright with no more than 20° of lean.

8. The hole shall be filled in both at the bottom and at the top, and packed firmly without injuring the bark of the tree.

9. Trees shall be planted at the prescribed spacing to give the desired stocking and in the locations shown on the plans.

10. Trees shall be planted so that they are visibly tight, are not loose in the ground, and can withstand being pulled from the ground by the terminal bud.

11. If the installation of tree shelters has been specified in the plans, final acceptance of the planting shall not occur until acceptance of tree shelters. Acceptance for self-staking conical shelters shall be made no earlier than seven (7) days following installation.

All work is subject to approval by the Engineer. The Engineer will notify the Contractor of any noncompliance with the foregoing requirements. After receipt of such notice, the Contractor shall immediately take corrective action. Such notice, when delivered to the Contractor or the Contractor's representative at the site of work, shall be deemed sufficient for the purpose of notification. If the Contractor fails or refuses to comply promptly, the Engineer may issue an order stopping all or part of the work until satisfactory corrective action has been taken. No part of the time lost due to any such stop orders shall be made the subject of claim for extension of time or excess cost or damages to the Contractor.

(o) Plant Establishment Period: There is no plant establishment period for Reforestation.

Method of Measurement:

Reforestation shall be measured by the number of each plant installed and accepted.

EXAMPLE TABLE

Bareroot Hardwood and Pine	Each
Atlantic White Cedar Tublings	Each
Spruce Plugs	Each

Basis of Payment:

Payment for Reforestation shall be paid for at the unit bid price each for the various items of the planting schedule accepted, which price and payment shall constitute full compensation for furnishing all plants, cold-storage space, labor, materials, tools, equipment, tree shelters, water, and incidentals necessary to complete the item.

Appendix I

Bedding for Reforestation

Description:

Bedding for Reforestation shall consist of the construction of raised planting beds and planting mounds for reforestation projects as designated on the plans or accompanying details, or as directed by the Engineer.

Materials:

All bedding harrows and tractors utilized are subject to approval by the Department. Within thirty (30) days of the award of the contract, the Contractor shall supply the Department with the name and model number of the bedding harrow and tractor, and the harrow and tractor manufacturer's guidelines for equipment size, power, and drawbar pounds pull. The width of the hourglass roller and the overall width of the tractor, as measured from outside track to outside track, shall be included with this information.

The planting beds shall be constructed utilizing a heavy-duty bedding harrow. The bedding harrow shall have a minimum net weight of 3,500 pounds. Unless specified on the plans, the bedding harrow shall have a maximum disk cut width of 8.0 feet and a minimum disk cut width of 6.0 feet. The bedding harrow shall have an hourglass roller with a maximum width of 8.0 feet and a minimum width of 6.5 feet. The bedding harrow used shall be the Series T1R, TRBR, or TRBW, Heavy-Duty Bedding Harrows, as manufactured by Rome Industries, Inc., Cedartown, GA, or Model BH-6, as manufactured by Marden Manufacturing Company, Inc., Auburndale, FL, or an approved equivalent.

The disking tool shall possess a minimum of six (6)disk blades, each with a minimum diameter of thirty (30) inches and a minimum disk thickness of one-half (0.5) inch. Each disk blade shall be a cutout (notched) blade. It is the Contractor's responsibility to ensure that the disking operation, disking width, and disk sizes employed provide sufficient soil for the mounding operation and that the resulting mounds are compacted by the hourglass roller.

A crawler-tracked tractor shall be utilized for the bedding operations. The tractor shall conform to the bedding harrow and tractor manufacturer's guidelines for minimum size, power, and drawbar pounds pull at the bedding harrow's full weight (roller water-filled) for the onsite soil conditions. The tractor shall have the hydraulic lines and characteristics necessary for proper operation of the bedding harrow as designed and recommended by the manufacturer of the bedding harrow. If directed by the Engineer or indicated on the plans, the hourglass roller shall be filled with water to the maximum capacity of the roller. It shall be the Contractor's responsibility to ensure that all equipment possesses sufficient power and is of appropriate design and weight distribution to complete the construction of the mounds as specified.

Unless specified on the plans, the bedding shall be conducted in irregular patterns and not in straight or parallel rows. When irregular bed patterns are constructed or when instructed by the Engineer, the width of the tractor utilized shall not exceed the width of the hourglass roller. Whenever possible, the widest allowable roller shall be utilized. When directed by the Engineer, the tractor shall be a Caterpillar D4 Series, Komatsu D3 Series, or an approved equivalent.

It is the Contractor's responsibility to ensure that the equipment possesses sufficient power and is of appropriate design and weight distribution to work in wet soils.

Construction Methods:

The bedding shall be performed within the areas shown on the plans. Unless directed by the Engineer or indicated on the plans, the bedding pattern shall be random over the entire area except for the final bedding patterns shown on the plans. This random bedding pattern requirement mandates that the harrow repeatedly cross over newly made beds. Unless shown on the plans, bedding patterns conducted in straight lines shall be rejected without compensation to the Contractor. The tractor equipment shall have sufficient power to conduct these crossing operations efficiently, as solely determined by the Engineer. The bedding configuration shall be an irregular pattern and as shown on the plans and as directed by the Engineer. The Contractor shall pass the bedding harrow over the entire area designated for bedding at least twice prior to the final bedding runs. The Engineer may request additional passes, with the cost being incidental to the item. Final bedding runs shall consist of two parallel rows of the bedding harrow adjacent to each other in order to form a channel. The bed height developed shall be a minimum of twelve (12) inches tall as measured from the top of the mound to the bottom of the adjacent side furrows. If directed by the Engineer, the roller shall be occasionally lifted for short distances (ten (10) – twenty (20) feet) during the bedding operations.

The harrow shall be operated at a speed directed by the Engineer which shall be between two (2) and six (6) miles per hour. The construction of the planting beds shall occur during the specified work window, as shown on the plans or as directed by the Department. The Engineer may delay bedding because of dry soil conditions without any additional compensation to the Contractor. Commencement of the bedding operations shall begin within seven (7) days of the direction by the Engineer.

OPTIONAL PARAGRAPH: Depending on field conditions and the presence of clayey soils, as solely determined by the Engineer, the Engineer may direct the Contractor to disk/plow the area to be bedded with a heavy-duty disk or a deep tillage subsoiler prior to the actual bedding operations. The use and operation of a heavy-duty disk or subsoiler shall be incidental to this item, and no additional compensation shall be made by the Department.

Method of Measurement:

The quantity of Bedding for Reforestation to be paid for under this section shall be the number of square yards of beds placed to the limits shown on plans, measured as the horizontal plan surface area of the vertical projection of the limits, and measured once at the end of bedding operations, conforming with all the requirements of these specifications, complete and accepted.

This item also includes any other work specified on plans as incidental to this item.

Basis of Payment:

Bedding for Reforestation shall be paid for at the contract unit price per square yard bid and accepted for Section XXXXXX - Bedding for Reforestation, which price and payment shall constitute full compensation for all labor, equipment, tools, and incidentals necessary to complete the work.

Appendix J

Planting Freshwater Emergent Marsh

Description:

This work shall consist of furnishing the specified herbaceous plants and their proper planting by approved methods, as hereinafter specified, in the locations shown on the plans and as directed by the Engineer. Unless specified on the plans, no fertilizer shall be placed as part of the planting, and all references to fertilizer or fertilizer placement shall be omitted from this work.

Definitions:

Bulb, corm, tuber (BCT) shall be defined as various types of underground stems but does not include rhizomes, as defined in (Radford, et al.).[1]

Rhizome shall be defined as a horizontal underground stem.

Stolon shall be defined as an indeterminate, elongated, aboveground propagative stem with long internodes, capable of rooting at the tip and forming new plants. Runner and stolon shall be equivalent.

Dormant shall be defined as plant materials that are in an overwintering condition, that are cold hardy, and that are not actively producing new leaf or stem tissues. Dormancy shall not be defined by proposed planting dates or windows. It is the sole responsibility of the Contractor to ensure that when dormant materials are specified, the plants meet this definition.

The diameter of the stock shall be defined as the average length of the long and short center axes of the stock, as determined by the Engineer.

Local and nonlocal plant material sources shall be as determined by the Department.

NOTE: THE DEFINITIONS FOR LOCAL AND NONLOCAL MAY HAVE TO BE EXPANDED.

Materials:

(a) Plants*:* Plant materials shall conform to **one (1) or more** of the below categories for the stock type shown on the plans, as determined by the Engineer. Additional information concerning the characteristics of the stock may be shown on the plans. Tubling stock, peat pots, and container stock shall be considered acceptable substitutes for bareroot stock, sprigs,

[1] References cited in this appendix are listed in the References at the end of the main text.

plugs, and stolons. *OPTIONAL WITH EDITS:* All stock shall be free of seed and vegetative propagules of *Phragmites* (common reed), *Lythrum salicaria* (purple loosestrife), *Typhax glauca* (hybrid cattail) and *Myriophyllum spicatum* (Eurasian water-milfoil).

1. Nondormant Stock: All nondormant plants shall be healthy and vigorous with well-developed leaf, stem, and root systems. New root systems of cleaned plants shall be fresh and turgid with a bright color, not blackened. Plants shall appear without significant deleterious leaf spots, leaf damage, leaf discolorations, chlorosis, leaf wilting or curling, disease, or evidence of deleterious insect infestation that could adversely affect the survival or performance of the plants, as solely determined by the Engineer. Types of nondormant stock include sprigs, peat pots, plugs, tublings, containers, and mat stock.

   The minimum stem height of the plant stock shall be as shown on the plans. The minimum number of shoots per plant shall be as shown on the plans.

2. Dormant Stock: When examined, the plants shall exhibit live buds or shoots. For some species, these buds and shoots may be found within the inner tissues of the dormant plants. All stock, including the buds and shoots, shall be turgid, firm, and resilient. Internodes of rhizomes may be flexible and not necessarily rigid. Soft or mushy stock including the shoots and buds shall be rejected. The BCTs shall have a minimum of one (1) viable bud per plant with an appropriate root system or sufficient mass and tissue to allow for the development of vigorous stem and root systems. Each rhizome shall have a minimum of three (3) viable nodes (buds) per plant and be at least four (4) inches in length, or as shown on the plans. If required for the breaking of dormancy, each rhizome shall have the terminal bud removed at the nursery. The stock shall be free of significant deleterious insect infestation and disease that could adversely affect the survival or performance of the plants, as solely determined by the Engineer. Propagules with a blackened surface color are typical of healthy propagules of some species or habitats. Types of dormant stock include bareroot BCTs, rhizomes, stolons, plugs, tublings, sprigs, peat pots, containers, and mat stock.

   The minimum diameter or circumference for all dormant stock shall be as shown on the plans, as measured by the Engineer.

3. Stolons: When examined, the plants shall exhibit live buds or shoots. The stolons shall be firm and resilient. Soft or mushy stolons shall be rejected. Each stolon shall be a minimum of six inches (6") in length and have a minimum of four (4) viable nodes per plant, with sufficient mass and tissue types to allow for the development of vigorous stem and root systems.

4. Sprigs: Sprig material shall be healthy and vigorous with well-developed leaf, stem, and root systems. Unless shown on the plans, the sprigs shall have a minimum of one (1) viable bud per plant with an appropriate root system or sufficient mass and tissue types to allow for strong growth following planting. Rhizomatous species planted as sprigs

shall support a fully developed rhizome of a minimum length of four (4) inches, or as shown on the plans. Soft or mushy sprigs shall be rejected. Unless shown on the plans, all sprig material shall have a minimum aboveground height of twelve (12) inches. Sprig material may be trimmed at the nursery to reduce aboveground leaf/stem length to facilitate handling and reduced physiological stress. However, the trimming shall not damage basal bud tissues or reduce the number of leaves, stems, or tillers that arise from the base. The trimming shall result in a plant whose aboveground leaf/stem tissues are a minimum of twelve (12) inches in length. Roots shorter than ten (10) inches in length shall not be trimmed.

5. Plugs and Tublings: All stock shall comply with the requirements for dormant or non-dormant stock, detailed under this section. Plugs and tublings shall be propagated and grown in cells and not as bedded plants. The size and dimensions of the plugs shall be as specified on the plans for each species. The extracted root system of the stock shall conform to the shape and dimensions of the growing cells without sloughing soil or growth media, as determined during the onsite inspection. Materials not conforming to the dimensions of the cell may be rejected without compensation. The extracted root systems shall have the majority of the roots in vertical orientation. If the horizontal roots are thick and flattened and the root stays in a thick net the shape of the original cell when the media is shaken loose, the plant may be determined to be "pot bound" and shall be considered unacceptable stock.

   Immediately prior to shipment from the nursery, the plug stock shall be removed from the cells and properly packed for transport. Tubling stock shall be shipped to the job site in the growing cells. The use of styrofoam blocks or cells shall be prohibited when culturing stock because of problems associated with fine root penetration into styrofoam walls and torn roots following extraction. Unless shown on the plans, the cell cavities shall have a minimum cavity depth of eight (8) inches, a minimum cavity diameter of one and one-half (1.5) inches, and a minimum cavity capacity of ten (10) cubic inches. The size of the cell should be sufficient to promote the natural root formation and inhibit the crowding and knotting of the root system. The inner surface of the cell wall shall be vertically ribbed the full length of the cell wall in a manner that promotes downward root growth and limits root spiraling. Each cell shall have a minimum of four ribs and a bottom drainage hole. The cell shall be a white or yellow polyethylene. The choice of propagation tubes (cells) and growing shall be subject to approval by the Department.

6. Peat Pots: The peat-potted stock shall have been grown in one and three-fourths (1¾)- to two and one-fourth (2¼)-inch-sided peat pots (or larger size when appropriate for the species) long enough and under proper conditions for the root system to be sufficiently well developed through the sides and bottom of the pot to prevent easy removal of the plant from the pot and to prohibit removal or structural damage to the plant when submerged under water. Plants that can be

removed from the pots by holding the stem growth and gently pulling on the pots shall be rejected without compensation.

7. Container Stock: The container stock shall have been grown in the specified container (or larger size when appropriate for the species) long enough and under the proper conditions for new roots to have developed so that the full volume of the soil mass shall retain its shape and hold together when removed from the container and lightly shaken. Plants that can be removed from the pots by holding the stem growth and gently pulling on the pot or plants whose root system does not occupy the full volume of the pot may be rejected without compensation.

8. Mat Stock: Mat stock shall be defined as plant materials that have been grown in six (6)-inch by six (6)-inch squares of a coconut fiber matrix that is a minimum of one (1)-inch thick and a maximum of two (2)-inch thick, long enough and under the proper conditions for new rhizomes and roots (rootmass) to have developed so that the bulk of the plant rootmass is incorporated into the coconut fiber matrix to the extent that the plants cannot be removed from the fiber matrix without the tearing of the bulk of the rootmass from the plant. More than one (1) plant may be planted in each mat unit, but the goal of the stock type is to produce a dense interwoven rootmass, not a series of individual plants. The rhizome and root matrix of the plant materials shall be incorporated into a minimum of three-quarters of the upper surface of the mat, as viewed from above. Materials where the plants that can be removed from the fiber matrix by holding the stem growth and gently pulling on the stem shall be rejected, as solely determined by the Engineer. Plant materials that pull loose from the fiber matrix blanket once submerged shall not be accepted at the time of installation or at the time of plant acceptance. The coconut fiber matrix shall have a minimum bulk density of XXXXXX and a minimum sheer strength of XXXXXX, or as shown on the plans.

Unless shown on the plans, the number of plants planted in each mat unit shall be judged by the supplier. The height of nondormant mat stock shall be as shown on the plans.

Unless the volume of the specified container is greater than the volume of the peat pot or tubling, peat pots and tublings shall be considered acceptable substitutes for individual plants, with one (1) peat pot or tubling equivalent to one (1) individual plant, subject to approval by the Department. Individual plants grown in pint, quart, or gallon containers or containers larger than specified on the plans shall be considered acceptable substitutes for individual plants, with each container equivalent to one (1) individual plant. These plants shall satisfy the material and planting requirements of container stock, as contained in this specification. If these larger containers are to be utilized, the Contractor shall submit a complete planting method, including tool and fertilizer identification, for approval by the Engineer at least thirty (30) days prior to the intended date of installation. The container stock shall have been grown in that container long enough for new roots to have developed so that the soil mass shall retain its shape and holds together when removed from the container. No additional compensation

for the cost of material or installation shall be made by the Department for plants supplied in larger containers than specified.

For certain plant species, propagation via terminal meristem tissues is required to produce a plant that can readily break dormancy and develop shoots and roots. It is the sole responsibility of the Contractor to ensure that all plant propagules possess the ability to break dormancy readily and grow when properly installed.

All plants may be inspected for viability and specification adherence by the Engineer. Plant materials that are thin and weak for that species shall not be accepted, as solely determined by the Engineer. Materials that represent undersized stock, newly emerged seedlings, undersized seedlings, or materials not conforming with the specifications, as solely determined by the Engineer, may be rejected at the time of delivery, installation, or acceptance without compensation. Undersized stock including seedlings may be planted with the written permission of the Department, but such stock shall be subject to a Plant Establishment Period, as presented in Subsection (p) Plant Establishment Period. Alternatively, the Department may reject the use of undersized stock without any compensation to the Contractor.

(b) Genetic/Elevational/Exposure Origin:

THIS SEGMENT OF THE SPECIFICATION DESCRIBES THE GEOGRAPHICAL, ELEVATIONAL, AND HABITAT ORIGINS OF THE SOURCE MATERIALS AND WILL HAVE TO BE PROVIDED BY THE USER. ONE SHALL VERIFY NURSERY LOCATION.

Plants may be grown in nurseries outside of these geographical and elevational boundaries, subject to approval by the Department, but the immediate genetic origin of the materials must meet the above geographical specifications, as solely determined by the Department. The genetic stock shall be chosen to provide typical forms of the species and include the capacity to bear fertile fruits, as approved by the Department.

(c) Nomenclature: For the herbaceous wetland plants**,** *A Synonymized Checklist of the Vascular Flora of the United States, Canada and Greenland: Volume II; The Biota of North America* (Kartesz and Kartesz, University of North Carolina Press, 1980 or later edition) shall be the authority for the plant names, unless indicated on the plans. The Contractor shall supply certification from the suppliers that the plants supplied are the plants specified or agreed to under substitution. No compensation shall be made for materials or the cost of installation for plant species that are not specified.

OPTIONAL WITH EDITS: **(d) Weighting Requirements:** Except for quart- or gallon-container plant materials, all stock, including peat pots and mat stock, shall be preweighted. If the supplier of the plants offers preweighted plants or agrees to preweight the plants at an additional cost, the Contractor shall purchase preweighted plants from the plant supplier. The method of preweighting shall not reduce the viability of the plants. Only if the supplier does not preweight or shall not agree to preweight the plant materials may the Contractor preweight the individual plants. If the Contractor preweights the plants, the method

of preweighting shall be submitted to the Engineer for review and approval. This weighting may involve the use of No. 8 penny nails or larger nails and No. 8 rubber bands, or as shown on the plans. The use of other methods for weighting is subject to approval by the Engineer. For *Nuphar*, this preweighting shall be accomplished by securing the rhizome tightly to a holed brick or through the use of two lengths of 12-gauge wire wrapped around the outside of the rhizome and extending into the soil a minimum of twelve (12) inches deeper than the bottom of the *Nuphar* rhizome.

If the Contractor or his Landscape Subcontractor possesses a record of successful herbaceous marsh plantings and has the approval of the Engineer, the weighting requirement for individual plantings may be waived. However, the Engineer may reimpose the preweighting and weighting requirements at any time for all or some of the specified species. Bagged and mat plantings shall be weighted.

NOTE: OUTSIDE OF THE BAGGED AQUATIC STOCK, FEW, IF ANY, EXPERIENCED WETLAND MITIGATION CONTRACTORS WILL ENDORSE THE USE OF WEIGHTED MATERIALS. THE WEIGHTING OPTION IS PRIMARILY PRESENTED TO HELP ENSURE THAT THE PLANTS STAY IN THE SOIL AND TO HELP SERVE AS GUIDANCE TO INEXPERIENCED CONTRACTORS AND CREWS. AS WORDED, THE ABILITY OF THE ENGINEER TO REIMPOSE THE WEIGHTING EMPHASIZES THE REQUIREMENT FOR PROPER PLANT PLACEMENT. SOME CONTRACTORS FEAR THE WEIGHTING WILL DAMAGE THE STOCK. WEIGHTING IS MOST OFTEN USED WITH FALL PLANTINGS.

(e) Fertilizer*:* Fertilizer shall be a 20-10-5 analysis or an approved equal in accordance with the minimum guaranteed analysis:

Total Nitrogen (N)	20.00%
Derived from Urea-Formaldehyde	
7.0% Water Soluble Nitrogen	
13.0% Water Insoluble Nitrogen	
Available Phosphoric Acid (P_2O_5)	10.00%
Derived from Calcium Phosphate	
Soluble Potash (K_2O)	5.00%
Derived from Potassium Sulfate	
Combined Calcium (Ca)	2.60%
Derived from Calcium Phosphate	
Combined Sulfur (S)	1.60%
Derived from Ferrous and Potassium Sulfates	
Iron (Expressed as elemental Fe)	0.35%

The fertilizer shall be formulated into a tablet form weighing a minimum of ten (10) grams or twenty (20) grams per tablet, as shown on the plans and in this specification. The fertilizer shall conform to all applicable State and Federal regulations. The Engineer may require the

Contractor to furnish an affidavit from the vendor or a testing laboratory as to the available nutrients therein at no charge to the Department.

Fertilizer shall be furnished in new, clean, sealed, and properly labeled packages or containers. Fertilizer failing to meet the specified analysis may be used, as determined by the Department, provided sufficient materials are applied to comply with the specified nutrients per unit measure, without additional cost to the Department.

