

**River Restoration Toolbox  
Practice Guide 2**

Vegetative Restoration



Iowa Department of Natural  
Resources

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### Executive Summary

Vegetative restoration provides stream bank stability while improving the ecological function of both the stream and riparian area. Vegetative restoration is preferred over hard armoring and other engineered, flexible revetment techniques such as riprap and sheet piling because of the aesthetics, energy dissipation, and natural function of the vegetation. Vegetative restoration methods are often used in conjunction with other forms of restoration, such as channel bank grading, and are selected based on site conditions, constraints, and specific project objectives. The following techniques are detailed in this report:

1. Live Staking/Joint Planting
2. Live Fascines
3. Brush Layering
4. Erosion Control Matting
5. Sod Matting
6. Seeding
7. Nursery Stock, Bare Root, Vegetative Plug, and Transplanting

The *River Restoration Toolbox Practice Guide 2: Vegetative Restoration* (Practice Guide) has been developed to assist with the presentation of design and construction information for stream restoration in Iowa. It is intended to provide guidance to:

- Those responsible for reviewing and implementing stream restoration,
- Professionals responsible for the design of stream restoration projects,
- Others involved in stream restoration at various levels who may find the information useful as a technical reference to define and illustrate vegetative restoration techniques.

The Practice Guide includes a written assessment of the vegetative restoration practice and describes a variety of vegetative restoration techniques. Each technique includes design guidelines, a specifications list, photographs, and, when applicable, drawings.

**The information in the Practice Guide is intended to inform practitioners and others, and define typical information required by the State of Iowa to be included with the use of vegetative restoration techniques. The information and drawings are not meant to represent a standard design method for any type of technique and shall not be used as such. The Practice Guide neither replaces the need for site-specific engineering and/or landscape designs, nor precludes the use of information not included herein.**

The Practice Guide may be updated and revised to reflect up-to-date engineering, science, and other information applicable to Iowa streams and rivers.

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### 1.0 INTRODUCTION

Vegetative restoration refers here to the use of vegetation and natural materials to stabilize stream banks and riparian areas (e.g., buffers, etc.). Vegetative restoration provides a natural-looking stream bank while also reducing erosion, improving water quality, and enhancing wildlife habitat. Vegetative restoration provides an alternative to hard armoring and engineered, flexible revetment techniques that deflect energy; the presence of vegetation dissipates energy. Stream bank vegetation provides long-term stability; as the root systems grow they increase the strength and structure of the stream bank by creating a dense system of roots that resist erosion. A specific type of vegetative restoration called soil bioengineering involves the application of live plant material in a variety of arrangements, generally on a sloped surface, to provide engineered-stability function. The NRCS, National Engineering Handbook (NEH), Technical Supplement 14I, Streambank Soil Bioengineering, issued in August 2007 (NRCS 2007a), is an exhaustive resource for soil bioengineering techniques common in river restoration.

Vegetative restoration techniques can be relatively inexpensive and some techniques require little to no training to implement; this makes some types of vegetative restoration a good option for landowners. The State of Iowa recommends that property owners only consider undertaking the restoration of a stream bank themselves for heights of less than four feet and with slopes flatter than 6H:1V (IDNR 2006). Channel banks with a height of greater than four feet and steeper than 6H:1V are still candidates for vegetative restoration practices but require consultation with a professional.

Vegetative restoration success is largely affected by the plant species selection, timing of planting, handling, storage, installation procedure of the plant material, and their placement in the proper location relative to the stream (NRCS). The guidelines and specifications provided in this document are general and not a comprehensive design manual. It is the responsibility of the designer to understand the design approach and the feasibility of using these techniques on a case-by-case basis. The following criteria in no way replaces design discretion, experience, and training, and cannot incorporate every scenario. They are intended to flag common errors, promote empirically stable design ranges, assist designers and reviewers in communication, and adapt tested designs to Iowa conditions.