If specified on the plans or authorized by the Engineer, fertilizer for dormant plants shall be 18-6-12 fertilizer, or an approved equivalent. The fertilizer shall be one hundred percent (100%)-resin-coated prills and shall have a commercial designation of 18-6-12, containing a minimum eighteen percent (18%)-total nitrogen, six percent (6%)-available phosphoric acid, and twelve percent (12%)-soluble potash, with a control release for nitrogen, potassium, and phosphorous of eight (8) to nine (9) months at an average soil temperature of 70 °F. Fertilizer application shall be at the rate of fifteen (15) grams per plant.

If specified on the plans or authorized by the Engineer, fertilizer for nondormant plants shall be 19-6-12 fertilizer, or an approved equivalent. The fertilizer shall be one hundred percent (100%)-resin-coated prills and shall have a commercial designation of 19-6-12, containing a minimum nineteen percent (19%)-total nitrogen, six percent (6%)-available phosphoric acid, and twelve percent (12%)-soluble potash, with a control release for nitrogen, potassium, and phosphorous of three (3) to four (4) months at an average soil temperature of 70 °F. Fertilizer application shall be at the rate of fifteen (15) grams per plant.

If specified on the plans or authorized by the Engineer, fertilizer for nondormant plants shall be 18-5-11 fertilizer, or an approved equivalent. The fertilizer shall be one hundred percent (100%)-resin-coated prills and shall have a commercial designation of 18-5-11, containing a minimum eighteen percent (18%)-total nitrogen, five percent (5%)-available phosphoric acid, and eleven percent (11%)-soluble potash, with a control release for nitrogen, potassium, and phosphorous of twelve (12) to fourteen (14) months at an average soil temperature of 70 ° F. Fertilizer application shall be at the rate of fifteen (15) grams per plant.

(f) Water: Water shall be fresh water that is free from toxic substances and chemicals that may be injurious to plant growth. Trucks, hoses, and other watering equipment required to transport water from a source to the seeding area shall be included as part of the work in this section, and payment shall be incidental to this item.

(g) Submittals: Within thirty (30) days of the award of the contract, the successful bidder shall forward in writing a complete listing of the proposed planting materials and the genetic origins of the materials to the following address:

INSERT COMPETENT REVIEWER OR OFFICE WITHIN THE DEPARTMENT. THIS REVIEWER NEED NOT BE THE ENGINEER. THIS PERSON CAN BE PART OF THE DESIGN TEAM.

The Department will review these submitted materials. If deficient, as solely determined by the Department, additional information shall be forwarded to the Department. Any problems with obtaining any of the specified plant materials shall be forwarded in writing to the Department. The cause of the acquisition problem(s) shall be discussed in full, and a list of vendors contacted shall be included. The Contractor should be aware that more than one (1) vendor may be required to obtain all the necessary plant materials. Suggestions concerning appropriate substitutions may be included with this correspondence; however, only the Department may approve such substitutions.

Within sixty (60) days of the award of the contract, two (2) copies of a confirmed purchase order listing the quantity and species ordered shall be forwarded to the Engineer. At the same time, a third copy of the purchase order(s) shall be forwarded to the *ONE SHALL INSERT COMPETENT REVIEWER OR OFFICE,* at the above address. Only after written approval of the genetic origin of the source material by the Department shall the Contractor initiate the procurement of the plant material.

Sixty (60) days prior to planting, the Contractor shall submit two (2) copies, including one (1) mylar reproducible copy, of the proposed wetland layout plan to the Engineer, if different from the original contract drawings. An additional mylar reproducible copy shall be sent to the *INSERT COMPETENT REVIEWER OR OFFICE.* These plans shall be drawn at the same scale as the landscape plans and shall show the proposed locations of the plant materials to be installed. The locations of the permanent landscape stakes shall be shown on these plans. A list indicating the quantities of each species to be installed in each of the landscape blocks or planting areas shall be furnished with the proposed planting plan. To facilitate the preparation of these plans, the Engineer shall provide the Contractor with one (1) reproducible copy of the original landscape plan.

(h) Miscellaneous Materials: Aluminum tags shall be prestamped tags, 1½ inches in diameter, 0.050 inch thick with a 1/8-inch hole for nail placement.

Layout stakes shall be nominal one (1)- by two (2)-inch lumber a minimum of three (3) feet in length.

Location stakes shall be nominal two (2)- by two (2)-inch lumber a minimum of four (4) feet in length. The location stakes shall be pressure-treated with wood preservative.

Thermal-reflective tarps (heat shields) shall have one (1) side of the tarp manufactured of a white-faced material and one (1) side with a highly reflective metallic finish. Minimum size for the thermal tarps shall be nine (9) feet by fifteen (15) feet. The Department may require the use of thermal-reflective tarps specifically designed or advertised for forestry use at no additional charge to the Department.

Tarps used in the construction of wind barriers or for providing shade shall be tightly woven of coated tarps of sufficient size to perform that function efficiently, as determined by the Engineer.

Straw shall be stalks of oats, wheat, rye, or barley relatively free from seeds, noxious weeds, and other foreign material.

Construction Methods:

(a) General: During all phases of this work, including transport and onsite handling, the plant materials shall be carefully handled and packed to prevent injuries and desiccation. During transit and onsite handling, the plant material shall be kept from freezing and kept covered, moist, cool, out of the weather, and out of the wind and sun. Plants not properly transported, packed or handled, as solely determined by the Engineer, may be rejected by the Engineer without compensation and shall be removed from the site by the end of each workday. Plants shall be watered to maintain moist soil and/or plant conditions until accepted.

No planting shall occur until all the soil testing results have been reviewed by the Contractor, the Planting Subcontractor (if applicable), and the Engineer.

(b) Plan Review: If the Contractor or Landscape Subcontractor possesses a record of successful herbaceous wetland plantings that have received final approval from the U.S. Army Corps of Engineers, comments concerning the appropriateness of the various wetland plantings, composition of the planting blocks, stock size, planting techniques, and antiherbivory measures are welcomed and encouraged. These comments and suggestions shall be submitted to the Department within forty-five (45) days of the award of the contract. The Department may elect to reject some or all comments.

(c) Soil Testing*:* Soil tests shall be made to determine the soil gradation; nitrogen (ammonia, nitrate, and total Kjeldahl nitrogen), phosphorous, potassium, magnesium, calcium, manganese, and zinc levels; soluble salts, pH, buffer pH, and organic matter. Soil tests shall be conducted at a State agricultural laboratory or recognized commercial laboratory, subject to approval by the Engineer. The procedures and materials utilized in collecting the samples shall be as recommended by the laboratory. All laboratory results shall be forwarded to the Engineer. If the soluble salts exceed a value of 0.5 mmhos/cm (measurement of electrical conductivity in millimhos/centimeter) or the pH is lower than 5.0 or greater than 8.0, the Contractor shall immediately inform the Engineer to determine the proper action.

(NOTE: THE TESTING REQUIREMENTS SHOULD REFLECT REGIONAL CONCERNS, AND THE TESTS AND PARAMETERS GIVEN ABOVE MAY HAVE TO BE MODIFIED).

Each tested sample shall involve compositing six (6) to eight (8) soil locations, collected randomly, utilizing a soil probe. The soils shall be sampled to a depth of eight (8) inches. The Contractor shall perform one (1) soil test per each ten (10) acres of planting area, with a minimum of three (3) tests per site. If the in-place soils are derived from different sources, each source shall be analyzed separately at the same sampling rate or at a rate determined by the Engineer.

When directed by the Department, the placement of lime, iron sulfate, or other amendments shall be done according to and paid under Section XXXXXX - Soil Amendments. Unless authorized in writing by the Department or as shown on the plans, no other amendments shall be placed.

Unless specified on the plans, the laboratory conducting the soil tests shall forward recommendations for soil amendments based on a target pH of *INSERT APPROPRIATE VALUE*. If other soil amendments are authorized by the Department, such amendments shall be added as recommended by the soil testing laboratory. The payment for the placement of these other amendments shall be negotiated prior to the work.

The soil testing schedule shall be as shown on the plans.

(d) Plant Inspection: The Contractor shall be responsible for all certificates of inspection of plant materials that may be required by Federal, State, or other authorities to accompany shipments of plants.

The successful bidder shall furnish complete information as to the location of all plants that the Contractor intends to supply and use. The Department reserves the right to inspect, tag (seal), and approve all plants at the source of supply. This inspection and tagging shall not in any way eliminate the right of rejection at the site. Inspection prior to moving nursery material shall not be considered as approval. If requested, the nursery shall forward dried whole plants, flowering stalks, inflorescences, or the seed/fruit of the plant material at no additional cost to the Engineer or Department.

Any plant delivered to the site that is damaged or desiccated, possesses a dried root system, or does not meet the material specifications shall not be accepted. The Department reserves the right to reject all stock that is found to be unsatisfactory. No payment shall be made for any unsatisfactory materials or materials not accepted by the Department. All rejected plant material shall be removed from the project site by the close of the working day.

Notice shall be given to the Engineer not less than seventy-two (72) hours before the plant material is to be on the project site. Inspections of the plant materials, including root systems, may be made by the Engineer.

(e) Planting Schedule: No later than forty-five (45) days prior to the estimated planting date, the Contractor shall submit to the Engineer an Estimated Planting Schedule. This estimated schedule shall include the plant shipping dates from the suppliers, plant delivery dates at the construction site or designated delivery point, planting dates for each of the shipments, plant quantities, and an estimate of the planting crew size. The use of multiple plant material shipping dates shall be acceptable. This schedule shall be subject to approval by the Engineer. The Contractor shall adhere to this schedule unless directed by the Engineer or as a result of factors beyond the Contractor's control, such as inclement weather.

(f) Plant Transport: All transport/shipping/handling methods and materials shall be performed according to best nursery and horticultural practices and are subject to approval by the Department. If directed by the Engineer, a description of the transport materials, packing procedures and shipping methods shall be provided. If determined deficient by the Engineer, the shipping materials, procedures, and shipping shall be modified to an acceptable standard, as solely determined by the Engineer. Each shipping container shall be clearly labeled as to species, quantity, lift date, and packing date. For nonlocal sources, transit time from the plant source/nursery to the construction site or designated delivery point shall be direct and shall not exceed seventy-two (72) hours for dormant material or twenty-four (24) hours for nondormant material, or as approved by the Engineer.

Nonlocal plants shall be scheduled for shipping so that the plants arrive at the construction site or designated delivery location no earlier than twenty-four (24) hours prior to the anticipated planting date for those specific plants. With the permission of the Engineer, the period of onsite storage may be extended if the Contractor can demonstrate to the Engineer's satisfaction the ability to store the materials onsite without damaging the viability of the plant materials. However, it is the sole responsibility of the Contractor to ensure that the plants are properly stored.

If directed by the Engineer, plant stock source shall be considered local. With local sources, plant materials shall be transported daily from the nursery to the construction site and only in quantities to meet that day's estimated planting needs.

(g) Plant Handling: If the plants are not planted on the day of delivery, the plants shall be stored onsite in a shaded location or in a well-ventilated vehicle during which time the material shall be kept from freezing and kept covered, moist, cool, and out of the wind and sun. If not installed on the day of delivery, all stock shall be covered in straw or another material, as approved by the Engineer, until the time of installation. The Engineer may direct that local stock be returned to the nursery.

Unless directed by the Engineer, all nondormant plants shall be handled, culled, and sorted in a shaded location. If insufficient natural shade exists, shade shall be erected by the Contractor using tarps or other materials approved by the Engineer. If directed by the Engineer, thermal-reflective tarps shall be used to cover the plant materials.

If wind speeds exceed ten (10) miles per hour, a wind barrier shall be erected immediately adjacent to the stockpiling area. Whenever appropriate, the wind barrier shall be relocated or repositioned to protect the quality of the stock. The wind barrier shall be constructed utilizing tightly woven or coated tarps, or as approved by the Engineer. The materials and methods used in the construction of the wind barrier shall be subject to approval by the Engineer. With the approval of the Engineer, the Contractor may elect to utilize the transport vehicle as a temporary storage area, subject to the above restrictions and guidelines, including the placement of thermal-reflective tarps. The construction of wind barriers or shade or the use of thermal-reflective tarps shall be incidental to this item, and no additional compensation to the Contractor shall be made by the Department.

(h) Planting Season (Window): The planting dates for nondormant plants shall be from *INSERT DATE* to *INSERT DATE*, provided the ground is not frozen or as shown on the plans. Dormant wetland herbaceous species may be planted from *INSERT DATE* to *INSERT DATE*, provided the ground is not frozen or as shown on the plans. At the discretion of the Department, nondormant stock of the same plant species as specified may be substituted at the same bid price as dormant stock. The Department may reject the use of dormant plants and/or certain planting windows, as shown on the plans.

If the plant materials are not installed within the specified planting window, the Engineer may institute a one (1)-year plant establishment period for the planting, as solely determined by the Engineer. The requirements for this planting establishment period shall be as outlined in Subsection (p) Plant Establishment Period. With later plantings, the Engineer may also required planting under a flooded condition, as directed by the Engineer and at no additional cost to the Department.

NOTE: IF APPROPRIATE, ONE SHALL HAVE ONLY A SINGLE PLANTING WINDOW AND DELETE THE REFERENCES TO OTHER WINDOWS.

(i) Plant Installation Period: After plant delivery to the construction site or to the designated delivery location, all dormant nonlocal plant material shall be installed within fifty-eight (58) hours, and all nonlocal dormant plant material shall be installed within thirty-four (34) hours. Shipments of plant materials may be staggered over several days. Local materials shall be installed on the day of delivery.

To prevent the desiccation of the herbaceous wetland plant materials, the Contractor shall complete the plantings of the wetland systems within five (5) calendar days of the initial plantings of each of those systems. During this period, it is the sole responsibility of the Contractor to ensure that the soil is kept saturated and the plants are not desiccated, as solely determined by the Engineer.

(j) Layout: Prior to planting, the Contractor shall stake all of the planting blocks/areas. A layout stake shall be placed at fifty (50)-foot intervals along the perimeter of the planting areas/blocks and at each corner of each planting block/area, or as directed by the Engineer. The stakes shall be numbered or coded indicating the appropriate blocks/areas and species to be planted. The stakes shall be driven firmly into the soil a minimum of twleve (12) inches. If a low permeability liner is present, the stakes shall be driven to a maximum of depth of fifteen (15) inches or to a maximum depth as specified on the plans and the stake shall not penetrate the liner material.

At the same time, the Contractor shall install the location stakes. Location stakes shall be placed ten (10) feet up-slope of the emergent wetland border at the boundary between each of planting blocks/areas or as shown on the plans. Unless specified on the plans, location stakes need not be installed inside the emergent marsh. The location stakes shall be driven firmly into the soil a minimum of twenty-four (24) inches. The location stakes shall be tagged with one-and-one-half-inch (1½")-diameter aluminum prestamped tags to indicate the appropriate block

numbers/planting areas, as shown on the plans. The typical location stake will require two tags, one tag for each of the bordering planting blocks/areas.

OPTIONAL 1: (k) Landscape Dewatering: The initiation of the landscape dewatering shall not occur until authorized by the Engineer. Except for the bagged wetland plant material and mat stock or when specified on the plans, all wetland plantings shall occur without the presence of surface waters to the maximum practicable extent. During the planting operations and if a water outlet structure is present, any excess waters shall be initially discharged via the outlet structure. Any additional landscape dewatering that is required may be accomplished via pumping operations. The Contractor shall provide adequate dewatering measures to facilitate an efficient planting. All dewatering methods and disposal of water shall be subject to the Engineer's approval including the number of pumps, the size of the pumps, pumping locations, outlet locations, and any soil erosion control measures that may be required. Pumping operations shall be limited to the elevations required to allow plantings of the designated areas without the presence of surface waters. Each day, the previous day's logs for the pumping activities and estimated pumping quantities shall be submitted directly to the Engineer. If directed by the Engineer, the pumping operations shall immediately cease, and the planting shall occur under flooded conditions.

OPTIONAL 2: (k) Landscape Dewatering: Prior to planting, the height of the outlet structure shall be set at the elevation shown on the plans. The wetland shall then be flooded to this elevation, and maintained at this elevation throughout the entire planting period. Any excess waters shall be initially discharged via the outlet structure manipulations. Any additional landscape dewatering or watering that is required may be accomplished via pumping operations. This work could require both pumping water into and out of the wetland system over the course of the planting. The Contractor shall provide adequate pumping measures to facilitate an efficient planting. All dewatering and watering methods and disposal of water shall be subject to the Engineer's approval including the number of pumps, the size of the pumps, pumping locations, outlet locations, and any soil erosion control measures that may be required. Pumping operations shall be limited to the elevations required to allow plantings of the designated areas at the specified water depth. Each day, the previous day's logs for the pumping activities and estimated pumping quantities shall be submitted directly to the Engineer. If directed by the Engineer, the pumping operations shall immediately cease and the planting shall occur in onsite conditions.

When pumping is required, the waters pumped shall be filtered and free of suspended solids to the maximum possible extent. The waters shall be pumped and deposited in such a manner as to cause the smallest practical amount of disturbance to the surface or subsurface soils, thus minimizing the quantity of suspended solids found in the water columns of the wetland. Prior to the flooding operations, the Engineer shall approve the location and method of flooding.

NOTE: IF DESIRED, LANDSCAPE DEWATERING CAN BE DELETED IN ITS ENTIRETY. THE TWO OPTIONS GIVEN HERE WILL ALLOW FOR EITHER A FLOODED OR A NONFLOODED PLANTING. FOR MOST EMERGENT MARSHES (OUTSIDE THE NYMPHACEAE AND THE AQUATICS), THE INITIAL WATER DEPTH

AT THE TIME OF THE PLANTING SHOULD PROBABLY NOT EXCEED FOUR (4) INCHES. THE PUMPING OPERATIONS COULD BE TREATED AS A SEPARATE CONTINGENCY PAY ITEM WITH THE MAXIMUM CONTINGENCY VOLUME BASED ON MARSH SYSTEM VOLUME CALCULATIONS. ONE SHALL NOT ALLOW THE CONTRACTOR TO ABUSE A SEPARATE PAY ITEM FOR DEWATERING/FLOODING VIA EXCESSIVE PUMPING.

(l) Setting Plants: If more than one (1) species is shown per planting block or area, the individual species shall be planted randomly mixed within each block or area to the maximum extent practicable, as solely determined by the Engineer. Subdividing mixed planting blocks or areas and then planting as monocultures shall be strictly prohibited. If the system is lined with a low permeability liner, the liner shall not be punctured, exposed, or disturbed during the planting process. Deeper planting shall be allowed with the approval of the Engineer. All stock shall be planted upright. All planting procedures, tools, and methods are subject to approval by the Department. Team planting by several persons each performing different tasks is encouraged.

Where planting blocks or areas of erect emergent species abut nonflooded habitats, the planting shall be extended above the designed water elevation a minimum linear distance of three (3) feet, but only where the soils are or are expected to be saturated, even if the saturation is seasonal. **PLANT THE SLOPES**. This requirement does not include members of the Waterlily Family, the Nymphaceae.

NOTE: ONE SHALL VERIFY THE PLANTING DEPTHS FOR THE SPECIES BEING UTILIZED. RECOMMENDATIONS FOR SOME PLANTINGS AT A MINIMUM DEPTH OF ONE (1) INCH, AND A MAXIMUM DEPTH OF TWO (2) INCHES WILL NOT BE UNCOMMON, EVEN FOR SOME DORMANT STOCK. IF DESIRED, THIS INFORMATION CAN BE SHOWN ON THE PLANTING TABLE THAT WILL APPEAR ON THE APPROPRIATE PLAN SHEETS. THIS WILL ALLOW FOR SELECTING DIFFERENT PLANTING DEPTHS FOR THE VARIOUS SPECIES.

1. Individual Stock Except for Stolons:

(a) Dormant Bareroot BCT and Rhizomes: Each individual plant shall be planted so that the top of BCT or rhizome is at a minimum depth of two (2) inches and a maximum depth of three (3) inches below the soil surface. The entire BCT, rhizome, and root system shall be placed below the soil surface.

OPTIONAL: To limit herbivory, excessive dead stem/leaf tissues that would protrude above the soil surface shall be removed with a cutting blade prior to planting. No part of the plant may be exposed above the soil surface.

(b) Nondormant Bareroot BCT and Rhizomes: Each individual plant shall be planted so that the top of the BCT or rhizome is at a minimum depth of one (1) inch and a

maximum depth of two (2) inches below the soil surface. The entire stock and root system shall be placed below the soil surface.

(c) Peat Pots, Tublings, and Plugs: The individual peat pots and plugs shall be planted in the soil at least one (1) inch deeper than grown in the nursery or source location and to a depth that will ensure that the top of the BCT, rhizome and the attached rootmass lies at least one (1) inch below the soil surface. The maximum planting depth shall be two (2) inches deeper than grown in the nursery.

(d) Sprigs: Unless directed by the Engineer, the plants shall be planted (1) in the soil at a depth one (1) to two (2) inches deeper than grown in the nursery or source location; (2) to a depth that will ensure that the top of the rhizome lies one (1) to two (2) inches below the soil surface; and (3) so that all portions of the root system are in the soil. If dry conditions are anticipated, deeper plantings shall be acceptable as approved by the Engineer.

The number of sprigs planted per planting hole shall be _____.

In order to place the plants at the appropriate depth in the soil, the soil surface shall be opened with a tile spade or other appropriate hand or power tool. If peat-potted stock is utilized, an auger shall be used to develop the planting hole. The depth of auger placement shall allow for easy plant placement at the specified depth while limiting the formation of air pockets beneath the planting hole. Prior to planting, each side of the peat pot shall be split with a razor to facilitate growth of the stock.

Prior to placement of the plant in the planting hole, a ten (10)-gram fertilizer tablet shall be placed in the bottom of the planting hole. The plant(s) shall then be placed at the appropriate depth with the root system oriented downward. While the plant is in this position, the soil profile or section shall be fully and firmly closed with an appropriate hand tool. Once the soil is closed, firm foot pressure shall be applied over buried stock or in several positions immediately adjacent to exposed plantings to ensure good soil and plant contact, and to remove any air pockets and voids. If a soil depression is formed above or immediately adjacent to the planting location, enough soil shall be sloughed from the surrounding area and firmly tamped into the depression to leave the planting area at the same elevation as the surrounding soil.

If pint-, quart-, or gallon-container stock is utilized, a hole of sufficient width and depth shall be excavated to allow easy placement of the plant at a depth one (1) to two (2) inches deeper in the soil than grown in the nursery or source location. Prior to the placement of the plant in the planting hole, a twenty (20)-gram fertilizer tablet or two ten (10)-gram tablets shall be placed in the bottom of the planting hole. If the root system of container stock is container-bound, the root system shall be carefully freed and any container-bound or cramped roots shall be separated and spread out when placing the plant so that the roots can grow without further constriction of the root mass. The planting hole shall then be backfilled with the excavated soil and tamped firmly to remove all air pockets and voids. If a soil depression is formed above or

immediately adjacent to the planting location, enough soil shall be sloughed from the surrounding area and firmly tamped into the depression to leave the planting area at the same elevation as the surrounding soil.

2. Stolons: In order to place the stolon at the appropriate depth in the soil, the soil surface shall be opened with a spade or other appropriate hand or power tool. Prior to placement of the plant in the planting hole, a ten (10)-gram fertilizer tablet shall be placed in the bottom of the planting hole. The stolon shall be placed in the soil so that the first node is located at a soil depth of approximately three (3) inches, the second node at a soil depth of approximately two (2) inches, the third node at a depth of approximately one (1) inch, and the fourth node at the soil surface. While holding the stolon at the appropriate depth, the soil profile or section shall be fully closed. Once the soil is closed, firm foot pressure shall be applied over the stolon to ensure good soil and plant contact, and to remove any air pockets.

3. Bagged Stock (Submerged Aquatic Vascular Bed): Prior to bagging, all plants shall be preweighted individuals. Five BCTs or rhizomes shall be placed in each mesh bag and tied off. If required for proper placement or if directed by the Engineer, additional weights shall be placed in the bags. The bags shall then be dropped into the water column at the appropriate spacing across the planting area. No fertilizer treatments shall be required. Prior to planting, the type of mesh bag utilized shall be submitted to the Department for review and approval.

4. Mat Stock: Mat Stock shall be gently placed into the water column upright at the appropriate spacing and press onto the surface of the soil, or if the water column is deeper than four (4) feet in depth then allowed to sink to the bottom of the water column. Materials shall not be thrown or tossed into the water column. The mat shall be weighted as shown on the plans. No fertilizer treatments shall be required.

(m) Fertilizer Placement: In order to limit algal blooms, all fertilizer shall be placed in the bottom of planting holes. At no time shall fertilizer be placed in the water column or on top of a soil surface. At the direction of the Engineer, fertilizer placement shall cease.

(n) Flooding: When applicable to the wetland design, the wetland systems shall be flooded with fresh water to the elevation specified on the plans or to the elevation selected by the Engineer. To prevent desiccation of the herbaceous plant materials, the flooding of the wetlands shall commence immediately following the planting, and the flooding shall be completed according to the schedule as shown on the plans. If no flooding schedule is shown, the flooding shall be completed within two (2) weeks of the initiation of the flooding operation. During the flooding period, the Contractor shall be responsible for ensuring that the planting areas are kept moist at all times and the plant materials are not subject to desiccation. Whenever possible, this flooding shall be accomplished via structure manipulations.

When pumping is required, the waters pumped shall be filtered and free of suspended solids to the maximum possible extent. The waters shall be pumped and deposited in such a manner as to cause the smallest practical amount of disturbance to the surface or subsurface soils, thus

minimizing the quantity of suspended solids found in the water columns of the wetland. Prior to the flooding operations, the Engineer shall approve the location and method of flooding.

(o) Acceptance: The wetland plant material shall be evaluated for acceptance thirty (30) days after all the following have been completed or satisfied:

1. The plant material has been satisfactorily installed.

2. The wetland systems have been flooded to the specified structure elevation or to an elevation directed by the Engineer (Subsection N).

3. All specified fencing has been installed and accepted adjacent to the planting areas.

4. All specified herbivory prevention measures have been installed and accepted.

5. No compensation shall be made for the installation or the cost of the material for plants not properly planted, including those plants whose roots are exposed at the time of acceptance or those plants subjected to desiccation.

OPTIONAL ITEMS WITH EDITS:

6. All specified wildlife stump and log placements have been installed and accepted as shown on the plans.

7. All individuals of *Phragmites*, *Lythrum salicaria*, and *Typha* have been weeded via full root extraction from the planting area.

During this acceptance period, the Contractor shall be responsible for ensuring that the planting areas are kept moist or flooded, as appropriate for the wetland design. Plant materials determined to be dead or seriously weakened shall not be accepted, with the exceptions noted herein. If all herbivory prevention measures and fencing have been installed on time and as specified and identified on the plans, as solely determined by the Engineer, those plants absent or damaged via herbivory, as solely determined by the Engineer, shall be credited for acceptance. Plants absent for reasons other than herbivory shall not be accepted. If all herbivory prevention measures and associated fencing were not initially installed on time and as specified, all absent or seriously damaged plant materials including those damaged or lost to herbivory, as solely determined by the Engineer, shall not be accepted, as solely determined by Engineer. If no herbivory measures are identified on the plans, the Contractor shall not be responsible for any plant losses due to herbivory, as solely determined by the Engineer. If indicated on the plans or if indicated by the Engineer, various types of fencing and other plan features shall be considered to be antiherbivory measures, including silt fencing or other fencing adjacent to flooded habitats.

Except as indicated in the previous paragraph, plant materials found dead, absent, seriously damaged, weakened or desiccated, floating on the water surface, deposited along the edge of

the wetland, exposed on soil, or within the water column shall be replanted prior to acceptance at no additional cost to the Department or replaced with new materials, as solely directed by the Engineer. If new materials are required in order to achieve full acceptance, such materials shall be acquired and installed by the Contractor at no additional cost to the Department. Installation of these materials shall not occur until all herbivory prevention measures have been installed and reaccepted.

No compensation shall be made for the installation or the cost of the material for plants not properly planted, including those plants whose roots are exposed within the acceptance period.

Bagged stock and mat stock shall be an exception to the above guidelines. These materials shall be accepted thirty (30) days after installation, based on all the above criteria, with the exception of Item 5. If the plants have remained flooded, as appropriate for the design as solely determined by the Engineer, there shall be no survival guarantee for the bagged stock or mat stock.

(p) Plant Establishment Period: Generally, there is no plant establishment period for the plantings. However, if the work of the Contractor results in (a) planting outside the specified planting window; (b) extending the height or duration of natural flood events beyond the design conditions of the project, as solely determined by the Engineer; or (c) through the use of undersized stock, as solely determined by the Engineer, the Engineer may institute a one (1)-year guarantee period for the designated planting stock, with a fifty percent (50%)-survival (including vegetative off-shoots) or twenty percent (20%)-coverage criteria. If the one (1)-year guarantee is instituted, the Department may require bonding by the Contractor for the full cost of the plant material, labor, all incidentals' costs associated with the work, and all other associated items, as solely determined by the Department. In lieu of bonding, the Department may elect to withhold fifty percent (50%) of the payment for this work until this survival determination has been made by the Department.

The one (1)-year period shall begin at the time of the initial acceptance of the planting, extend a minimum of six (6) months, and then extend to the next August 15 calendar date, at which time final acceptance will be determined by the Department. This one (1)-year guarantee may be considerably longer in duration than 365 calendar days. The Department may shorten the length of the plant establishment period or reduce the coverage or survival requirements. The Department may elect not to include volunteer species or species not identified for planting in specific areas or planting blocks into the estimates of survival or coverage. At the end of the plant establishment period, individual planting blocks or areas of the planting that do not exhibit either twenty percent (20%)-aerial cover or fifty percent (50%)-survival of the plants that were planted in each of the individual planting blocks or areas shall be determined to be deficient, as solely determined by the Department. Percent aerial cover shall be the proportion of the ground or water surface occupied by the perpendicular projection to the ground or water surface from the outline of the aerial parts of the plants. Foliage cover, defined as the perimeter projection of the crowns, shall not be utilized for these estimates. For this determination, each of the individual planting blocks or areas shall be individually assessed, distinct and separate from all other planting blocks or areas, as solely determined by the Department. If no blocks or

planting areas are shown on the plans, the Department shall designate planting blocks on an approximate fifty (50)-foot by fifty (50)-foot grid, as solely determined by the Department. Those blocks or planting areas deemed to be deficient shall be replanted at no cost to the Department, as solely determined by the Department. The Contractor shall be solely responsible for the survival of the planting material. Losses attributed to waterfowl herbivory, wildlife herbivory, disease, eutrophication, inappropriate hydrological regimes, drought, insect damage, fire, wind or wave energies, ice scouring or vandalism **shall not** lower the minimum survival or coverage requirements, nor shall such losses be credited against the survivalship or coverage requirements. Species selected for replanting shall be determined by the Department. The new plantings shall be of a density to comply with the full planting densities shown on the plans, as solely determined by the Engineer. Materials, installation, and acceptance requirements shall be as originally specified herein, including all elements and conditions of Subsection (o) Acceptance. During any required replantings, all antiherbivore measures, as identified by the Engineer, shall be installed and maintained by the Contractor according to the appropriate specifications at no cost to the Department.

(**NOTE**: ONE SHALL VERIFY ALL THE REQUIREMENTS OF THE PLANT ESTABLISHMENT PERIOD. THE INSTITUTION OF THE GUARANTEE PERIOD IS MOST LIKELY TO OCCUR WITH LATE PLANTINGS. PLANTING LATE SHOULD BE AVOIDED, AS LATE PLANTINGS WILL LIMIT THE POTENTIAL FOR THE FORMATION OF AN INTERLOCKING ROOT NETWORK THAT WILL RESIST HERBIVORY, ICE SCOURING, AND WAVE DAMAGE, AND NOT NECESSARILY BECAUSE OF PHYSIOLOGICAL CONSIDERATIONS. LATE PLANTINGS WILL ALSO REDUCE THE OPPORTUNITY FOR VEGETATIVE SPREAD, SEED PRODUCTION, THE ACCUMULATION OF STARCH RESERVES FOR THE NEXT YEAR'S GROWTH, AND MAY INCREASE THE POTENTIAL FOR WEED COLONIZATION. ENTERING THE SECOND YEAR, EUTROPHICATION IMPACTS MAY BE HEIGHTENED BECAUSE OF THE SMALLER STARCH RESERVES. PLANTS PLACED IN EXTENDED COLD STORAGE DURING THE DELAY WILL EXPERIENCE INCREASED RESPIRATION, THEREBY DEPLETING CARBOHYDRATES CRUCIAL TO OUTPLANTING SURVIVAL.

LATE PLANTINGS ARE PARTICULARLY TROUBLESOME WHEN SHIFTED FROM THE EARLY SPRING TO MIDSUMMER OR LATE SUMMER. THE PLANT ESTABLISHMENT PERIOD MAY ALSO BE INSTITUTED WHEN THE CONTRACTOR HAS CONSTRUCTED A TEMPORARY BERM AROUND THE MITIGATION TO CURTAIL SEASONAL FLOODING. IF PLANTED AREAS THEN FLOOD PRIOR TO REMOVAL OF THE BERM, THE HEIGHT AND DURATION OF THE FLOODING COULD "DROWN" SOME OF THE STOCK. THIS AUTHOR SUGGESTS THAT THIS REQUIREMENT BE PLACED AS A PLAN NOTE).

(q) Replacement Plantings: When requested, the Contractor shall arrange for replacement plantings of the species requested by the Department and any antiherbivory measures at the original bid prices plus inflation as measured by the Regional Consumer Price

Index for a three (3)-year period following the initial acceptance of the planting (U.S. Department of Commerce).

(r) As-Builts: Within fourteen (14) days of the installation of the plants, the Contractor shall submit two (2) copies, including one (1) mylar reproducible copy, of the layout plan to the Engineer, if different from the original contract drawings. In addition, two (2) mylar reproducible copies shall be sent to the *Insert Title and Office*. Unless directed by the *Insert Title and Office*, these plans shall be drawn to a scale of one inch (1") = 50¢ and shall show as-built locations for the plant material used. The locations and labeling of the permanent landscape stakes shall be shown on these plans.

A list of the quantities of each species installed in each of the planting blocks or areas shall be submitted with the plans. Any deviations from the original landscape plans, including approved substitutions, or from the proposed layout plan that was submitted to the Engineer sixty (60) days prior to the planting, shall be clearly marked and documented.

Method of Measurement*:*

Planting, Freshwater Emergent Marsh shall be measured by the number of each plant installed and accepted.

Basis of Payment:

Payment for Planting, Freshwater Emergent Marsh shall be paid for at the unit bid price each for the various items of the planting schedule accepted, which price and payment shall constitute full compensation for furnishing all plants, labor, materials, tools, equipment, and incidentals necessary to complete the item. Compensation for landscape dewatering, pumping, flooding, soil testing, fertilizer, layout stakes, location stakes, planting block layout, and as-built drawings shall be included in the unit bid price for Planting, Freshwater Emergent Marsh. No separate payment shall be made for accessory items as herein specified as necessary or required, but all costs thereof shall be included in the unit prices bid for the Pay Item.

Appendix K

Planting Salt Marsh

NOTE: THE FERTILIZER SEGMENT OF THIS SPECIFICATION ASSUMES A LOW MARSH PLANTING WITH THE FERTILIZER BEING PLACED IN THE BOTTOM OF THE PLANTING HOLE. THIS PROCEDURE IS ALSO SUITABLE FOR HIGH MARSH PLANTINGS. ALTERNATIVELY, THE SPECIFICATION CAN BE REVISED, AND THE MAINTENANCE FERTILIZER CAN BE BROADCAST ON THE SOIL SURFACE AT THE TIME OF A HIGH MARSH PLANTING, COGNIZANT OF THE NEXT SPRING TIDE.

Description:

This work shall consist of furnishing the specified herbaceous plants and their proper planting by approved methods, as hereinafter specified, in the locations shown on the plans and as directed by the Engineer.

Definitions:

Dormant shall be defined as plant materials that are in an overwintering condition, cold-hardy, and that are not actively producing new leaf and stem tissues. Dormancy shall not be defined by proposed planting dates or windows. It is the sole responsibility of the Contractor to ensure that when dormant materials are specified, the plants meet this definition.

The diameter of the stock shall be defined as the average length of the long and short center axes of the stock, as determined by the Engineer.

Local and nonlocal plant material sources shall be as determined by the Department.

NOTE: THE DEFINITIONS FOR LOCAL AND NONLOCAL NEED TO BE EXPANDED.

Materials:

(a) Plants: Plant materials shall conform to **one or more** of the below categories for the stock shown on the plans, as determined by the Engineer. Additional information concerning the characteristics of the stock may be shown on the plans. Tubling stock, peat pots, and container stock shall be considered acceptable substitutes for sprigs and plugs. During propagation, all stock shall be periodically examined for signs of rust infestation (fungal infestation) or scale infestation (insect infestation). If rust is present, the stock shall be treated with a fungicide labeled for rust at a time appropriate for rust control and in accordance with the manufacturer's instructions. *OPTIONAL WITH EDITS:* All stock shall be free of seed and vegetative propagules of *Phragmites* (common reed).

1. Nondormant Plants: All nondormant plants shall be healthy and vigorous with well-developed leaf, stem, and root systems. New root systems of cleaned plants shall be white. Plants shall appear without significant deleterious leaf spots, leaf damage, leaf discolorations, chlorosis, leaf wilting or curling, osmotic stress, disease, or evidence of deleterious insect infestation that could adversely affect the survival or performance of the plants, as solely determined by the Engineer. Nondormant stock types include sprigs, plugs, tublings, peat pots, and containers.

The minimum stem height of the plant stock shall be as shown on the plans. The minimum number of shoots per plant shall be as shown on the plans.

2. Dormant Stock: When examined, the plants shall exhibit live buds or shoots. For some species, these buds and shoots may be found within the inner tissues of the dormant plants. All stock, including the buds and shoots, shall be turgid, firm, and resilient. Internodes of rhizomes may be flexible and not necessarily rigid. Soft or mushy shoots, rhizomes, or rootstocks shall be rejected. Nonrhizomatous and nonstoloniferous species shall have a minimum of one (1) viable bud per plant with an appropriate root system or sufficient mass and tissue types to allow for the development of vigorous stem and root systems. Except for sprig material, each rhizome or stolon shall have a minimum of three (3) viable buds per plant and be at least four (4) inches in length, or as shown on the plans. If required for the breaking of dormancy, each rhizome shall have the terminal bud removed at the nursery. The stock shall be free of significant deleterious insect infestation and disease that could adversely affect the survival or performance of the plants, as solely determined by the Engineer. Blackened rootstocks are typical of healthy propagules of some species. Types of dormant stock include sprigs, plugs, tublings, peat pots, and containers.

The minimum diameter or circumference for all dormant rootstocks shall be as shown on the plans, as measured by the Engineer.

3. Sprigs: Sprig material shall be healthy and vigorous with well-developed leaf, stem, and root systems. Unless shown on the plans, the sprigs shall have a minimum of one (1) viable bud per plant with an appropriate root system or sufficient mass and tissue types to allow for strong growth following planting. Rhizomatous species planted as sprigs shall support a fully developed rhizome of a minimum length of four (4) inches, or as shown on the plans. Soft or mushy sprigs shall be rejected. Unless shown on the plans, all sprig material shall have a minimum aboveground height of twelve (12) inches. Sprig material may be trimmed at the nursery to reduce aboveground leaf/stem length to facilitate handling and reduced physiological stress. However, the trimming shall not damage basal bud tissues or reduce the number of leaves, stems, or tillers that arise from the base. The trimming shall result in a plant whose aboveground leaf/stem tissues are a minimum of twelve (12) inches in length. Roots shorter than ten (10) inches in length shall not be trimmed.

4. Plugs and Tublings: All stock shall comply with the requirements for dormant or nondormant stock, detailed under this section. The size and dimensions of the plugs shall be as specified on the plans for each species. Tublings and plugs shall be propagated and grown in

cells and not as bare rootstock or as bedded plants. The extracted root system shall conform to the shape and dimensions of the growing cells without sloughing soil or growth media, as determined during the onsite inspection. Materials not conforming to the dimensions of the cell may be rejected without compensation. The extracted root system of the tublings and the plugs shall have the majority of the roots in vertical orientation. If the horizontal roots are thick and flattened and the root stays in a thick net the shape of the original cell when the media is shaken loose, the plant may be determined to be "pot bound" and shall be considered unacceptable stock.

Immediately prior to shipment from the nursery, the plug stock shall be removed from the cells and properly packed for transport. Tubling stock shall be shipped to the job site in the growing cells. The use of styrofoam blocks or cells shall be prohibited when culturing stock because of problems associated with fine root penetration into styrofoam walls and torn roots following extraction. Unless shown on the plans, the cell cavities shall have a minimum cavity depth of eight (8) inches, a minimum cavity diameter of one and one-half (1.5) inches, and a minimum cavity capacity of ten (10) cubic inches. The size of the cell should be sufficient to promote the natural root formation and inhibit the crowding and knotting of the root system. The inner surface of the cell wall shall be vertically ribbed the full length of the cell wall in a manner that promotes downward root growth and limits root spiraling. Each cell shall have a minimum of four (4) ribs and a bottom drainage hole. The cell shall be a white or yellow polyethylene. The choice of propagation tubes (cells) and growing shall be subject to approval by the Department.

5. Peat Pots: The peat-potted stock shall have been grown in one and three-fourths (1¾)- to two and one-fourth (2¼)-inch sided peat pots (or larger size) long enough and under proper conditions for the root system to be sufficiently well-developed through the sides and bottom of the pot to prevent easy removal of the plant from the pot and to prohibit removal or structural damage to the plant when submerged under water. Plants that can be removed from the pots by holding the stem growth and gently pulling on the pots shall be rejected without compensation.

6. Container Stock: The container stock shall have been grown in the specified container (or larger size when appropriate for the species) long enough and under the proper conditions for new roots to have developed so that the full volume of the soil mass shall retain its shape and hold together when removed from the container and lightly shaken. Plants that can be removed from the pots by holding the stem growth and gently pulling on the pot or plants whose root system does not occupy the full volume of the pot shall be rejected without compensation.

Unless the volume of the specified container is greater than the volume of the peat pot, peat pots shall be considered acceptable substitutes for individual plants, with one peat pot equivalent to one individual plant. Individual plants grown in pint, quart, or gallon containers or containers larger than specified on the plans shall be considered acceptable substitutes for individual plants, with each container equivalent to one (1) individual plant. These plants shall satisfy the material and planting requirements of container stock, as contained in this

specification. If these larger containers are to be utilized, the Contractor shall submit a complete planting methodology, including tool and fertilizer identification, for approval by the Engineer at least thirty (30) days prior to the intended date of installation. The container stock shall have been grown in that container long enough for new roots to have developed so that the soil mass shall retain its shape and hold together when removed from the container. No additional compensation for the cost of material or installation shall be made by the Department for plants supplied in larger containers than specified.

For certain plant species, propagation via terminal meristem tissues is required to produce a plant that can readily break dormancy and develop shoots and roots. It is the sole responsibility of the Contractor to ensure that all plant propagules possess the ability to break dormancy readily and grow when properly installed.

All plants may be inspected for viability and specification adherence by the Engineer. Plant materials that are thin and weak for that species shall not be accepted, as solely determined by the Engineer. Materials that represent undersized stock, newly emerged seedlings, undersized seedlings, or materials not conforming to the specifications, as solely determined by the Engineer, may be rejected at the time of delivery, installation, or acceptance without any compensation. Undersized stock including seedlings may be planted with the written permission of the Department, but such stock shall be subject to a Plant Establishment Period, as presented in *Subsection (p) Plant Establishment Period.* Alternatively, the Department may reject the use of undersized stock without any compensation to the Contractor.