### 1.1 PLANT SELECTION

The use of plant species native to Iowa is required. Native plant species are adapted to the specific conditions found along Iowa rivers and their associated riparian areas; with the exception of annual crop covers, they offer the best chance for long-term growth, and correspondingly the stability and function of the riverine ecosystem. Non-native species can become invasive and threaten the diversity of species and vigor of native plants; their use can ultimately threaten stream bank stability and other riverine ecosystem functions. *The Iowa Riverside Plant Selection (rev. 12/15/2016)* guide should be consulted, along with other national

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guides (NRCS, others, see References), to aid in plant species selection. Seedlings will not include any species identified by the most up to date "Iowa Noxious Weeds" list (Iowa Code §317.1A, 2017) and/or those listed on the Corps "Excluded Species Plant List" found on the Rock Island District's regulatory branch homepage.

Each native riparian plant species has different characteristics that may make them better suited for a specific project, or elevation along a given channel bank, and plant selection and installation (planting) method should be determined to address the issues and goals present at a site. For example, willows with a deep, spreading root system may be better suited for a bank stabilization project when compared to a species with a shallow root system. When shade and reduced in-stream temperatures are a desired goal, a native riparian tree species may be more appropriate than native shrubs, grasses, and forbs. However, intermixing the stand with diversity that includes matting root species between deeper rooting plants can also reduce soil mobilization. All plants used on stream banks should be selected with attention to how much inundation (depth under water) they can withstand and for how long (duration) they can stand inundation (IDNR 2016). Local expertise and guidelines should be consulted when selecting the appropriate plant material.

When implementing vegetative restoration, success is dependent on vegetation survival and growth. Harvesting vegetation in areas near the project site where soil and hydrology are similar, or otherwise procuring vegetation adapted for the conditions at the project site, will improve chances of success. Specific species selection is dependent on the hydrology and soil of the project site and should be selected for each planting zone and condition (e.g., proximity to flow, slope, sun, shade, presence of trails, resistance to scouring flow, etc.) present (Iowa DNR 2016).

### 1.2 SITE PREPARATION

Site preparation is an important component of revegetation. Hard soil should be tilled to a depth of 4-6" and then be smoothed so there are no abrupt breaks in slope. The tops of slopes should be level and rounded over to avoid low spots where surface water runoff can concentrate and cause gullies to form. There should be no clumps of soil present on the surface.

Prior to planting the soil should be tested and evaluated to determine the need for amendment. Fertilizers containing phosphorus and nitrogen should be avoided in riparian areas. High nutrients concentration in streams and rivers are a threat to aquatic organisms. Soil amendments can include topsoil, lime to adjust soil pH, compost, and mycorrhizal spores. The use of any soil amendments should follow the manufacturer's recommendations.

### 1.3 VEGETATION CARE

Following the installation of vegetation, the site should be cared for until the plants are fully established.

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- Mulch – Most vegetation will require mulch to protect the plants from the weather and to retain moisture. Weed free straw mulch is the most common mulch for large, seeded areas. Individual plants may be mulched with wood chips, pine straw, etc.
- Water – Vegetation should be watered immediately after planting and at any time lack of rainfall threatens plant survival.
- Other protection – Vegetation should be protected against threats present at the site, such as animals browsing, ATV and vehicle traffic, foot traffic (human and animal), and weather (wind, flooding, temperature), etc.
- Inspection and maintenance – Vegetation should be inspected regularly for adequate growth, disease, pests, and other damage (e.g. – predation, vandalism, etc.). Maintenance consists of spraying for insects and diseases, weeding, watering, and installing covers, barriers, and/or supports.

### 1.4 PLANTING SCHEDULE

Scheduling a time to plant vegetation is dependent on a variety of local conditions. Per the NRCS (NRCS, 1998), planting should be geared for periods during which the plants will have adequate moisture for establishment, yet will not be subject to high flow events. If local conditions have created high runoff, then the planting window may be pushed back to the early summer. However, summer plantings should generally be avoided because of hot temperatures and dry conditions, leading to high desiccation rates and limited chances of success. Conversely, fall plantings are susceptible to frost heave and ice flows in winter which may rip out roots that are not yet established. Even when planting occurs at a proper time, a flash flood event may damage vegetation before it is fully established. Consequently, flexibility in planting schedule, inspection, and maintenance of vegetation is critical to successful revegetation.