(b) Genetic Origin:

THIS SEGMENT OF THE SPECIFICATION MUST BE PROVIDED BY THE USER. ONE SHALL VERIFY NURSERY LOCATION.

Plants may be grown in nurseries outside of these geographical and elevational boundaries, subject to approval by the Department, but the immediate genetic origin of the materials must meet the above geographical specifications. The genetic stock shall be chosen to provide typical forms of the species and include the capacity to bear fertile fruits, as approved by the Department.

(c) Salinity Acclimation: To avoid salt shock to the stock, all stock shall be acclimated to the salinity concentration shown on the plans. Acclimated shall be defined as growing at the prescribed salinity concentration for a minimum period of two (2) weeks prior to the shipment of the stock to the construction site. Growers should be aware that acclimation of the stock may take several weeks and that the acclimation treatment is most likely to be a gradual, stepwise process.

(d) Nomenclature: For the herbaceous wetland plants, *A Synonymized Checklist of the Vascular Flora of the United States, Canada and Greenland: Volume II - The Biota of North America* (Kartesz and Kartesz, University of North Carolina Press, 1980, or later edition) shall be the authority for the plant names, unless indicated on the plans. The

Contractor shall supply certification from the suppliers that the plants supplied are the plants specified or agreed to under substitution. No compensation shall be made for materials or the cost of installation for plant species that are not specified.

(e) Fertilizer: At the time of the planting, fertilizer shall be a 20-10-5 analysis or an approved equal in accordance with the minimum guaranteed analysis:

Total Nitrogen (N)	20.00%
Derived from Urea-Formaldehyde	
7.0% Water Soluble Nitrogen	
13.0% Water Insoluble Nitrogen	
Available Phosphoric Acid (P_2O_5)	10.00%
Derived from Calcium Phosphate	
Soluble Potash (K_2O)	5.00%
Derived from Potassium Sulfate	
Combined Calcium (Ca)	2.60%
Derived from Calcium Phosphate	
Combined Sulfur (S)	1.60%
Derived from Ferrous and Potassium Sulfates	
Iron (Expressed as elemental Fe)	0.35%

The fertilizer shall be formulated into a tablet form weighing a minimum of twenty (20) grams per tablet. The fertilizer shall conform to all applicable State and Federal regulations. The Engineer may require the Contractor to furnish an affidavit from the vendor or a testing laboratory as to the available nutrients therein at no charge to the Department.

Unless indicated on the plans, the postplanting fertilizers shall be a fertilizer with a commercial designation of 20-10-10, containing a minimum twenty percent (20%)-available nitrogen (N), ten percent (10%)-available phosphoric acid (P_2O_5), and ten percent (10%)-water soluble available potash. Fifty percent (50%) of the nitrogen shall be water soluble forms of ammonium sulfate or urea and fifty percent (50%) by weight of the nitrogen content available from ureaformaldehyde. Nitrate-based fertilizers shall not be accepted.

The ureaformaldehyde specified above shall meet the following requirements:

Total Nitrogen (TN) Cold Water Insoluble	38% Minimum
Nitrogen ($IN25^o$)	25% Minimum
Activity Index (AI)	45% Minimum
Urea Nitrogen	3.5% Minimum

Fertilizer shall be furnished in new, clean, sealed, and properly labeled packages or containers. Fertilizer failing to meet the specified analysis may be used as determined by the Engineer, provided sufficient materials are applied to comply with the specified nutrients per unit measure without additional cost to the Department.

If specified on the plans or authorized by the Engineer, fertilizer for dormant plants shall be 18-6-12 fertilizer, or an approved equivalent. The fertilizer shall be one hundred percent (100%)-resin-coated prills and shall have a commercial designation of 18-6-12, containing a minimum eighteen percent (18%)-total nitrogen, six percent (6%)-available phosphoric acid, and twelve percent (12%)-soluble potash, with a control release for nitrogen, potassium, and phosphorous of 8 to 9 months at an average soil temperature of 70 °F. Fertilizer application shall be at the rate of twenty-eight (28) grams per plant.

If specified on the plans or authorized by the Engineer, fertilizer for nondormant plants shall be 19-6-12 fertilizer, or an approved equivalent. The fertilizer shall be one hundred percent (100%)-resin-coated prills and shall have a commercial designation of 19-6-12, containing a minimum nineteen percent (19%)-total nitrogen, six percent (6%)-available phosphoric acid, and twelve percent (12%)-soluble potash, with a control release for nitrogen, potassium, and phosphorous of 3 to 4 months at an average soil temperature of 70 °F. Fertilizer application shall be at the rate of twenty-eight (28) grams per plant.

(f) Fresh water: Fresh water shall be water with a salinity concentration of less than 0.5 parts salt per thousand that is free from toxic substances and chemicals that may be injurious to plant growth. Trucks, hoses, and other watering equipment required to transport water from a water source to the planting area shall be included as part of the work in this section with all costs incidental to this item.

(g) Submittals: Within thirty (30) days of the award of the contract, the successful bidder shall forward in writing a complete listing of the proposed planting materials and the genetic origins of the materials to the following address:

INSERT COMPETENT REVIEWER OR OFFICE

The Department will review these submitted materials. If deficient, as solely determined by the Department, additional information shall be forwarded to the Department. Any problems with obtaining any of the specified plant materials shall be forwarded in writing to the Department. The cause of the acquisition problem(s) shall be discussed in full, and a list of vendors contacted shall be included. The Contractor should be aware that more than one (1) vendor may be required to obtain all the necessary plant materials. Suggestions concerning appropriate substitutions may be included with this correspondence; however, only the Department may approve such substitutions.

Within sixty (60) days of the award of the contract, two (2) copies of a confirmed purchase order listing the quantity and species ordered shall be forwarded to the Engineer. At the same time, a third copy of the purchase order(s) shall be forwarded to the *INSERT COMPETENT REVIEWER OR OFFICE*, at the above address. Only after written approval of the genetic origin of the source material by the Department shall the Contractor initiate the propagation of the source material.

Sixty (60) days prior to planting, the Contractor shall submit two (2) copies, including one (1) mylar reproducible copy, of the proposed wetland layout plan to the Engineer, if different from the original contract drawings. An additional mylar reproducible copy shall be sent to the *INSERT COMPETENT REVIEWER OR OFFICE*. These plans shall be drawn at the same scale as the landscape plans and shall show the proposed locations of the plant materials to be installed. The locations of the permanent landscape stakes shall be shown on these plans. A list indicating the quantities of each species to be installed in each of the landscape blocks or planting areas shall be furnished with the proposed planting plan. To facilitate the preparation of these plans, the Engineer shall provide the Contractor with one (1) reproducible copy of the original landscape plan.

(h) Miscellaneous Materials: Aluminum tags shall be prestamped tags, one and one-half (1½) inches in diameter, five-hundredths (0.050) inch thick with a _-inch hole for nail placement.

Layout stakes shall be nominal one (1)- by two (2)-inch lumber a minimum of three (3) feet in length.

Location stakes shall be nominal two (2)- by two (2)-inch lumber a minimum of four (4) feet in length. The location stakes shall be pressure-treated with wood preservative.

Thermal-reflective tarps (heat shields) shall have one (1) side of the tarp manufactured of a white-faced material and one (1) side with a highly reflective metallic finish. The Department may require the use of thermal-reflective tarps specifically designed or advertised for forestry use at no additional charge to the Department.

Tarps used in the construction of wind barriers or for providing shade shall be tightly woven or coated tarps of sufficient size to perform that function efficiently, as determined by the Engineer.

Straw shall be stalks of oats, wheat, rye, or barley relatively free from seeds, noxious weeds, and other foreign material.

Construction Methods:

(a) General: During all phases of this work, including transport and onsite handling, the plant materials shall be carefully handled and packed to prevent injuries and desiccation. During transit and onsite handling, the plant material shall be kept from freezing and kept covered, moist, cool, out of the weather, and out of the wind and sun. Plants not properly transported, packed or handled, as solely determined by the Engineer, may be rejected by the Engineer without compensation and shall be removed from the site by the end of each workday. Plants shall be watered to maintain moist soil and/or plant conditions until installed.

No planting shall occur until all the soil testing results have been reviewed by the Contractor, the Planting Subcontractor (if applicable), and the Engineer.

(b) Plan Review: If the Contractor or Landscape Subcontractor possesses a record of successful herbaceous wetland plantings that have received final approval from the U.S. Army Corps of Engineers, comments concerning the appropriateness of the various wetland plantings, composition of the planting blocks, planting techniques, and antiherbivory measures are welcomed and encouraged. These comments and suggestions shall be submitted to the Department within thirty (30) days of the award of the contract. The Department may elect to reject some or all comments.

(c) Soil Testing: Soil tests shall be made to determine the soil gradation; nitrogen (ammonia, nitrate, and Kjeldahl nitrogen), phosphorous, potassium, magnesium, calcium, manganese, and zinc levels; soluble salts, pH, buffer pH, and organic matter. Soil tests shall be conducted at a State agricultural laboratory or recognized commercial laboratory, subject to approval by the Engineer. The procedures and materials utilized in collecting the samples shall be as recommended by the laboratory. All laboratory results shall be forwarded to the Engineer. If the soluble salts are less than 16,000 mmhos/cm or exceed a value of 60,000 mmhos/cm (measurement of specific conductance) or the pH is lower than 5.0 or greater than 8.0, the Contractor shall immediately inform the Engineer to determine the proper action.

(NOTE: THE TESTING REQUIREMENTS SHOULD REFLECT REGIONAL CONCERNS AND THE TESTS AND PARAMETERS GIVEN ABOVE MAY HAVE TO BE MODIFIED. SALINITIES TABLES CAN BE FOUND IN COWARDIN (1979);[1] 16,000 mMHOS/CM IS ROUGHLY EQUIVALENT TO A SALINITY OF TEN (10) PARTS PER THOUSAND AND 52,000 mMHOS/CM A SALINITY OF THIRTY-FOUR AND ONE-HALF (34.5) PARTS PER THOUSAND (SEAWATER.), 60,000 mMHOS/CM IS EQUIVALENT TO FORTY (40) PARTS PER THOUSAND. HYPERSALINE ENVIRONMENTS MAY LIMIT THE GROWTH OF SPARTINA).

Each tested sample shall involve compositing six (6) to eight (8) soil locations, collected randomly, utilizing a soil probe. The soils shall be sampled to a depth of eight (8) inches. The Contractor shall perform three (3) soil tests per each ten (10) acres of planting area, with a minimum of five (5) tests per site or as shown on the plans. If the in-place soils are derived from different sources, each source shall be analyzed separately at the same sampling rate or at a rate determined by the Engineer.

When directed by the Department, the placement of lime, iron sulfate, or other amendments shall be done according to and paid under Section XXXXXX - Soil Amendments. Unless authorized in writing by the Department or as shown on the plans, no other amendments shall be placed. Unless specified on the plans, the laboratory conducting the soil tests shall forward recommendations for soil amendments based on a target pH of *INSERT APPROPRIATE VALUE*. If other soil amendments are authorized by the Department, such amendments shall be added as recommended by the soil testing laboratory. The payment for the placement of these other amendments shall be negotiated prior to the work.

The soil testing schedule shall be as shown on the plans.

[1] References cited in this appendix are listed in the References at the end of the main text.

(d) Plant Inspection: The Contractor shall be responsible for all certificates of inspection of plant materials that may be required by Federal, State, or other authorities to accompany shipments of plants.

The successful bidder shall furnish complete information as to the location of all plants that the Contractor intends to supply and use. The Department reserves the right to inspect, tag (seal), and approve all plants at the source of supply. This inspection and tagging shall not in any way eliminate the right of rejection at the site. Inspection prior to moving nursery material shall not be considered as approval.

Any plant delivered to the site that is damaged or desiccated, possesses a dried root system or dried rootstock, or does not meet the material specifications shall not be accepted. The Department reserves the right to reject all stock that is found to be unsatisfactory. No payment shall be made for any unsatisfactory materials or materials not accepted by the Department. All rejected plant material shall be removed from the project site by the close of the working day.

Notice shall be given to the Engineer not less than seventy-two (72) hours before the plant material is to be on the project site. Inspections of the plant materials, including root systems, may be made by the Engineer.

(e) Planting Schedule: No later than forty-five (45) days prior to the estimated planting date, the Contractor shall submit to the Engineer an Estimated Planting Schedule. This estimated schedule shall include the plant shipping dates from the suppliers, plant delivery dates at the construction site or designated delivery point, planting dates for each of the shipments, plant quantities, and an estimate of the planting crew size. The use of multiple plant material shipping dates shall be acceptable. This schedule shall be subject to approval by the Engineer. The Contractor shall adhere to this schedule unless directed by the Engineer or as a result of factors beyond the Contractor's control, such as inclement weather.

(f) Plant Transport: All transport/shipping/handling methods and materials shall be performed according to best nursery and horticultural practices and are subject to approval by the Department. If directed by the Engineer, a description of the transport materials, packing procedures, and shipping methods shall be provided. If determined deficient by the Engineer, the shipping materials, procedures, and shipping shall be modified to an acceptable standard, as solely determined by the Engineer. Each shipping container shall be clearly labeled as to species, quantity, lift date, and packing date. For nonlocal sources, transit time from the plant source/nursery to the construction site or designated delivery point shall be direct and shall not exceed seventy-two (72) hours for dormant material or twenty-four (24) hours for nondormant material, or as approved by the Engineer.

Nonlocal plants shall be scheduled for shipping so that the plants arrive at the construction site or designated delivery location no earlier than twenty-four (24) hours prior to the anticipated planting date for those specific plants. With the permission of the Engineer, the period of onsite storage may be extended if the Contractor can demonstrate to the Engineer's satisfaction the ability to store the materials onsite without damaging the viability of the plant materials.

However, it is the sole responsibility of the Contractor to ensure that the plants are properly stored.

If directed by the Engineer, plant stock source shall be considered local. With local sources, plant materials shall be transported daily from the nursery to the construction site and only in quantities to meet that day's estimated planting needs.

(g) Plant Handling: If the plants are not planted on the day of delivery, the plants shall be stored onsite in a shaded location or in a well-ventilated vehicle, during which time the material shall be kept from freezing and kept covered, moist, cool, and out of the wind and sun. If not installed on the day of delivery, all stock shall be covered in straw or another material, as approved by the Engineer, until the time of installation.

Unless directed by the Engineer, all nondormant plants shall be handled, culled, and sorted in a shaded location. If insufficient natural shade exists, shade shall be erected by the Contractor using tarps or other materials approved by the Engineer. If directed by the Engineer, thermal-reflective tarps shall be used to cover the plant materials.

If wind speeds exceed ten (10) miles per hour, a wind barrier shall be erected immediately adjacent to the stockpiling area. The wind barrier shall be constructed utilizing tightly woven or coated tarps, or as approved by the Engineer. The materials and methods used in the construction of the wind barrier shall be subject to approval by the Engineer. With the approval of the Engineer, the Contractor may elect to utilize the transport vehicle as a temporary storage area, subject to the above restrictions and guidelines, including the placement of tarps. The construction of wind barriers or shade or the use of thermal-reflective tarps shall be incidental to this item, and no additional compensation to the Contractor shall be made by the Department. The Engineer may direct that local stock be returned to the nursery.

(h) Plant Watering: From the time the plant materials leave the nursery or collection site until the time planted materials are installed and full unrestricted tidal flow is established, all stock shall be watered with fresh water, as to prevent the development of hypersaline conditions and water stress. Saline or brackish water shall not be utilized.

(i) Planting Seasons: The planting dates for nondormant plants shall be from *INSERT DATE* to *INSERT DATE*, provided the ground is not frozen and as shown on the plans. Dormant wetland herbaceous species may be planted from *INSERT DATE* to *INSERT DATE,* provided the ground is not frozen and as shown on the plans. At the discretion of the Department, nondormant rootstocks of the same plant species as specified may be substituted at the same bid price as dormant stock. The Department may reject the use of dormant plants and/or certain planting windows, as shown on the plans.

If the plant materials are not installed within the specified planting window, the Engineer may institute a one (1)-year plant establishment period for the planting, as solely determined by the Engineer. The requirements for this planting establishment period shall be as outlined in Subsection (p) Plant Establishment Period.

NOTE: IF APPROPRIATE, ONE SHALL HAVE ONLY A SINGLE PLANTING WINDOW AND DELETE THE REFERENCES TO OTHER WINDOWS.

(j) Plant Installation Period: After plant delivery to the construction site or to the designated delivery location, all dormant nonlocal plant material shall be installed within fifty-eight (58) hours, and all nonlocal dormant plant material shall be installed within thirty-four (34) hours. Shipments of plant materials may be staggered over several days. Local materials shall be installed on the day of delivery.

To prevent the desiccation of the herbaceous wetland plant materials, the Contractor shall complete the plantings of the wetland systems within five (5) calendar days of the initial plantings of each of those systems. During this period, it is the sole responsibility of the Contractor to ensure that the soil is kept saturated and the plants are not desiccated or subjected to salt stress or osmotic stress, as solely determined by the Engineer.

(k) Layout: If layout stakes or location stakes are shown on the plans, the Contractor shall stake these locations as specified prior to the planting. The stakes shall be numbered or coded indicating the appropriate blocks/areas and species to be planted. The layout stakes shall be driven firmly into the soil a minimum of eighteen (18) inches. The locations stakes shall be driven firmly into the soil a minimum of twenty-four (24) inches. The location stakes shall be tagged with one-and-one-half-inch (1-1/2") diameter aluminum prestamped tags to indicate the appropriate block numbers/planting areas, as shown on the plans.

(l) Setting Plants: All planting tools and methods are subject to approval by the Department. Plants shall be placed in an upright position on the highest microtopographic positions, while maintaining the required planting spacing and densities. Deeper plantings shall be allowed with the approval of the Engineer. All planting procedures, techniques, and tools are subject to approval by the Engineer. Unless indicated on the plans, topsoiling and mulching treatments shall not be required. Plants shall **not** be installed during periods of inundation.

The Engineer may allow the use of machine planting of sprigs, but only after a submittal of the planting procedure, including machine material description. If machine planting is authorized, the quality of the installation shall not be reduced from that described herein. At any time, the Engineer may decide to withdraw permission for machine planting without any additional compensation to the Contractor and require hand planting of all stock.

1. Sprigs: Unless directed by the Engineer, the plants shall be planted (1) in the soil at a depth one (1) to two (2) inches deeper than grown in the nursery or source location; (2) to a depth that will ensure that the top of the rhizome lies one (1) to two (2) inches below the soil surface; and (3) so that all portions of the root system are in the soil. If dry conditions are anticipated, deeper plantings shall be acceptable as approved by the Engineer.

The number of sprigs planted per planting hole shall be _____.

2. Peat Pots, Tublings, and Plugs: The individual peat pots and plugs shall be planted in the soil at least one (1) inch deeper than grown in the nursery or source location and to a depth that will ensure that the top of the rootstock mass lies at least one (1) inch below the soil surface. The maximum planting depth shall be two (2) inches deeper than grown in the nursery.

In order to place the plants at the appropriate depth and position in the soil, the soil surface shall be opened with a tile spade, hoedad, or other appropriate hand or power tool. If peat-potted stock is utilized, an auger shall be used to develop the planting hole. The depth of auger placement shall allow for easy plant placement at the specified depth while limiting the formation of air pockets beneath the planting hole. Prior to planting, each side of the peat pot shall be split with a razor to facilitate root and rhizome growth.

Prior to placement of the plant in the planting hole, a twenty (20)-gram fertilizer tablet shall be placed in the bottom of the planting hole. The plant(s) shall then be placed at the appropriate depth with the root system oriented downward. While the plant is in this position, the soil profile or section shall be fully and firmly closed with an appropriate hand tool. Once the soil is closed, firm foot pressure shall be applied in several positions immediately adjacent to the plantings to ensure good soil and plant contact, and to remove any air pockets and voids. If a soil depression is formed above or immediately adjacent to the planting location, enough soil shall be sloughed from the surrounding area and firmly tamped into the depression to leave the planting area at the same elevation as the surrounding soil or slighty higher.

If pint-, quart- or gallon-container stock is utilized, a hole of sufficient width and depth shall be excavated to allow easy placement of the plant at a depth one (1) to two (2) inches deeper in the soil than grown in the nursery or source location. Prior to the placement of the plant in the planting hole, a twenty (20)-gram fertilizer tablet shall be placed in the bottom of the planting hole. If the root system of container stock is container-bound, the root system shall be carefully freed; any container-bound or cramped roots will be separated and spread out when placing the plant so that the roots can grow without further constriction of the root mass. The planting hole shall then be backfilled with the excavated soil and tamped firmly to remove all air pockets and voids. If a soil depression is formed above or immediately adjacent to the planting location, enough soil shall be sloughed from the surrounding area and firmly tamped into the depression to leave the planting area at the same elevation as the surrounding soil.

(m) Fertilizer Placement: During the initial planting, all fertilizer shall be placed in the bottom of planting holes. At no time shall fertilizer be placed in the water column or on top of a soil surface. Soluble fertilizers should not be placed in direct contact in the rootstocks.

If requested by the Engineer, postplanting fertilizer shall be uniformly broadcast over the planting area during low tides. This work shall be done at the uniformly agreed-upon lump sum bid price for the application of 1,000 pounds of 20-10-10 fertilizer per acre of planting area.

(NOTE: THE APPLICATION OF POSTPLANTING FERTILIZER IS BEST HANDLED AS A SEPARATE SPECIFICATION WITH A SEPARATE UNIT BID PRICE FOR THE WORK, BASED ON THE CONTINGENCY QUANTITY SHOWN ON THE PLAN SUMMARY SHEET. IT IS ADVISED THAT THIS WORK BE DELETED FROM THIS SPECIFICATION).

(n) Tidal Flooding: If indicated on the plans, the planting shall be performed under free-flow tidal conditions. If the planting is performed under diked or bermed conditions that curtail tidal flows, the natural tidal flow shall be restored within twenty-four (24) hours of concluding the installation of the plant materials. During the period when the tidal waters are curtailed, the Contractor shall be responsible for ensuring that the planting areas are kept moist at all times and that the plant materials are not subject to desiccation or salt stress.

(o) Acceptance: The wetland plant material shall be evaluated for acceptance fourteen (14) days after all the following have been completed or satisfied:

1. The plant material has been satisfactorily installed.

2. If the site has been bermed or diked, normal tide flows are present.

3. All specified fencing has been installed and accepted adjacent to the planting areas.

4. All specified herbivory prevention measures have been installed and accepted.

5. No compensation shall be made for the installation or the cost of the material for plants not properly planted, including those plants whose roots are exposed at the time of acceptance or those plants subject to desiccation.

During this acceptance period, the Contractor shall be responsible for ensuring that the planting areas are kept moist or flooded, as appropriate for the wetland design. Plant materials determined to be dead or seriously weakened shall not be accepted, with the exceptions noted herein. If all herbivory prevention measures and fencing have been installed on time and as specified and identified on the plans, as solely determined by the Engineer, those plants absent or damaged via herbivory, as solely determined by the Engineer, shall be credited for acceptance. Plants absent for reasons other than herbivory shall not be accepted. If all herbivory prevention measures and associated fencing were not initially installed on time and as specified, all absent or seriously damaged plant materials including those damaged or lost to herbivory, as solely determined by the Engineer, shall not be accepted. If no herbivory measures are identified on the plans, the Contractor shall not be responsible for any plant losses due to herbivory, as solely determined by the Engineer. If indicated on the plans or if indicated by the Engineer, various types of fencing and other plan features shall be considered to be antiherbivory measures, including silt fencing or other fencing adjacent to flooded habitats.

Except as indicated in the previous paragraph, plant materials found dead, absent, seriously damaged, weakened or desiccated, floating on the water surface, deposited along the edge of

the wetland, exposed on soil, or within the water column shall be replanted prior to acceptance at no additional cost to the Department or replaced with new materials, as solely directed by the Engineer. If new materials are required in order to achieve full acceptance, such materials shall be acquired and installed by the Contractor at no additional cost to the Department. Installation of these materials shall not occur until all herbivory prevention measures have been installed and accepted.

No compensation shall be made for the installation or the cost of the material for plants not properly planted, including those plants whose roots are exposed within the acceptance period.

(p) Plant Establishment Period: Generally, there is no plant establishment period for the plantings. However, if the work of the Contractor results in (a) planting outside the specified planting window; (b) extending the height or duration of natural flood events beyond the design conditions of the project; or (c) through the use of undersized stock, as solely determined by the Engineer, the Engineer may institute a one (1)-year guarantee period for the designated planting stock, with a fifty percent (50%)-survival (including vegetative off-shoots) or 40 percent (40%)-coverage criteria. If the one (1)-year guarantee is instituted, the Department may require bonding by the Contractor for the full cost of the plant material, labor, all incidentals' costs associated with this work, and all other associated items, as solely determined by the Department. In lieu of bonding, the Department may elect to withhold fifty percent (50%) of the payment for this work until this survival determination has been made by the Department.

The one (1)-year period shall begin at the time of the initial acceptance of the planting, extend a minimum of six (6) months, and then extend to the next August 15 calendar date, at which time final acceptance will be determined by the Department. This one (1)-year guarantee may be considerably longer in duration than 365 calendar days. The Department may shorten the length of the plant establishment period or reduce the coverage or survival requirements. The Department may elect not to include volunteer species or species not identified for planting in specific areas or planting blocks into the estimates of survival or coverage. At the end of the plant establishment period, individual planting blocks or areas of the planting that do not exhibit either forty percent (40%)-aerial cover or fifty percent (50%)-survival of the plants that were planted in each of the individual planting blocks or areas shall be determined to be deficient, as solely determined by the Department. Percent aerial cover shall be the proportion of the ground or water surface occupied by the perpendicular projection to the ground or water surface from the outline of the aerial parts of the plants. Foliage cover, defined as the perimeter projection of the crowns, shall not be utilized for these estimates. For this determination, each of the individual planting blocks or areas shall be individually assessed, distinct and separate from all other planting blocks or areas, as solely determined by the Department. If no blocks or planting areas are shown on the plans, the Department shall designate planting blocks on an approximate fifty (50)- by fifty (50)-foot grid, as solely determined by the Department. Those blocks or planting areas deemed to be deficient shall be replanted at no cost to the Department, as solely determined by the Department. The Contractor shall be solely responsible for the survival of the planting material. Losses attributed to waterfowl herbivory; wildlife herbivory; disease; eutrophication; inappropriate hydrological regimes; drought; insect damage; fire, wind,

or wave energies; ice scouring; or vandalism **shall not** lower the minimum survival or coverage requirements, nor shall such losses be credited against the survivalship or coverage requirements. Species selected for replanting shall be determined by the Department. The new plantings shall be of a density to comply with the full planting densities shown on the plans, as solely determined by the Engineer. Materials, installation, and acceptance requirements shall be as originally specified herein, including all elements and conditions of **Subsection (o) Acceptance.** During any required replantings, all antiherbivore measures, as identified by the Engineer, shall be installed and maintained by the Contractor according to the appropriate specifications at no cost to the Department.

(**NOTE:** ONE SHALL VERIFY ALL THE REQUIREMENTS OF THE PLANT ESTABLISHMENT PERIOD. THE INSTITUTION OF THE GUARANTEE PERIOD IS MOST LIKELY TO OCCUR WITH LATE PLANTINGS. PLANTING LATE SHOULD BE AVOIDED, AS LATE PLANTINGS WILL LIMIT THE POTENTIAL FOR THE FORMATION OF AN INTERLOCKING ROOT NETWORK, WHICH WILL RESIST HERBIVORY, ICE SCOURING, AND WAVE DAMAGE, AND NOT NECESSARILY BECAUSE OF PHYSIOLOGICAL CONSIDERATIONS. LATE PLANTINGS WILL ALSO REDUCE THE OPPORTUNITY FOR VEGETATIVE SPREAD, SEED PRODUCTION, THE ACCUMULATION OF STARCH RESERVES FOR THE NEXT YEAR'S GROWTH, AND MAY ALSO INCREASE THE POTENTIAL FOR WEED COLONIZATION. ENTERING THE SECOND YEAR, EUTROPHICATION IMPACTS MAY BE HEIGHTENED BECAUSE OF THE SMALLER STARCH RESERVES. PLANTS PLACED IN EXTENDED COLD STORAGE DURING THE DELAY WILL EXPERIENCE INCREASED RESPIRATION, THEREBY DEPLETING CARBOHYDRATES CRUCIAL TO OUTPLANTING SURVIVAL.

LATE PLANTINGS ARE PARTICULARLY TROUBLESOME WHEN SHIFTED FROM THE EARLY SPRING TO MIDSUMMER OR LATE SUMMER. THE PLANT ESTABLISHMENT PERIOD MAY ALSO BE INSTITUTED WHEN THE CONTRACTOR HAS CONSTRUCTED A TEMPORARY BERM AROUND THE MITIGATION TO CURTAIL TIDAL FLOODING. IF PLANTED AREAS THEN FLOOD PRIOR TO REMOVAL OF THE BERM, THE HEIGHT AND DURATION OF THE FLOODING COULD "DROWN" SOME OF THE STOCK. THIS AUTHOR SUGGESTS THAT THIS REQUIREMENT BE PLACED AS A PLAN NOTE).

(q) Replacement Plantings: When requested, the Contractor shall arrange for replacement plantings of the species requested by the Department and any antiherbivory measures at the original bid prices plus inflation as measured by the Regional Consumer Price Index for a three (3)-year period following the initial acceptance of the planting (U.S. Department of Commerce).

(r) As-Builts: Within fourteen (14) days of the installation of the plants, the Contractor shall submit two (2) copies, including one (1) mylar reproducible copy, of the layout plan to the Engineer, if different from the original contract drawings. In addition, two (2) mylar reproducible copies shall be sent to the *Insert Title and Office*. Unless directed by the *Insert*

Title and Office, these plans shall be drawn to a scale of one inch (1") = fifty (50) feet and shall show as-built locations for the plant material used. The locations and labeling of the permanent landscape stakes shall be shown on these plans.

A list of the quantities of each species installed in each of the planting blocks or areas shall be submitted with the plans. Any deviations from the original landscape plans, including approved substitutions, or from the proposed layout plan that was submitted to the Engineer sixty (60) days prior to the planting, shall be clearly marked and documented.

Method of Measurement:

Planting, Salt Marsh shall be measured by the number of each plant installed and accepted.

Basis of Payment:

Payment for Planting, Salt Marsh shall be paid for at the unit bid price each for the various items of the planting schedule accepted, which price and payment shall constitute full compensation for furnishing all plants, labor, materials, tools, equipment, water, and incidentals necessary to complete the item. Compensation for landscape dewatering, flooding, soil testing, fertilizer, layout stakes, location stakes, planting block layout, and as-built drawings shall be included in the unit bid price for Planting, Salt Marsh (*Spartina*). No separate payment shall be made for accessory items as herein specified as necessary or required, but all costs thereof shall be included in the unit prices bid for the Pay Item.

Appendix L

Clay Liner

NOTE: DEPENDING ON THE APPLICATION AND THE LOCATION WITHIN THE WETLAND, A FRIABLE PLANTING MEDIUM MAY NEED TO BE PLACED ON TOP OF THE LINER COVER. ONCE THIS SOIL IS PLACED, NO EQUIPMENT OR VEHICLE ACCESS SHOULD BE PERMITTED UNDER THE SPECIFICATION FOR THE PLACEMENT OF THE PLANTING MEDIUM.

Description:

Clay liner shall consist of furnishing material for and construction of a relatively impermeable clay liner, as shown on plans, for the creation of ponds and marshes. Clay liner shall include furnishing, delivering, placing and compacting suitable materials for clay liner and liner cover obtained from borrow sources, on prepared subgrade at the prescribed locations and conforming to the prescribed lines, grades, cross sections, and dimensions shown on the plans or as directed by the Engineer. This work shall also include setting-out, testing, and any dewatering of the site as required for the construction of the clay layer.

Materials:

(a) Clay Liner: The materials used for the clay liner shall conform to the Unified Classification System designation CL or CH and shall be free from organics, ashes, muck, wood, brush, roots, sod, rubbish, garbage, and any other matter that may decay. The Contractor shall perform material classification tests on representative samples taken from the source of the clay liner material and shall furnish the results to the Engineer for approval. The pH of the liner material shall be restricted to the range of *(INSERT DESIRED RANGE)*.

(b) Liner Cover: The materials used for the liner cover shall be free from ashes, muck, wood, brush, roots, sod, rubbish, garbage, and any other matter that may decay. The Contractor shall determine the gradation requirements for the liner cover material based on the gradation of the clay liner material following the filter design criteria listed below:

1. The ratio of D_{15} of the liner cover material to D_{85} of the clay liner material shall be less than 5.

2. The ratio of D_{15} of the liner cover material to D_{15} of the clay liner material shall be less than 20.

3. The ratio of D_{15} of the liner cover material to D_{15} of the clay liner material shall be greater than 4.

4. The ratio of D_{50} of the liner cover material to D_{50} of the clay liner material shall be less than 25.

D_{15}, D_{50}, and D_{85} mentioned above represent the particle sizes from a particle size distribution plot at fifteen percent (15%), fifty percent (50%), and eighty-five percent (85%), respectively, finer by weight. The pH of the material shall be restricted to a range of *INSERT DESIRED RANGE*.

Construction Methods:

The clay liner shall be constructed in accordance with Section *(INSERT SPECIFICATION CODE FOR EARTHWORK)*, except as provided herein.

(a) Setting-Out: The Contractor shall establish a grid system, with grid line intervals not to exceed 200 feet in each of two (2) directions perpendicular to one another, covering the whole of the clay liner area as shown on the plans or as directed by the Engineer. The proposed grid layout shall be submitted to the Engineer for his approval before placing any material for the clay liner. Each of the areas delineated inside the grid shall constitute one (1) testing area.

(b) Subgrade for Clay Liner: The subgrade shall be conform to the requirements of Section *(INSERT SPECIFICATION CODE FOR STANDARD SUBGRADE)*, to grade and contour as shown on the plans or as directed by the Engineer, with a firm and even surface and to the complete satisfaction of the Engineer, prior to placing the clay liner.

(c) Dewatering: Dewatering shall be the responsibility of the Contractor and shall be carried out by pumping, well points, or other approved methods as required at all times during construction. The water table within the construction area shall be kept at least three (3) feet below the bottom of excavation. Adequate dewatering shall be provided in order to maintain stable slopes for the clay liner construction.

(d) Test Strip: The Contractor shall construct a test strip, within the clay liner limits as shown on the plans, on a prepared subgrade as specified, to a width of 24 feet and a length of 200 feet minimum. The clay liner material shall be placed in a single layer to achieve a minimum compacted depth of nine (9) inches. The single layer shall be compacted by the Contractor, using the compacting equipment proposed for use on the Project. The test strip shall be tested at a minimum of three (3) locations as directed by the Engineer, and shall meet the requirements for compaction and permeability before it is approved.

Test strip construction shall be repeated if the minimum specified compaction or maximum allowable permeability is not achieved, or whenever the source or quality of material is changed or whenever the compaction equipment changes. If at any time the specified compaction or permeability is not achieved, the Contractor shall modify or change his procedures to obtain the required compaction.

The Contractor shall obtain the Engineer's approval for the test strip before proceeding with the construction of other clay liner areas shown on the plans. If the Engineer approves the test strip, then it shall remain as part of the finished construction. If the test strip fails to meet the

required compaction or permeability values after modification of the Contractor's procedures, then the material in the test strip shall be entirely removed by the Contractor and replaced in accordance with the requirements of the specifications. Removing, replacing, and compacting the unsatisfactory test strip material, and all additional testing required, shall be entirely at the Contractor's expense.

(e) Clay Liner: The clay liner shall be constructed on prepared subgrade, and spread in such a manner that the material is not contaminated by foreign material, and that after compaction, a uniform thickness, free from defects and discontinuities, of not less than nine (9) inches is achieved.

The Engineer shall take representative soil samples from the clay liner material, as it is delivered to the site. If any such sample indicates that the material does not conform to requirements specified, the Engineer will test additional samples taken from materials in place in the construction and will delineate any areas containing the unsatisfactory materials. The Contractor shall remove this unsatisfactory material to the depth and within the areas designated by Engineer and replace it with material conforming to the requirements of these Specifications. Removing and replacing unsatisfactory material shall be entirely at the Contractor's expense.

The material shall be deposited in uniform layers not to exceed twelve (12) inches in thickness, loose measurement, and compacted as specified. The loose thickness of the material may be modified by the Engineer if the Contractor can demonstrate to the satisfaction of the Engineer that the compacting equipment he proposes to use can compact the clay liner to the specified minimum, or greater compaction, and will achieve the specified maximum, or lesser permeability, when compacted in layers thicker than the specified twelve (12) inches maximum.

Materials shall be placed neither when frozen nor on a frozen surface or in standing water.

(f) Compaction: A moisture density curve shall be developed from representative samples of the material in accordance with ASTM D 698, prior to placing any clay liner material. The clay liner shall be compacted at one-half to two percent (½ to 2%) wetter than the optimum moisture content, as established by the moisture density curve such that a minimum of ninety-five percent (95%) of optimum density is achieved.

If the material is too moist to permit suitable compaction, it shall be allowed to dry until the moisture content will permit acceptable compaction. If the material as placed is too dry, water shall be added, or the material shall be removed and replaced with moister material.

Pulverizing or other manipulation of the material in order to obtain the required consistency for compaction shall not be permitted, unless expressly authorized by the Engineer.

Compaction shall be accomplished by rolling with a sheepsfoot tamping roller or other approved compacting equipment as best suited to the general character of the material being

compacted and to the space limitation of the area being compacted, or as otherwise approved by the Engineer.

The type and weight of the compacting equipment used shall be such that uniform density is obtained throughout the depth of the layer of material being compacted. The equipment that the Contractor proposes to use shall at all times be subject to the approval of the Engineer.

Trucks, carryalls, scrapes, tractors, tractor wagons, or other hauling equipment shall not be considered compacting equipment as specified above.

Material placed adjacent to structures in areas inaccessible to the usual compaction equipment shall be compacted with mechanical tampers and/or vibratory equipment of a type approved by the Engineer.

Testing as directed by the Engineer for compaction of the clay liner shall be carried out immediately following compaction of each area. The clay liner within each area shall be tested for moisture content and density by the nuclear method (ASTM D 3017 and D 2922). A total of _ successful tests for moisture content and _ successful tests for density by the nuclear method shall be required.

The density of the compacted material, when tested in the field, shall be not less than ninety-five percent (95%) of maximum dry density developed in accordance with AASHTO T180.

All test data, referenced by location, shall be submitted to the Engineer for his approval.

The Contractor shall be solely responsible for performing the work to meet the specified minimum compaction.

At all times during this work the Contractor shall provide and maintain ditches, temporary pipes and other temporary or permanent construction, at his own expense, to permit ready runoff of water and to ensure proper drainage for the entire area.

(g) Permeability: The permeability of the clay liner shall not exceed *INSERT VALUE* centimeters per second (___X10E-___ cm/sec).

Testing of the clay liner shall be in accordance with ASTM D 5084-90: Test Method for Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter. Testing shall include taking core samples as directed by the Engineer, preparing the core samples as required, and testing the core samples at the laboratory.

Test samples shall be taken from the clay liner as directed by the Engineer at any time after compaction of each section of the clay liner. A total of __ successful tests shall be required.

If any permeability test results exceed the specified permeability limit, the Contractor shall remove the unsatisfactory clay liner material as directed by the Engineer and replace it in

accordance with the specifications. Removing and replacing the unsatisfactory clay liner material shall be entirely at the Contractor's expense.

(h) Liner Cover: Liner cover shall be constructed to the lines, grades, and thicknesses shown on the plans above the clay liner, when specified. The material shall be deposited in uniform layers and proof-rolled with two (2) passes of a power roller.

The roller shall be of the three-wheel or tandem, self-propelled type, weighing not less than three (3) tons or more than six (6) tons. All wheels shall be flat (smooth). In lieu of the equipment specified, the Contractor may, upon written permission from the Engineer, operate other compacting equipment that will produce equivalent, relative compaction in the same period of time as the specified equipment.

OPTIONAL: **(i) Testing:** The Department shall, at no cost to the Contractor, arrange with a laboratory to cut core samples from the completed clay liner that will be used to determine the thickness and permeability of the clay liner. The Department's laboratory will also patch and compact the cored holes, with clay liner material provided by the Contractor for the purpose of the project.

Method of Measurement:

The number of square yards of Clay Liner, nine (9) inches compacted depth, measured on surface shall be the area measured for payment. No separate measurement or payment shall be made for the liner cover. The work associated with the liner cover is incidental to this item.

Basis of Payment:

The payment for Clay Liner shall be made as measured above at the unit price bid per square yard for the Section XXXXXX - Clay Liner, which price and payment shall constitute full compensation for furnishing, placing, compacting and testing the material, and for furnishing all tools, labor, work, and incidentals necessary to complete the work. All dewatering is incidental to this item.

Appendix M

Wetland Subgrade Treatment

NOTE: A FRIABLE PLANTING MEDIUM WILL NEED TO BE PLACED ON TOP OF THE SUBGRADE TREATMENT. ONCE THIS SOIL IS PLACED, NO EQUIPMENT OR VEHICLE ACCESS SHOULD BE PERMITTED UNDER THE SPECIFICATION FOR THE PLACEMENT OF THE PLANTING MEDIUM.

Description:

Wetland Subgrade Treatment shall consist of backfilling areas of relatively high permeable soils with relatively low permeable soils in order to provide a low infiltration base for wetland establishment. This work shall include grading the subgrade in the areas of sandy soils and backfilling with silty, clayey soils and grading and compacting to the required lines and grades as further specified.

Definitions:

(a) Type A Soils: Type A soils include GRAVEL, SAND, Gravel and Sand mixtures, and Silty SAND classified according to the Burmister Soil Classification System, or material designations A-1, A-2, and A-3 classified according to the AASHTO Classification System. The Unified Soil Classification System may be used in lieu of the AASHTO Classification System.

(b) Type B Soils: Type B soils include SILT, SILT and CLAY, CLAY and SILT, Silty CLAY, and CLAY classified according to the Burmister Soil Classification System, or material designations A-4, A-5, A-6, and A-7 classified according to the AASHTO Classification System. The Unified Soil Classification System may be used in lieu of the AASHTO Classification System.

Materials:

The materials used for subgrade preparation shall be Type B soils. Not all soils within these designations will necessarily achieve the required infiltration rate. The Contractor may modify the material by mixing with sodium bentonite in order to achieve the required infiltration rate. If bentonite is mixed with the Type B soils, the mixing of the bentonite shall be uniform throughout the upper six (6)-inch depth of the subgrade preparation..

Sodium bentonite used shall be high-swelling sodium bentonite or sodium bentonite containing polyacrylate polymer to maximize wetting, expansion, and dispersing action in all types of soils. High swelling is defined as the ability of two (2) grams of untreated base bentonite, when mechanically reduced to -100 mesh, to swell in water to an apparent volume of sixteen (16) cubic centimeters or more, when added a little at a time, to one hundred (100) cubic centimeters of distilled water in a graduated cylinder. The colloid content of the base bentonite

shall exceed eighty-five percent (85%), as measured by evaporating the suspended portion of a two percent (2%) solution after twenty-four (24) hours of sedimentation in a glass graduated cylinder or beaker.

Construction Methods:

(a) Limits of Subgrade Preparation: After the elevation of the excavation floor has been achieved, the Engineer shall determine the areas of Type A soils that need overexcavation for subgrade preparation.

The Contractor shall excavate the area of subgrade preparation to a depth of twelve (12) inches below the elevation of the proposed subgrade as directed by the Engineer. The actual horizontal extent of subgrade preparation shall be determined by the Engineer based on the materials encountered during excavation. The excavation work performed at the elevation of the excavation floor for subgrade preparation shall be measured and paid under Section XXXXXX.

Prior to placing the Type B soils, the excavation floor shall be shaped and compacted to lines and grades with a firm and even surface, to the satisfaction of the Engineer.

(b) Test Strip: The Contractor shall construct a test strip within the area of subgrade preparation to a width of twenty-four (24) feet and a length of eighty (80) feet minimum. The compacting equipment utilized for test strip construction shall be the same as those proposed for use on the project. The test strip shall be tested at a minimum of two (2) locations as directed by the Engineer, and shall meet the requirements for compaction and infiltration before it is approved.

Test strip construction shall be repeated if the minimum specified compaction or maximum allowable infiltration is not achieved. If the Engineer approves the test strip, then it shall remain as part of the finished construction. If the test strip fails to meet the required compaction or infiltration values, then the Contractor shall modify his procedures and/or material and retest at the Contractor's expense.

(c) Subgrade Treatment: The Type B soils shall be placed in two (2) layers; each shall be placed and spread in such a manner that the material is not contaminated by foreign material, and that after compaction a uniform thickness, free from defects and discontinuities, of not less than six (6) inches is achieved.

The material shall be deposited in uniform layers not to exceed twelve (12) inches in thickness, loose measurement, and compacted as specified. The loose thickness of the material may be modified by the Engineer if the Contractor can demonstrate to the satisfaction of the Engineer that the compacting equipment he proposes to use can compact the Type B soils to the specified minimum, or greater compaction, and will achieve the specified maximum, or lesser permeability, when compacted in layers thicker than the specified twelve (12) inches maximum.

Materials shall be placed neither when frozen nor on a frozen surface or in standing water.

(d) Compaction: A moisture density curve shall be developed from representative samples of the Type B soils in accordance with ASTM D 698, prior to placing. The Type B soils shall be compacted at one-half to two percent (½ to 2%) wetter than the optimum moisture content, as established by the moisture density curve, such that a minimum of ninety-five percent (95%) of optimum density is achieved.

If the material is too moist to permit suitable compaction, it shall be allowed to dry until the moisture content will permit acceptable compaction. If the material as placed is too dry, water shall be added or the material shall be removed and replaced with moister material.

Pulverizing or other manipulation of the material in order to obtain the required consistency for compaction shall not be permitted, unless expressly authorized by the Engineer.

Compaction shall be accomplished by rolling with a sheepsfoot tamping roller or other approved compacting equipment as best suited to the general character of the material being compacted and to the space limitation of the area being compacted, or as otherwise approved by the Engineer.

The type and weight of the compacting equipment used shall be such that uniform density is obtained throughout the depth of the layer of material being compacted. The equipment that the Contractor proposes to use shall at all times be subject to the approval of the Engineer.

Trucks, carryalls, scrapes, tractors, tractor wagons, or other hauling equipment shall not be considered as compacting equipment as specified above.

Material placed adjacent to structures in areas inaccessible to the usual compaction equipment shall be compacted with mechanical tampers and/or vibratory equipment of a type approved by the Engineer.

Testing as directed by the Engineer for compaction of the Type B soils shall be carried out immediately following compaction of each area. The Type B soils placed and compacted within each area shall be tested for moisture content and density by the nuclear method (ASTM D 3017 and D 2922). Testing for moisture content and density by the nuclear method shall be performed following a 200¢ × 200¢ grid pattern.

The density of the compacted material, when tested in the field, shall be not less than ninety-five percent (95%) of maximum dry density developed in accordance with AASHTO T180.

All test data, referenced by location, shall be submitted to the Engineer for his approval.

The Contractor shall be solely responsible for performing the work to meet the specified minimum compaction.

At all times during the backfilling of the site with Type B soils, the Contractor shall provide and maintain ditches, temporary pipes, and other temporary or permanent construction, at his own expense, to permit ready runoff of water and to ensure proper drainage for the entire area.

(e) Infiltrometer Tests: The Contractor shall perform field infiltrometer testing following a 200¢ × 200¢ grid pattern at the final subgrade elevation.

The Contractor shall possess the following equipment for the infiltrometer testing:

1. Eight to twelve-inch (8" to 12") diameter rings, one (1) foot in length, Gauge 14, made of cold rolled steel or approved equivalent.

2. A circular cover plate, ten to fourteen-inch (10" to 14") diameter, to aid in driving the cylinder into the soil.

3. A heavy pounding device to drive the cylinder into the soil.

4. A metric ruler to measure water depths.

The Contractor shall perform infiltrometer tests following the procedures outlined below:

1. Select the area for testing as directed by the Engineer.

2. Place the cylinder and cover with the cover plate.

3. Drive the cylinder carefully into the soil to a depth of five inches (5"). Keep the top of the cylinder horizontal while driving.

4. Fill the cylinder with water gently, so as not to disturb the soil surface, to about one (1) inch from the top of the cylinder.

5. Immediately take the reading of the water level. The measurement shall be made from a premarked point on the top of the cylinder to the water surface.

6. Repeat the water level measurements at the following times:

    - 1, 2, 4, 10, 20, 30, and 60 minutes;
    - 5, 10, and 24 hours; and
    - 2, 3, 4, 5, 6, 7,8, 9, and 10 days.

7. Cover the cylinder with the cover plate at all times, except when taking the readings, in order to prevent errors resulting from rainfall and evaporation.

8. Calculate the infiltration rate by plotting the results on log-log paper.

The Contractor shall provide all infiltration data, calculations, and results to the Engineer. If the infiltration rate calculated is greater than 0.00001 centimeters per second (1X10E-5 cm/sec), then the Contractor shall reduce the infiltration by additional compaction or by replacing the material within the representative grid area and repeat the test as directed by the Engineer.

All testing shall be performed in the presence of the Engineer. The Contractor shall utilize an adequate number of infiltrometers to prevent delays in construction.

Method of Measurement:

The number of square yards of Wetland Subgrade Treatment, twelve (12) inches compacted depth, measured on the surface shall be the area measured for payment.

Basis of Payment:

The payment for Wetland Subgrade Treatment shall be made as measured above at the unit price bid per square yard for the Section XXXXXX - Wetland Subgrade Treatment, which price and payment shall constitute full compensation for grading, placing, compacting and testing the material, and for furnishing all tools, labor, work, and incidentals necessary to complete the work.

Appendix N

Subsoil Tillage

Description:

Subsoil Tillage shall consist of conducting deep tillage in areas designated on the plans or as directed by the Engineer. Unless indicated on the plans, the depth of tillage shall be twenty-four (24) inches vertical.

Materials:

The subsoiler used in the work shall be specially designed for subsoil tillage. All subsoilers and tractors utilized are subject to approval by the Department. Within thirty (30) days of the award of the Contract, the Contractor shall supply the Department with the name and model number of the subsoiler and tractor, and the subsoiler and tractor manufacturer's guidelines related to equipment size, power, and drawbar pounds pull. Plows or disks shall not be utilized for this work.

The subsoiler shall have a minimum net weight of _____ pounds *(INSERT VALUE)*. Unless specified on the plans, the subsoiler shall have the capability of operating with a minimum of five (5) steel shanks, and the distance between adjacent shanks shall not exceed thirty (30) inches. Unless specified on the plans or directed by the Engineer, the maximum number of shanks as designed for the subsoiler shall be utilized when conducting this work. Each steel shank shall have the minimum dimensions of one and one-half inches by seven and one-half inches by thirty inches (1½" × 7½" × 30"). Larger shanks are acceptable. The minimum vertical tillage depth shall be twenty-four (24) inches as measured by field performance, as determined solely by the Engineer. Each shank shall be equipped with replaceable steel points.

(NOTE: WEIGHTS OF SUBSOILERS ARE HIGHLY VARIABLE. THE MINIMUM WEIGHT FOR HEAVY-DUTY SUBSOILER SUPPORTING FIVE (5) SHANKS WILL BE ABOUT 5,000 POUNDS. SUBSOILERS WITH MINIMUM WEIGHTS OF 6,500 POUNDS MAY BE REQUIRED FOR MANY APPLICATIONS.)

A crawler-tracked tractor shall be utilized for the subsoiling operations. The tractor shall conform to the subsoiler and tractor manufacturer's recommendations as to minimum size, power, and drawbar pounds pull for the subsoiler with reference to specified tillage depth, soil texture, and soil conditions. The tractor shall have the hydraulic lines and characteristics necessary for proper operation of the subsoiler as designed and recommended by the manufacturer. It shall be the Contractor's responsibility to ensure that all equipment possesses sufficient power and is of appropriate design and weight distribution to complete the subsoiling operations.

Construction Methods:

Subsoil tillage shall be performed within the areas shown on the plans. Unless directed by the Engineer or indicated on the plans, the subsoiling operation shall be conducted in two (2) series of passes, with the second series of passes being made perpendicular to the first series or as directed by the Engineer. The distance between parallel passes of the same series shall not exceed the distance between the individual shanks. Unless directed by the Engineer, the subsoiler shall be operated at a speed of four to five (4 to 5) miles per hour. If shown on the plans, the subsoil tillage shall be conducted during the specified period. Commencement of the subsoiling operations shall begin within seven (7) days of the direction by the Engineer and completed within fourteen (14) days.

NOTE: IT IS HIGHLY RECOMMENDED THAT THE PLAN SHEETS INDICATE THE REQUIRED WINDOW FOR CONDUCTING THIS WORK. FALL TILLAGE, FOLLOWED BY A SPRING PLANTING, WILL BE A COMMON STAGING.

Method of Measurement:

The quantity of Subsoil Tillage to be paid for under this section shall be the number of square yards accepted to the limits shown on the plans, conforming with all the requirements of these specifications, complete and accepted.

Basis of Payment:

Subsoil Tillage shall be paid for at the contract unit price per square yard bid and accepted for Section XXXXXX - Subsoil Tillage, which price and payment shall constitute full compensation for all labor, equipment, tools, and incidentals necessary to complete the work.

Appendix O

Topsoil Stripping

Description:

Topsoil Stripping shall consist of stripping the topsoil and any other additional soil to the depth specified on the plans, and stockpiling the soils as indicated on the plans or as specified.

Construction Methods:

The stripping and stockpiling of these soils shall conform to the requirements of the plans or as specified. To minimize soil erosion, the stockpiles shall be seeded and/or mulched as shown on the plans or as directed by the Engineer. The cost for furnishing and installing this seeding and/or mulching shall be measured and paid as bid under the appropriate items of Section XXXXXX, as determined by the Engineer.

Method of Measurement:

The yardage of approved and acceptable Topsoil Stripping shall be the yardage measured based on the surveyed cross sections of the stockpile areas, and computed by the method of average end areas with factors for conversion to in-place volumes. The factors for conversion to in-place volumes shall be determined by the Engineer and shall be agreed to by the Contractor prior to beginning Topsoil Stripping. The initial ground contours shall be verified by the Contractor prior to ground disturbance. Cost for this topographic verification shall be incidental to the item.

Basis of Payment:

The yardage of Topsoil measured and computed as described above shall be paid for at the contract unit bid price per cubic yard for Section XXXXXX - Topsoil Stripping, which price and payment shall constitute full compensation for stripping and stockpiling the soil, and for all labor, equipment, tools, and incidentals necessary to complete the work.

Appendix P

Wetland Soil Excavation

(*THIS SPECIFICATION ASSUMES THE PRESENCE OF A VERY WET SOIL AND SOME ROAD HAULING. IF THESE CONDITIONS ARE NOT ANTICIPATED, THE SPECIFICATION WILL REQUIRE CONSIDERABLE EDITING).*

Description:

Wetland Soil Excavation shall consist of the excavation, transport, and placement of wetland soils, including organics and root mat, as detailed on the plans and according to these specifications or as directed by the Engineer.

Materials:

When shown on the plans, the Contractor shall comply with all machinery descriptions, requirements, and limitations, with all machinery being subject to approval by the Engineer.

OPTIONAL: Unless authorized by the Engineer, low ground pressure equipment, as advertised by the manufacturer and subject to approval by the Engineer, shall be utilized for the excavation. Within thirty (30) days of the award of the contract, manufacturer's specifications and advertised materials for all excavation equipment shall be forwarded to the Engineer for approval.

Construction Methods:

(a) General: The Contractor shall fully construct the wetland soil placement area prior to excavation of the wetland soils and root mat. No excavation of wetland soil shall occur until all dewatering, construction staging, and plan sheet items related to the excavation of the wetland soils have been completed to the satisfaction of the Engineer. If directed by the Engineer, travel mats shall be utilized for the excavation or hauling, with the cost of the mats being incidental to the item. Areas may be cleared of aboveground standing vegetation prior to conducting this work, but soils may not be grubbed, excavated, plowed, or otherwise disturbed.

(b) Work Dates: Unless specified on the plans, this work shall be initiated and completed between *INSERT WORKING WINDOW*. No excavation activities shall occur prior to this date.

(c) Soil Excavation: The depth to which excavation shall be carried out shall be determined as detailed on the plans or as directed by the Engineer. Excavation outside those areas depicted on the plans shall not be allowed. Excavation shall be constructed and protected in such a manner as to prevent the entry of undesirable materials into the excavated areas.

OPTIONAL PARAGRAPH: Prior to placement of the wetland topsoil in the designated stockpiling area, all roots and stems and foreign objects greater than two (2) inches in diameter shall be removed. This removal shall not include the removal of soil or organics to the maximum extent practicable, as solely determined by the Engineer. Individual rootmass of trees and shrubs shall be vigorously shaken to remove soil and organics. The method used by the Contractor to remove this material is subject to the approval of the Engineer. Any material removed from the wetland topsoil shall be disposed of by the Contractor, subject to approval by the Engineer and without any additional compensation.

(d) Hauling: The Contractor shall transport excavated material to the wetland mitigation site as specified in the plans. Temporary stockpiling of the soils shall be prohibited, unless otherwise directed by the Engineer. The transport shall be immediate, with the exception of the dewatering provisions herein. Unless specified on the plans or directed by the Engineer, the material shall be dewatered prior to hauling in order to prevent leakage due to excessive water during transport, as specified herein. The Contractor shall not lower the water content of the material below the amount required for hauling without leakage, as solely determined by the Engineer. If directed by the Engineer, the wetland soil shall be immediately transported to the mitigation site without dewatering the soils. The Contractor may use water-tight trucks for hauling in lieu of dewatering. During hauling operations, the trucks shall not be overloaded, in order to prevent spillage or loss of material.

The volume of material that can be hauled by a single truck shall be limited to the volume that can be fully covered and protected during transport, as solely determined by the Engineer. At all times, the Contractor shall exercise all practicable and reasonable measures to prevent leakage and spillage during transportation. At the time of hauling, the trucks shall have covering tarps tightly secured to at least six (6) tie points. On all sides of the truck bed, including the rear, the tarps shall extend at least one (1) foot downward from the top of the bed. The type of tarp, the number of tie points, and the method of securing the tarp shall be subject to approval by the Engineer. The Engineer may direct a specific method for securing the tarps to the trucks including specifying the number and location of the tie points and the methodology for securing the tarps to the trucks. The Contractor shall be required to fully comply with these directions without any additional compensation to the Contractor. Alternative methods and materials for securing and covering the truck beds during transport shall not be utilized without prior approval of the Engineer. At any time, the Engineer may withdraw permission for alternative methods and require the trucks to be covered as herein specified without any additional compensation to the Contractor. During hauling operations, the trucks shall meet the load restriction requirements of Section XXXXXX and shall be operated in such a manner as to prevent spillage.

If hauling operations result in any leaking of water/muck or fine material to the road surface, the Contractor shall clean the road surface immediately or at intervals specified by the Engineer. If leakage during transport is unacceptable, as solely determined by the Engineer, the Contractor shall cease further excavation operations until a dewatering/transport plan is accepted and approved by the Engineer.

(e) Dewatering: If the material is to be dewatered, the Contractor shall provide a temporary dewatering area located within 200 feet of the excavation, subject to the approval of the Engineer, or utilize a site designated on the plans. If a suitable area is not available within 200 feet, the Contractor shall provide an area as close as possible to the excavation, subject to the approval of the Engineer. The Contractor shall prepare plans for the dewatering area for approval by the Department. These plans shall include the construction of a construction entrance and shall also include adequate erosion control measures, such as reinforced silt fence and controlled outlets. Any excavation activities at the dewatering site shall be subject to the approval of the Engineer.

It is the Contractor's responsibility to comply with all applicable regulations in siting and operating the dewatering area. Adequate measures shall be provided to prevent the loss of materials during the dewatering process. The dewatering area shall be graded to achieve optimum drainage of the system without undue loss of soils, propagules or seeds, as solely determined by the Engineer. The period of dewatering shall not exceed three (3) days. The Contractor shall restore the dewatering area to its original condition subsequent to dewatering operations, to the satisfaction of the Engineer.

(f) Placement: Within twenty-four (24) hours of transport to the mitigation site, wetland soils shall be placed in accordance with these specifications and in reasonably close conformity with the lines, grades, and typical cross sections shown on the plans and/or as directed by the Engineer. Soils shall be loosely placed and firmed, but the soils shall not be compacted or rolled. If directed by the Engineer, the soil shall be loosened via a light harrow or other mechanical tool, as directed by the Engineer with all costs incidental to this item. Such harrow operations shall not result in the turning under the wetland topsoil or mixing the wetland topsoil with deeper soils. The construction of the wetland soil placement area shall be done and paid for under those items indicated on the plans. Any temporary stockpiling of the wetland soils shall be incidental to this item. Once placed, no equipment or vehicle access shall be permitted. No parking shall be permitted. The Contractor shall not stage any work from these areas.

The Contractor shall dewater the wetland soil placement area to the extent shown on the plans during and subsequent to placement of the wetland soils. The dewatering shall be continued for a period of one (1) month or until the material is stabilized, whichever is longer, following the placement of wetland soils. At the direction of the Engineer, this dewatering period may be reduced or eliminated. This dewatering requirement shall not be extended into any groundwater monitoring periods indicated on the plans. If directed by the Engineer, the wetland soil placement area shall be thoroughly watered as directed, with the work and payment in accordance with Section XXXXXX - Watering.

Method of Measurement:

The quantity of Wetland Soil Excavation measured for payment shall be to the payment limits shown on the plans as computed by the method of average end areas, which areas shall be based on cross sections taken of the original ground prior to excavation, and sections taken

after the wetland soils have been excavated. Allowance shall not be made for excavation beyond the grades and typical sections shown on the plans or established by the Engineer. Computations for payment shall be measured in cubic yards.

The excavation and removal of slides within the excavation shall not be measured, and no payment shall be made for the removal of such materials. No payment shall be made for material excavated or displaced beyond the payment limits shown on the plans.

Basis of Payment:

The payment for Wetland Soil Excavation shall be made at the unit bid price for Wetland Soil Excavation, which price and payment shall constitute full compensation for excavation, constructing necessary haul roads, hauling, material dewatering, temporary stockpiling placement of the muck, maintaining the work in a finished condition until acceptance, and for all labor, equipment, tools, and incidentals necessary to complete the work. The cost of dewatering, construction, maintenance, restoration of the dewatering areas, and travel mats shall be incidental to this item.

Appendix Q

Use of Fascine for Soil Erosion Prevention

Description:

Fascine installation shall consist of furnishing, delivering, and installing fascines in the locations depicted on the plans, according to attached details and as hereinafter specified.

Definitions:

(a) General: A fascine shall be defined as a bundle of live, freshly cut woody branches that has been tightly bound into a cylindrical shape tapering toward the ends, as shown on the details and as described within this specification.

A plant material bundle shall be defined as a bundle of live, freshly cut woody branches that has been securely bound and wrapped in wet burlap. Plant material bundles shall be utilized for the construction of fascines at the construction site.

Freshly cut shall be defined as having been cut/harvested no earlier than twenty-four (24) hours prior to individual fascine construction.

Dormant shall be defined as the plant being in an overwintering state without the presence of leaves or swelling buds.

(b) Class A Fascines: Class A fascines shall be defined as fascines constructed of freshly cut branches and installed within forty-eight (48) hours of the cutting/harvesting of the plant materials.

(c) Class B Fascines: Class B fascines shall be defined as fascines constructed of freshly cut branches and installed within 120 hours of cutting/harvesting the plant materials. With the Class B fascine, the initial twenty-four (24)-hour period shall be utilized for the cutting/harvesting of the plant material, fascine construction or preparation of plant material bundles, and placement of the plant materials on the shipping transport. The next seventy-two (72) hours shall be allowed for shipping and delivery of the plant materials to the construction site or shipping delivery point. After arrival at the construction site or shipping delivery point, the Class B fascine shall be installed within twenty-four (24) hours.

Materials:

(a) Fascine Construction: The fascines shall be constructed of live, untrimmed branch systems of the species shown on the plans. The minimum length of the individual branch systems shall be five (5) feet, with a minimum cut-end basal diameter of one-half inch (½") and a maximum cut-end basal diameter of one and one-half inches (1½"), or as shown of the plans. Each individual fascine unit shall be a minimum length of eight (8) feet or as shown on the

plans. Plant material used in the construction of the fascines shall be live, freshly cut, and fully dormant. All branch systems and the subsequent fascines shall have continuous barks and nonspilt stems to the maximum extent practicable, as solely determined by the Engineer.

Each fascine shall be constructed so that the individual branch systems are uniformly distributed throughout the central core of the fascine bundle. The core of the bundle shall be defined as the central three-quarters (¾) of the fascine bundle length, or that portion of the bundle that is not within one and one-half (1.5) feet of either end of the fascine, whichever is longer. When placed, approximately one-half (½) of the branch systems shall be oriented in one (1) direction, with the other half in the opposite direction.

The fascine shall be constructed of a sufficient number of branch systems so that after the fascine is tightly compressed and tightly bound on minimum eighteen inch (18")-centers with the designated strapping, the diameter of the central three-quarters (¾) segment of the fascine bundle is a minimum diameter of eight inches (8") and a maximum diameter of ten inches (10"), or as shown on the plans. The strapping shall be as designated on the plans and shall be either nylon strapping, ungalvanized steel strapping, or 3-ply binder twine. If no strapping material is designated, 3-ply binder twine shall be utilized. If binder twine is utilized, a minimum of three (3) wraps of the twine around the fascine shall be required at each tie. Branch systems shall not be trimmed except for the removal of branches that protrude more than three (3) inches beyond the maximum diameter of the bundle. Fascines that are loosely bound, as solely determined by the Engineer, shall have additional strapping applied or be removed and rejected, as directed by the Engineer. The Engineer may inspect the tightness of the binding of the fascine by squeezing the fascine with both hands at the ties. When squeezing at the ties, the fascine diameter shall not be reduced by more than one (1) inch. Regardless of origin, each fascine shall be clearly tagged and labeled as to species, plant material cut date, fascine construction date, and shipping date, if applicable.

Unless immediately installed, each individual fascine or plant material bundle shall be fully wrapped in wet burlap immediately following construction of the fascine. This burlap shall be kept moist at all times until installation of the fascines. After cutting the branches and until installation of the fascines, the fascines and associated plant materials shall be kept from freezing and kept shaded, covered, cool, moist, and out of the wind and sun.

Any variance from these guidelines shall be approved in writing by the Department prior to initiating the change(s). Upon request by the Department, the Contractor shall supply a complete methodology concerning the proposed construction methods.

(b) Water: Water shall be fresh water that is free from toxic substances and chemicals that may be injurious to plant growth. Trucks, hoses, and other watering equipment required to transport water from a source to the work area shall be included as part of the work with all costs incidental to this item.

(c) Miscellaneous Materials:

Nylon strapping: The nylon strapping shall be of a strong, nonelastic nylon composition a minimum of one-fourth (¼) inch wide with a self-locking clasp.

Ungalvanized steel strapping: The steel strapping shall be made of ungalvanized, 10-gauge steel wire (minimum diameter _ inch).

3-ply binder twine: The twine shall be strong, durable _-inch natural fiber twine that has received the approval of the Engineer.

Burlap: Burlap shall be jute burlap with a dry weight of approximately eight (8) ounces per square yard. Jute burlap will be soaked in water for a minimum of twenty-four (24) hours prior to use with fascines, plant material bundles, and all plant materials.

Stakes: Stakes shall be composed of solid, reasonably knot-free hardwood and have dimensions of two (2) inches by four (4) inches by twenty-four (24) or thirty-six (36) inches, tapered to a point, as shown on the detail.

(d) Genetic/Elevational/Exposure Origin:

THIS SEGMENT OF THE SPECIFICATION DESCRIBES THE GEOGRAPHICAL AND HABITAT ORIGINS OF THE SOURCE MATERIALS AND WILL HAVE TO BE PROVIDED BY THE USER.

The genetic origin shall be chosen to provide typical forms of the species and shall include the capacity to bear fertile fruits, as approved by the Department.

(e) Submittals: Within thirty (30) days of the award of the contract, the successful bidder shall forward in writing a complete listing of the proposed planting materials and the genetic origins of the materials to the Department. The Department will then review these submitted materials. If deficient, as solely determined by the Department, additional information shall be forwarded to the Department. Only after written approval of the genetic origin of the source material by the Department shall the Contractor initiate the procurement of the source material. Within thirty (30) days of the award of the contract, the Contractor shall forward confirmed purchase orders for all specified plant materials to the Department.

Construction Methods:

(a) General: All work, including plant handling and material transport procedures, shall be subject to approval by the Engineer. Any changes in the plant handling and material transport procedures directed by the Engineer shall be incidental to this item. During all phases of this work, including transit, the plant materials shall be kept from freezing and kept covered, cool, moist, well-ventilated, and out of the wind and sun.

Fascines shall be installed during the time period shown on the plans or as directed by the Engineer.

(b) Material Transport: Unless directed by the Engineer, offsite transport vehicles shall be capped trucks or trailers with good means of ventilation. Plant transport vehicles shall not be open-bed vehicles. The transport compartment shall not be heated.

While in transit, fascines, plant material bundles, and all plant materials shall be wrapped in wet burlap, packed and protected in such a way as to prevent the drying, heating, bruising, stem splits, removal of bark, or possible desiccation of the plant tissues. Unless supported by spacers, racks, or platforms, stacking of fascines or plant material bundles is limited to three (3) fascines or bundles high. Packing of the fascines and plant materials shall be done in a manner that will ensure that fascines and plant materials are secure in their shipping positions and that there is good ventilation around all plant materials.

For Class B fascines, the fascines or plant material bundles shall first be wrapped in wet burlap and then wrapped in 3-ply kraft polyethylene paper for shipping/transport to the construction site. No more than three fascines or plant material bundles shall be wrapped together in a single 3-ply kraft polyethylene package.

At least twelve (12) inches of air space between the top of the plant materials and the vehicle roof shall be maintained when transporting the plant materials. The plant materials shall then be covered with secured tarps; nothing else shall be placed on top of the plant materials. If the materials are not packed according to best plant handling practices, as solely determined by the Department, the Department may reject all materials without compensation. The fascines and plant materials shall be packed and marked in such a way as to allow quick and easy identification of the plant materials.

At the work site, the transport vehicles shall be parked in a shaded location and away from the wind. The plant materials shall then be off-loaded and stockpiled in a location previously approved by the Engineer. Ideally, this location shall provide natural shade and protection from wind.

(c) Fascine Handling: Following fascine construction, immediate installation is preferred. If fascines are temporarily stockpiled, the fascines shall be stockpiled in a shaded location subject to approval by the Engineer. If directed by the Engineer, the entire stockpiling area shall be shaded with thermal-reflective tarps (WHITE SIDE UP). All tarps are subject to approval by the Engineer. Fascines shall not be stacked more than three (3) high, and stacking practices shall allow for good air circulation between the individual fascines. If wind speeds exceed fifteen (15) miles/hour, a wind barrier shall be erected adjacent to the stockpiling area, subject to approval by the Department. With the approval of the Engineer, the Contractor may elect to utilize the transport vehicle as a temporary storage area, subject to the above restrictions and guidelines, including the placement of tarps. The stockpiling area shall be periodically watered to keep the materials moist and as directed by the Engineer.

During all phases of this work, all fascines and plant materials shall be gently handled. Plant materials shall not be thrown to the ground, into a stockpiling area or between workers. All work shall be done in such a manner as to protect the plant tissues from damage. One shall not crush, stand, or sit on the planting materials. Plant materials shall be freed from the shipping materials by cutting the binding strap, pulling the binding tab or other approved method, as determine by the Engineer.

(d) Inspection: The Contractor shall be responsible for all certificates of inspection of plant materials that may be required by Federal, State, or other authorities to accompany shipments of plants. The successful bidder shall furnish complete information as to the location of all plant materials that he/she intends to supply and use. The Department reserves the right to inspect, tag (seal), and approve all plant materials at the source of supply. This inspection and tagging shall not in any way eliminate the right of rejection at the site.

(e) Installation Conditions: Fascine placement shall not occur in frozen ground or during periods of freezing air temperatures. The Engineer may stop fascine placement and/or trench excavations due to weather or any other conditions that are not favorable. Unsatisfactory conditions may include, but are not restricted to, temperatures above 60 °F, relative humidity below forty percent (40%), wind speed greater than fifteen (15) miles/hour, or available soil moisture less than fifty percent (50%). If directed by the Engineer, fascine trenches shall be watered twenty-four (24) hours prior to fascine placement as directed by the Engineer. This watering shall be incidental to the item.

(f) Fascine Placement: Trench construction and fascine placement shall be as shown on the plans and details. Trench excavation should not precede fascine placement by more than one (1) hour. Trenches for fascine placement shall be excavated to a depth of approximately three-quarters (¾) the maximum diameter of the fascine, with a trench width of no more than one and one-half (1.5) times the maximum width of the fascine. After proper fascine placement in the trench, as shown on the plans, backfill soil shall be placed and firmly tamped into the fascine and trench. The resulting backfill shall fill the void and airspaces between the individual branches so that when the fascine layer and trench are walked, the layer is not springy or readily compressible, as solely determined by the Engineer. If the backfill soil is of such a texture as to make it impractical to incorporate that soil properly into the fascines, the Engineer may modify the compaction requirements to reflect field conditions or require that the suitable soil be provided for the backfill operation at no additional cost to the Department. If directed by the Engineer, fascine trenches and/or all backfilling operations shall be hand labor.

(g) Fascine Staking: Fascines will be staked as shown on the plans and details. Stakes shall be driven into the ground a minimum of eighteen (18) inches so that a firm hold is obtained. If the soil consists of sand or a firm hold is not obtained with a twenty-four (24)-inch stake (i.e., the stake can be moved by hand) or if directed by the Engineer, a thirty-six (36)-inch stake shall be used. If the soil is compacted to the degree that a twenty-four (24)-inch stake cannot readily penetrate the soil to the required eighteen (18) inches, subject to the approval of the Engineer, a _-inch- or one-half (½)-inch-diameter reinforcing bar of equivalent length shall

be utilized. If reinforcing bars are used, the top four (4) inches shall be bent at the soil line over to a 90° angle securing the fascine in place.

(h) Plant Establishment Period: There is no plant establishment or guarantee period for Fascine Installation. If directed by the Engineer, fascine locations shall be watered in accordance with and payment under Section XXXXXX - Watering.

DELETE ONE OF THE FOLLOWING METHODS OF MEASUREMENT.

Method of Measurement:

The quantities for Fascine Installation, Class __ for which payment will be made shall be the total number of the linear feet of fascine actually installed and accepted, as measured by trench length.

Method of Measurement:

No separate measurement shall be made for Fascine Installation. Payment shall be made at the contract lump sum price at each site for Fascine Installation, Class __.

DELETE ONE OF THE PARAGRAPHS UNDER BASIS OF PAYMENT.

Basis of Payment:

Fascine Installation shall be paid for at the contract lump sum bid for Section XXXXXX, Fascine Installation, Class __, which price and payment shall constitute full compensation for all plant materials, labor, equipment, water, materials, tools, excavation, backfilling, and incidentals necessary to complete the item.

Payment for Fascine Installation, Class __ shall be paid for at the contract unit bid price per linear foot, which price and payment shall constitute full compensation for all plant materials, labor, equipment, water, materials, tools, excavation, backfilling, and incidentals necessary to complete the item.

Appendix R

WESTERN REGION
RIPARIAN WOODLAND AND MARSH REVEGETATION
Technical Specifications

ZENTNER & ZENTNER
Land Planning & Restoration

Walnut Creek
Sacramento

1.0 PRECONSTRUCTION PREPARATION AND GENERAL REQUIREMENTS

1.1 PROJECT ASSUMPTIONS AND DEFINITIONS

These technical specifications describe a riparian woodland and marsh restoration effort (the "Project") on approximately one hundred (100) acres in the Central Valley of California (the "Project Site"), of which approximately fifty (50) acres will be restored to riparian habitats and fifty (50) acres to marsh. The authorizing entity for the Project is the U.S. Army Corps of Engineers (the "Corps"), which will supply an oversight Agent (the "Contracting Officer").

The U.S. Soil Conservation Service (SCS) has classified the soil of the Project Site as consisting primarily of the Sacramento and Willows Associations. These associations are poorly drained, nearly level alkaline clays that formed in basins. Percolation and soil aeration are limited; water retention is high. These conditions favor plants adapted to high water levels and poor aeration of the rooting zone. Soil fertility is relatively low from a commercial standpoint but native species are adapted to these conditions; amending the soil with sulfur or fertilizers will encourage weed growth.

Historically, the site was probably flooded for much of the winter, but summer conditions varied from saturated (in the lowest points) to relatively dry (on higher ground). Typical winter flooding of the site is now infrequent but prolonged. However, summer water levels are now relatively high (compared with prehistoric levels) due to irrigation of adjacent lands. The Project Site includes a drainage canal with relatively clean water suitable for irrigation. Accordingly, irrigation water for the planted trees and shrubs shall be supplied via pumping to a drip irrigation system. Power for the pump will come from adjacent power lines used to supply power to agricultural pumps in nearby lands.

Based on the historic soil and hydrology conditions and records (*cf*. Kuchler's *Natural Vegetation of California*), the predominant native habitat onsite was tule marsh dominated by

common tule (*Scirpus acutus*). Stringers of riparian woodland probably also occurred on slightly higher and more permeable alluvial soils deposited by Putah Creek as it wandered over the floodplain. These would be dominated by (from wettest to driest) Gooding's willow (*Salix goodingii*), arroyo willow (*S. lasiolepis*), sandbar willow (*S. hindsiana*), Fremont cottonwood (*Populus fremontii*), box elder (*Acer negundo*), and Oregon ash (*Fraxinus latifolia*). An understory of creeping wild rye (*Leymus triticoides*), Baltic rush (*Juncus balticus*), and salt grass (*Distichlis spicata*) would have dominated the riparian understory and created a relatively dense mat. Buttonbush (*Cephalanthus occidentalis*) swamps would have occurred in isolated oxbows. Each of these species is still found on adjacent lands, indicating a high potential for restoration.

Important species not found today but which probably occurred or could occur given the modified conditions onsite include California hibiscus (*Hibiscus californica*) in perennial wet areas adjacent to the tule marshes; brown dogwood (*Cornus glabrata*) on swamp edges in association with the buttonbush; blue elderberry (*Sambucus mexicana*) and valley oak (*Quercus lobata*) in drier areas; and wild rose (*Rosa californica*) throughout the upper riparian zone.

This project assumes that all Low Terrace riparian trees (*Salix* and *Populus*) will be supplied as cuttings or container stock by the Contractor. All other trees and shrubs will be supplied as container stock by the Corps through a contract with a local nursery. All marsh plants will be supplied by the Contractor either through salvage of onsite or adjacent sources or through the use of nursery-propagated plugs.

A number of exotics now occur onsite. Most problematic is the widespread peppergrass (*Lepidium latifolia*) and, to a lesser extent, yellow star thistle (*Centaurea solstitialis*). Therefore, disturbance of the soil is to be avoided if at all possible. These weeds appear to be completely excluded in those areas dominated by a creeping wild rye-Baltic rush association or salt grass.

1.2 TASK SUMMARY

The following task summary is provided to facilitate development of a Work Schedule and to summarize the major phases of the Project. The Contractor will submit and follow a Work Schedule presented to the Contracting Officer in the Detailed Plan unless specific changes in that schedule are agreed to by the Contracting Officer. Each task is identified along with the Project phase as that phase is described in these specifications and the optimal month(s) for completion of this task. Restoration scheduling is governed by more or less absolute requirements. Cuttings must be planted while dormant; in this region that typically occurs between November 1 and January 1, although this may vary depending on the season, and dormancy can be extended by placing plants in cold storage. Riparian nursery stock and salvaged marsh plants are best planted between October 1 and January 1 but, with irrigation, can be planted as late as March 1. Nurseries typically require that all plants be picked up by December 31, but an onsite nursery can often be established to store plants over the period from January 1 to March 1. In addition, despite the requirements of the plants, few restoration

construction jobs begin as planned. Accordingly, the dates shown below assume a contract start date of August 1.

	TASK	PHASE	MONTH
1.	Submittal and approval of Detailed Plan.	Preconstruction	August
2.	Identify all salvage and preservation plants and areas and access routes.	Site Preparation	September
3.	Remove all trees and shrubs to be removed and all debris, mow.	Site Preparation	September
4.	Install signage.	Site Preparation	September
5.	Complete weed control.	Site Preparation	September - October
6.	Salvage and store marsh topsoil.	Grading	September
7.	Rough grade.	Grading	September
8.	Reapply marsh topsoil.	Grading	September - October
9.	Install pump, mains, laterals, and valves.	Irrigation Installation	October
10.	Auger planting holes for nursery stock.	Planting Preparation	October
11.	Backfill planting holes.	Planting Preparation	October
12.	Install drip tubing.	Irrigation Installation	October
13.	Collect and root cuttings.	Planting	November
14.	Plant marsh plugs and seed.	Planting	November
15.	Auger planting holes for cuttings and plant.	Planting	December
16.	Plant nursery stock.	Planting	December
17.	Add mulch and screens to nursery stock.	Planting	December
18.	Install riparian understory plugs and seed.	Planting	December

1.3 ENVIRONMENTAL PROTECTION

The land and biological resources within the boundaries of the Project and outside the limits of actual construction performed under this contract shall be preserved in their present condition or be restored to a condition after completion of construction that will appear to be natural and not detract from the appearance or ecological value of the Project. The Contractor shall confine his construction activities to areas identified for construction in the Detailed Plan. Compaction or disturbance of the surface soils of the Project Site outside the construction limits shall not occur without the express written consent of the Contracting Officer. In no case shall lands adjacent to the Project Site be disturbed without the written permission of the landowner. Any tree, shrub, or other landscape feature scarred or damaged by the Contractor's equipment or operations shall be restored as nearly as possible to its original condition at the Contractor's expense. The Contracting Officer shall decide what method of restoration shall be used.

If during construction the Contractor proposes to construct temporary roads, ditch crossings, utility lines or other temporary works not described in the Detailed Plan, the Contractor shall submit a detailed design of their layout, plan views and cross sections, and removal and restoration for approval by the Contracting Officer at least five (5) days prior to the start of such temporary work.

1.4 PREPARATION OF THE DETAILED PLAN

After contract award, the Contractor shall present a Detailed Plan to the Corps based on site-specific information and analyses, including the elements identified and following the procedures described in these Technical Specifications.

The Detailed Plan shall specifically include a detailed discussion of plant acquisition and documentation in securing the specified plant materials. Materials supplied by the Corps shall be checked at the nursery and their health and viability reviewed. Cutting sources shall be identified at this time. Any plant materials that are found to be unobtainable shall be identified prior to commencement of construction and substitutes and their origin acceptable to the Contracting Officer identified. Additional plant materials beyond those initially planted shall be grown by the Contractor at an appropriate nursery from planting stock taken from the region. A minimum of twenty percent (20%) of the total number of planted plants and a similar quantity of seed from the region of the Project Site shall be collected and propagated at this nursery.

2.0 CONSTRUCTION

2.1 SITE PREPARATION

2.1.1 Description

Generally, site preparation shall consist of (1) identification of all preservation and salvage areas and plants and access routes; (2) removal and disposal of trees and shrubs to be removed

and all debris; (3) installation of project signage; and (4) completion of preplanting weed control operations. The ultimate product required of the Contractor will be to return the site to a nonbuilt condition, with the exception of the features to be preserved, and to prepare the area for installation of the irrigation system and planting.

2.1.2 Construction Methods

Specific work required includes the following:

Prior to any construction, the Contractor shall contact the Underground Service Alert (U.S.A.) and any city, State, and Federal agencies that may have existing utilities within the Project in order to determine if underground utilities will be encountered. The Contracting Officer shall be responsible for providing property boundary and other benchmark data by this time.

The Contractor shall designate the trees, shrubs, other plants, and other features to be preserved or salvaged using plastic stakes, spray paint, or similar method. The Contractor shall provide temporary fencing around those features to be preserved to a distance of one and one-half (1.5) times the diameter of the driplines of any trees, shrubs, or vines so designated or five (5) feet beyond the designated edge of ground cover vegetation or similar feature. Any damage to the preserved features by the Contractor shall be corrected and the feature restored to its original condition by the Contractor at no expense to the Government.

Remove existing trees and shrubs as shown in the Detailed Plans, ensuring that only those plants designated for removal are taken. Grind the stumps to the ground and use a herbicide approved by the Owner to ensure that the plant will not resprout. Stump grindings or chipped trees and shrubs may be left on the site provided that they are spread evenly over the site in locations approved by the Ecological Monitor.

Remove site debris, including concrete rubble, garbage, old wire, and other obstructions to work. Dispose of all debris at a properly designated facility offsite.

Mow the riparian portion of the Project Site to approximately three (3) to four (4) inches in height using a flail mower, taking care to avoid all preservation features. Remove all thatch and dispose at a properly designated facility offsite.

Install project signage as provided in the Detailed Plan. Signage is proposed for this early stage in the belief that this may reduce trespassing, off-road vehicle use, pilfering, and vandalism. However, it is also highly likely that these signs will be vandalized over the course of the project.

Provide for weed control as identified in the Detailed Plan in the riparian area and dispose of properly. "Weeds" shall mean non-native grasses and forbs, e.g., yellow star thistle, pepper grass, and similar materials. "Control" includes mowing as required above and, following leaf-out of the weeds, application of a properly applied, postemergent translocating

herbicide, such as Round Up. The marsh area shall be graded and shall not require preplanting weed control operations.

2.2 GRADING

2.2.1 Description

Generally, this phase includes salvage, excavate, backfill, compact, rough and final grade, and reapply salvage as described on the Project Documents. This phase should result in the preparation of the Project Site to finish grades, ready for irrigation and plant installation.

2.2.2 Construction Methods

Specific work required includes the following:

- **Salvaging of Marsh and Understory Plants and Soil**

Tall (perennial) marsh salvage. Excavate with a backhoe, by hand, with a grade-all, or by other means acceptable to the Contracting Officer clumps approximately eighteen (18) by eighteen (18) by twelve (12) inches (deep) of marsh plants and soil. Remove by hand cattails or other invasive species before placing this material into a designated storage area. Cover the salvage piles with a water-permeable, shade-producing fabric, and weight the fabric with sandbags. These salvage storage piles are to be kept moist but not wet until reapplication.

Seasonal marsh and wet meadow salvage. Remove all surface debris. Mow the specified areas to three (3) inches and then strip the top four (4) inches of soil and plants from the areas. Place the salvaged material in designated storage areas. Cover the salvage piles with a water-permeable, shade-producing fabric, and weight the fabric with sandbags. These salvage storage piles are to be kept moist but not wet until reapplication.

Salvage the existing patches of native understory species at the riparian portion of the Project Site with a sod-cutter or similar equipment after these have been mowed. Store salvaged material onsite at a location approved by the Contracting Officer. Cover salvage material with a shading fabric and keep moist but not wet.

Tree salvage. Cut back the tree to three (3) to six (6) feet from the ground or to fifty percent (50%) of its height (whichever is greater) by removing branches and stems above this height. Remove the tree using a Vemeer spade taking as much of the root ball as possible without any further damage to the tree. Transport the tree immediately to containers. Cover the tree salvage area with a shade-producing fabric on poles, and keep the plants moist but not wet until planting.

Shrub salvage. Excavate shrubs using a backhoe, grade-all or similar method to collect two (2) by two (2) by two (2) feet blocks of shrubs. Remove by hand invasive species before placing this material into a container in a designated storage area.

■ **Grading and Reapplication of Salvaged Marsh Soils**

All grading shall be completed in accordance with the Detailed Plan. Grading of marsh areas shall be done "in the dry." Excavating the connecting channels to the permanent water source shall not occur until the Project Site has been completely graded, marsh soils salvaged and plants reapplied (as described in more detail below), and the grades verified and approved by the Contracting Officer.

In the perennial marsh areas, the Contractor shall apply the salvaged marsh soils and plants after completion and approval of all grading. Perennial marsh rootstock shall be placed a minimum of two (2) inches below the surface of the final grade.

In the seasonal marsh areas, the Contractor shall overexcavate basins, backfill with clay soils, and reapply salvaged soils and plants. Overexcavation shall require excavating the specified area eight (8) inches below final grade on an even slope throughout the basin. Clay soils from the Project Site shall be placed into these basins and compacted to ninety percent (90%) relative compaction as determined by the ASTM test designation D-1557-78 in two (2) three (3)-inch lifts. Wetland topsoil shall then be placed to create final grade. The wetland topsoil shall not be compacted, except to the extent that machinery working on the surface shall create compaction, but shall be spread to create an even slope across the basin without isolated depressions.

In the wet meadow areas specified in the Project Documents, the Contractor shall overexcavate basins, backfill with clay soils, and reapply salvaged soils and plants. Over-excavation shall require excavating the specified area ten (10) inches below final grade on an even slope throughout the basin. Clay soils from the Project Site shall be placed into these basins and compacted to ninety percent (90%)-relative compaction as determined by the ASTM test designation D-1557-78 with two (2) two (2)-inch lifts. Wetland topsoil shall then be placed to create final grade. The wetland topsoil shall not be compacted, except to the extent that machinery working on the surface shall create compaction, but shall be spread to create an even slope across the basin without isolated depressions.

2.3 PLANTING PREPARATION

2.3.1 Description

Generally, planting preparation consists of (1) identifying the locations of the planting holes and (2) preparing planting holes as shown on the Detailed Plan for the riparian area. The final product of this phase shall be fully prepared planting holes for the riparian plants. Note that irrigation installation in the riparian area (discussed as part of the next phase) shall occur concurrent with this phase to provide water for compacting the planting holes.

2.3.2 Construction Methods

Specific work required includes the following:

The Contractor shall identify all riparian plant locations by species using color stakes, paint on the soil surface, or similar methods as approved by the Contracting Officer. Planting basin locations may be altered at the discretion of the Contractor or Contracting Officer without any additional cost to the Corps if rocks or other underground obstructions are encountered that interfere with planting.

Upon approval of the layout, the Contractor shall auger a planting hole to a depth of four (4) feet with a minimum width of nine (9) inches for the riparian nursery stock provided by the Corps. The hole shall then be scarified. Note that this specification does not include cuttings. For cuttings, the augered hole shall be dug just prior to planting; a description is contained in the "Planting" phase.

For all riparian plants, planting hole construction should favor the rapid growth of the plant to the appropriate groundwater level. However, these plants are not adapted to lengthy periods of surface inundation or soil saturation (with the exception of buttonbush, a species with ecological adaptations similar to the swamp trees and shrubs of the southeastern United States). The soil is a relatively heavy clay with slow transmissivity of soil water.

In higher elevation areas onsite, where three (3) to four (4) feet of relatively dry soil will occur above the summer groundwater level, it is important that the plants reach this water quickly. A shallow planting hole in a clay soil will favor a shallow rooting system and high long-term mortality. Additionally, irrigation water will tend to stay near the surface, as soil permeability is relatively low.

Backfill all holes for Corps-supplied trees with clean material from excavation. When backfilling soil, compact and irrigate continuously. Ensure that no air pockets are left in the planting hole. If sufficient material is not available for backfilling, due to compaction, supplement the backfill material with compost, peat moss, manure, or similar materials described in the Detailed Plan.

2.4 IRRIGATION INSTALLATION

2.4.1 Description

Generally, this work shall consist of the construction and testing of a manually controlled, drip irrigation system, including a pump, pump pad and house, electrical connections for the pump to the adjacent power lines, valves, main and lateral lines (hard pipe), and polyethylene drip pipe with emitters for the riparian zone. No irrigation, aside from the inflow of drainage channel waters, is proposed for the marsh area; no irrigation is proposed for the riparian understory. As noted above, certain elements of the irrigation installation shall occur concurrent with planting preparation to ensure a water supply for compacting backfilled planting holes.

The final outcome of this phase will be a drip irrigation system constructed to provide an ensured supply of suitable water for the riparian area. Such a system requires a minimum of

soil disturbance and provides water directly where it is required, thereby eliminating the potential for weed growth due to summer watering. This system is also easily removable; the drip pipe that constitutes the large majority of the pipe can be pulled up by hand and the pump removed. The hard pipe (mains and laterals) would be left underground while the pump pad would be left in place for future temporary use in case of drought or other need.

2.4.2 Materials

Irrigation materials shall be furnished in the quantities and/or spacing and of the size and manufacture indicated in the Detailed Plan. These specifications assume that water can be pumped from the drainage ditch onsite with an electrical connection to the power lines directly adjacent to the site without costs aside from those typically incurred in construction and operation of an agricultural pump, the electrical connection, and appurtenant materials. The Contractor shall pay the monthly power fees. The Contractor shall furnish irrigation articles, equipment, or processes specified by name in the drawings and specifications. No substitution shall be allowed without prior written approval by the Contracting Officer.

The type of pump used shall be a Gould XSH 2 Horsepower centrifugal pump. This pump will deliver seventy-one (71) gallons per minute at thirty (30) pounds pressure. It will allow approximately 2,000 plants to be watered in one six (6)-hour cycle. It shall be placed on a four (4)-foot by six (6)-foot by four (4)-inch concrete pad with foundation bolts for a wooden shed. The pump shed shall be constructed with two (2)-inch by four (4)-inch wooden planks with a weatherproof roof. A two (2)-inch suction pipe made of galvanized metal shall be placed into levee water with a foot valve and screen. Water shall be discharged through a two (2)-inch galvanized pipe to the main line. A one (1)-inch conduit for the electrical connection shall be placed in the pad.

Electrical supply shall be drawn existing from existing power lines. Overhead service shall drop to a four (4)-inch by six (6)-inch by eighteen (18)-foot pressure-treated dip pole, with three (3) feet of the pole embedded underground. A Nema BR weatherproof combination meter, main and underground pull section, and a two (2)-pole circuit breaker (100 A, 10, 3 wire with 50 amp) shall also be installed. The overhead service rise shall have a weather head. One (1)-inch conduit, three (3) #4 THWN AUG> eight and one-half (8½)-inch copper clad steel ground rod, complete with ground clamp and #8 ground conductor for grounding; wire to pump dropped with three-fourths (¾)-inch polyvinyl (PVC) conduit to grade and below ninety (90) sweep to thirty (30) inches of cover; and #8/3 direct burial freebar ± 200 feet to pump controller shall also be installed. The Contractor shall provide direct burial marking tape at twelve (12) inches below grade.

Main lines of PVC, Class 200 (SDR 26) PSI NSF PVC shall be installed. Laterals (found on the discharge side of the valves) shall be Type 1120 - Class 315 for one-half (½)-inch, Class 200 for three-fourths (¾)-inch and larger (SDR 26) PSI, NSF PVC. Drip line shall be three-fourths (¾)-inch and one (1)-inch polyethylene tubing. Emitters shall be two (2) gallons per hour (gph). These are used instead of a one (1)-gph emitter because the smaller emitters tend to clog easily and increase maintenance efforts. Emitters larger than two (2) gph produce too

much water for the clay soil to absorb over the irrigation period and flood adjacent lands, producing weeds. Manual control valves shall be installed with pressure reducers and drip filter.

2.4.3 Construction Methods

Specific work required includes the following:

Prior to installation, the Contractor shall stake out all main and lateral routing. All layout shall be inspected by the Contracting Officer prior to installation. If equipment is incorrectly located without said inspection, it is the Contractor's responsibility to relocate it as per the Contracting Officer's directions without additional cost.

Construct pump pad adjacent to the onsite water source. Connect electrical power to pump pad. Install and test pump.

Install all main and lateral irrigation lines. All main trenches shall be a minimum of eighteen (18) inches and all laterals twelve (12) inches deep and wide enough to complete all required work. Trenching excavation shall follow layout and depth indicated on Detailed Plan. Lay pipe to an even grade and support pipe continuously on bottom of ditch. PVC pipe shall be installed so that there will be a small amount of excess length in the line to compensate for contraction and expansion of the pipe. This shall be accomplished by "snaking" the line in the trench during the time of installation. All cutting and gluing of pipe shall conform to professional standards.

Connect mainlines to the pump. Connections shall be made at approximate locations shown on the Detailed Plan. Connection points may be modified with the Contracting Officer's approval if site conditions so warrant.

Prior to the installation of any valves or backfilling, all main lines shall be tested under a hydrostatic pressure of 90 psi.

Install valves as noted in the Detailed Plan, each valve in its own valve box. Quick couplers are required with each valve and may be placed in the same valve box. Separate valves shall be installed for the cuttings and container stock reflecting the differing planting elevations. The lowland portions of the site may be extremely wet during the summer months due to high groundwater levels resulting from irrigation and may not require watering, while the plantings in the higher portions of the site may need water.

Backfill main and lateral irrigation line trenches with clean material from excavation. Compact backfill for trenching to a dry density equal to adjacent undisturbed soil in planting areas. Conform to adjacent grades without dips, sunken areas, humps, or other irregularities. If settlement occurs and adjustments in pipe, valves, planting, or other construction are necessary, the Contractor shall make all required adjustments without cost to the Corps.

Install drip lines as noted in the Detailed Plan. All drip lines are to be placed two (2) to three (3) inches below the soil surface and staked in place every ten (10) feet with a jute stake. Lines shall run directly to each planting hole with jute stakes placed on the line within one (1) foot of each side of the hole. The drip line shall emerge from the ground at the planting hole and cross the basin above ground. Place one (1) two (2)-gph emitter directly over the root ball of the plant or within one (1) inch of the base of the cutting. Open all end caps after installation and completely flush drip lines. Bury drip lines, ensuring no exposed lines.

The Contractor shall not allow or cause any of his work to be covered up or enclosed until it has been inspected, tested, and approved by the Contracting Officer. Should any work be closed or covered up before such inspection and tests are satisfactorily completed, the Contractor shall, at his own expense, uncover the work; after it has been inspected, tested, and approved, he then shall make all repairs with such materials as may be necessary to restore all work to its original and proper condition.

The Contractor shall furnish the Contracting Officer with a set of "As-Built" drawings of the main, lateral, and valve locations at the conclusion of the installation. Said plan shall be drawn on the project maps. The Contractor shall furnish the Contracting Officer with two (2) sets of valve keys and service wrenches for each type of valve installed in the system plus two (2) quick coupler valve keys, and two (2) hose swivels compatible with the quick coupler valves installed.

Upon completion of irrigation installation, the Contractor shall remove excess materials, rubbish, debris, etc., and his construction and installation equipment from the premises. Prior to commencing any planting operations, the Contractor shall operate the system to ensure one hundred percent (100%)-coverage in all systems and make all necessary adjustments at this time. The final inspection of the work shall be made by the Contracting Officer in the presence of the Contractor at the time the work is completed.

2.5 PLANTING

2.5.1 Description

Generally, this work shall consist of (1) installing Corps-supplied trees and Contractor-supplied cuttings, (2) installing marsh bareroot stock and plugs and seeding the marsh areas, and (3) plug planting and seeding the riparian area. The final outcome of this phase shall be riparian and marshland habitat planted in accordance with the Detailed Plan.

2.5.2 Materials

All plants shall be true to name. All Corps-provided plant materials shall meet the specifications of Federal, State, county, and municipal laws, requiring inspection for plant diseases and insect infestations. Plants shall be symmetrical, typical for species and variety, sound, healthy, vigorous, and free from plant diseases, insect pests or eggs, and shall have

healthy, vigorous, normal root systems, well filling their containers, but not to the point of being root-bound.

Pole cuttings shall be obtained from dormant stock on or near the Project Site. Cuttings shall be two and one-half (2½) to three (3) feet in length, a minimum of one-half (½) inch in diameter, and cut from new wood. Cuttings shall be collected sequentially in only enough quantity each day for one (1) day of planting effort. Approximately 300 cuttings can be planted in one (1) day by a three (3)-man crew. Consequently, assuming a three-man crew is used for planting, approximately 300 cuttings shall be collected each day. Cuttings shall be then placed in the drainage ditch onsite in mesh bags for a period of four to ten (4 to 10) days after cutting until root nodules form along the stem. As an option, seedlings grown to one (1)-gallon container size can be substituted in place of pole cuttings at no cost to the Corps. It shall be the Contractor's responsibility to pregrow the material and have it to a one (1)-gallon container size at the required planting time if this option is exercised.

Perennial marsh plant material shall be in the form of tubers, corms, and other materials appropriate for the particular species. No more than six (6) inches of vegetative growth (shoots, etc.) shall be present on the planting material.

Seasonal marsh and wet meadow plugs shall be in one-half (½) by one-half (½) by three (3) inches or larger plugs with full rooting within the container. No more than four (4) inches of vegetative growth shall be present on the planting material.

Riparian understory material shall be in the form of plugs, rhizomes, or other root-bearing materials. This material shall be cut from the material salvaged onsite and may range in size from one (1) by one (1) by three (3) by three (3) inches with a depth of one (1) to two (2) inches.

All seed used on the site shall be certified for percent germination, being in a weed- and disease-free condition, and the specifications followed the Detailed Plan. Seed that has become wet, moldy, or otherwise damaged shall not be accepted. Seed that is infested with smut or other diseases shall not be accepted. Seed shall be tested as provided at a laboratory approved by the Contracting Officer for percent germination and disease.

The Contractor shall not make substitutions of plant material except as specifically approved by the Contracting Officer. If specified revegetation material is not useable or obtainable (e.g., sufficient amount of specific seed), the Contractor and Corps shall determine an appropriate and acceptable substitute. It shall be the Contractor's responsibility to collect and propagate sufficient numbers of plants to ensure availability of replacement stock as needed for this Project.

Mulch shall be provided to a depth of three (3) inches for each tree. Mulch shall be nitrogen-treated medium or large wood bark chips or other locally available nitrogen-treated organic materials. (*NOTE: WEED MATS OR OTHER GROUND-COVERING FABRICS ARE OFTEN RECOMMENDED. IN OUR EXPERIENCE, WEED-CONTROL FABRIC IS*

RELATIVELY EXPENSIVE AND NOT COST-EFFECTIVE. DIRT OR ORGANIC MATTER INVARIABLY ENDS UP ON THE FABRIC, AND WEEDS SPROUT ON THIS DIRT AND ROOT INTO THE FABRIC, MAKING MANUAL CONTROL WITHOUT REMOVAL OF THE FABRIC EXTREMELY DIFFICULT. ADDITIONALLY, THE WEED MATS INCREASE SOIL TEMPERATURE AND MOISTURE UNDER THE MAT AND INCREASE PLANT FUNGAL DISEASE MORTALITY. A THREE (3)-INCH LAYER OF MULCH OVER THE PLANTING BASIN COSTS APPROXIMATELY THE SAME AMOUNT AS A WEED MAT COVER BUT PROVIDES A MORE NATURAL CONDITION WHILE STILL REDUCING WEED GROWTH.)

No fertilizer is proposed for the Project. The native species are adapted to the site conditions. Increasing soil fertility will increase weed cover.

2.5.3 Construction Methods

Specific work to be completed includes the following:

- **Riparian Woodland**

  - For Corps-supplied nursery stock

Pick up Corps-supplied nursery stock after preparations for planting have been completed and plant immediately. Unless unforeseen issues arise, only enough plants to be planted in any one day shall be picked up. Consequently, the Contractor shall begin each planting day by collecting plants from the nursery for that day's planting. Plant materials not installed on the day of delivery at the site due to unforeseen circumstances shall be stored and protected against damage from the elements or loss due to vandalism. Plant materials shall have their roots protected from drying out and shall be moist at all times. Do not remove container-grown stock from containers until planting.

The Contractor shall prepare planting basins for all plants. Holes shall be dug in the backfilled planting hole just big enough to accept the plant root ball. Plants shall be installed within the specified collar so that the crown is level with existing grade outside of water ring. The root ball shall be covered with one-fourth (¼) inch of soil, so that no nursery soil is showing, to prevent wicking and drying of root ball. A berm two (2) inches above grade and eighteen (18) inches in diameter shall be constructed, centered on the planting hole. The water ring must be made to hold water; any breaks or leakage shall be repaired by the Contractor.

Begin irrigation immediately upon completion of planting and continue irrigation until the plant basin is completely moistened.

Place mulch on the planting basins. Mulch shall be placed on planting basins to a depth of three (3) inches.

All plants shall be checked by the Contractor for settling and stress, and any corrections shall be made by the Contractor.

- For Contractor-supplied cuttings

The Contractor shall auger and scarify a planting hole at the approved locations for these plants in accordance with the Detailed Plan when root nodules have formed on the first batch of cuttings. One cutting of the appropriate species shall be placed in the augered hole to a minimum depth of two (2) feet with a maximum of one (1) foot of cutting above the ground. The cutting shall be placed firmly into the soil of the planting hole and the earth compacted around the cutting with a rubber mallet or similar tool. The very top of the cutting shall then be cut off at a forty-five (45) degree angle to shed rainwater. The Contractor shall ensure that nodes are pointing upward.

In the lowest areas on the Project Site, where the cuttings will be planted, summer soil water levels are high, due to the influence of irrigation on surrounding fields. In these cases, planting holes shall be relatively shallow (two (2) feet) and the cutting relatively short (three (3) feet, with a maximum of one (1) foot of cutting above the soil surface) to avoid excessive waterlogging of the cuttings. In other sites in the western region with more xeric conditions and low summer water levels, longer cuttings with deeper holes are required; Bertin Anderson has used twenty-four (24)-foot pole cuttings in the extremely arid conditions in the southwestern United States. Conversely, projects in northwestern California with a relatively high summer water level and high annual rainfall may use "footings" — cuttings that are approximately twelve (12) to eighteen (18) inch sections of live wood with ten (10) to twelve (12) inches in the soil.

The cutting planting hole shall be just slightly larger in diameter than the cutting. A six (6)-inch diameter hole in a clay soil, for example, will be almost impossible to compact properly around a one-half (½)-inch cutting and will result in air pockets in the hole.

- For riparian understory species

Riparian understory areas shall be planted by plug planting. Plugs are to be planted at a spacing of two (2) feet on center. Holes two (2) inches deep are to be prepared with a dibble or similar bar or instrument, and one (1) rooted plug placed in each hole. Each plug shall be settled and have surrounding soil compacted by hand, so that roots and soil are covered by compacted site soil.

■ Marsh

Perennial marshes shall be planted in the dry or wet with bare root materials (corms, tubers, etc.) as specified above. Material shall be placed on two (2)-foot centers. Root material shall be between two (2) and three (3) inches below the soil level. The planting holes shall be dug with a dibble or similar equipment, the bare root material placed in the hole, and the soil tamped around the planted material firmly.

Seasonal marsh and wet meadow material shall be planted in the dry or wet with plugs as specified above. Plugs shall be placed on two (2)-foot centers and planted with the top of the soil surface of the plug flush with the existing ground. The planting holes shall be dug with a dibble or similar equipment, the plug placed in the hole, and the soil tamped around the planted plug firmly.

- For all planting areas following planting of stock

Plant seed of the specified seed mix given in the Detailed Plan. Seed shall be planted using a "no-till" drill, with the drills set no more than ten (10) inches apart to a depth of one-fourth (¼) to three-fourths (¾) inches. Remove all debris resulting from landscaping work from site. Provide neatly dressed, finished planted areas. Review planted areas with Contracting Officer, and make adjustments as required. The Contractor shall secure the Contracting Officer's full acceptance of the work in writing before beginning any Maintenance Period.

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13. ABSTRACT ***(Maximum 200 words)***

This report explains the process involved when proceeding from a wetland mitigation design concept to a full engineering package that is suitable for public bid and advertisement. The information provided is geared toward educating nonengineering professionals engaged in developing wetland mitigation specifications. The biological foundations for the various elements are first presented, followed by full guideline specifications. The vegetation specifications address site preparation, plant material acquisition, transport, handling, and storage of seeds, herbs, and saplings, planting methods for various stock types, different seeding methods, timing of planting in conjunction with seasonal variations, hydrological considerations such as tidal cycle, water level and rainfall patterns, equipment access and type, protection measures for herbivory, inundation and vandalism, fertilization and amendment application, soil-nutrient testing, substrate handling, transport, and storage and minimization of impacts on existing wetland resources. The subgrade specifications target construction methods and equipment, soil-material testing, and performance. The other soil-related specifications quarantine and safeguard existing resources such as friable surface soils and wetland topsoils that can be used to "seed" a site.

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