### 1.5 SOIL BIOENGINEERING

Several techniques in this Practice Guide are soil bioengineering that require the use live cuttings. The choice of species, harvesting, storage, and preparation of these cuttings is critical to the success of these techniques.

#### 1.5.1 Soil Bioengineering Plant Species

Most stream bank soil bioengineering techniques involve cuttings taken from woody plant species adapted to the riparian environment. These cuttings root easily when inserted into the soil, especially if the cuttings are taken and installed (planted) when the plant is dormant. When stems are placed in contact with soil, they sprout roots; when they are in contact with air, they sprout stems and leaves. Many of these species are hardy pioneer species, making them ideal for rapid establishment on a restoration site. Generally, willows (*Salix spp.*), dogwoods (*Cornus*

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*spp.*), silver maple (*Acer sacc.*) and cottonwoods and poplars (*Populus spp.*) are suitable for soil bioengineering. Care should be exercised in selecting specific varieties of these plants; some root from cuttings more easily than others, and some do not root from cuttings at all.

Some of the benefits of using cuttings versus rooted stock include lower cost, ease of planting, shallower depth of planting, and a wide range of local ecotype availability.

### 1.5.2 Harvesting

Cuttings can be harvested (collected) any time during the dormant season, from “leaf-off” in autumn to just before the emergence of the buds in early spring. Iowa Department of Transportation (Iowa DOT) requires material may be harvested between November 15 and January 1 (Iowa DOT 2014). Some sources advise that cuttings can be collected during the growing season, but caution that all leaves must be removed from the stem prior to planting, and establishment and success will be lower (NRCS 1998).

Material to be harvested should be healthy and free of splits, rot, and insect infestation and should generally vary between 5 to 8 feet in length. The equipment should be sharp enough to make clean cuts. When harvesting in a dry area, collect material at least two years old; younger plants do not have enough stored energy for thorough root establishment. Cuttings from live material should leave at least one third of the parent plant intact, and be made from an appropriate part of the plant so that it is not damaged. For example, cutting the top off (coppicing) of certain trees will cause them to become more shrub-like than tree-like, and should be avoided.

Cuttings, and even prepared stakes, fascines, etc., can be obtained commercially. Care should be taken to ensure the procured plant species is appropriate for the site.

### 1.5.3 Storage and Handling

Typically, harvested live cuttings must be bundled, transported, and stored before use. After cutting, the materials are bundled and loosely bound with twine for transportation. If the materials require transportation in a motor vehicle, the material should be sheltered in a closed compartment or under a secured cover or tarp so it will not dry out.

Live cuttings should ideally be soaked in water before use; an optimal soaking duration is 14 days (NRCS 2007a). Alternatively, material can be planted the same day they are harvested if they are watered.

If cuttings are not installed at the time of harvest they should be stored at a dry location. Iowa DOT specifies cuttings be stored below 41° F and above 90% humidity and requires the use of a thermometer and hygrometer to verify these conditions. If stored outside in these conditions or refrigerated, live hardwood cuttings can last up to four months. The cuttings must be soaked and rehydrated before use.

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If storage conditions are damp or wet, it is important to monitor the cuttings for root development. The root process may start after 10 days; it can be difficult to use cuttings with these initial roots because they are typically very tender and difficult to handle and install without damaging them.

### 1.5.4 Preparation

Preparation of the dormant live cuttings is generally the same, regardless of method of installation. The side branches of the cuttings are removed with a minimum of two undamaged bud tips left intact (Iowa DOT 2014). Cuttings of the specified diameter are cut to length. Some methods require blunt cuts, others require angled cuts, and some techniques leave the growing tip uncut. These specifications are presented with each technique in this Practice Guide. All cuts should be smooth, leaving no splits or cracks.

### 1.5.5 Installation

Once prepared the plant materials should be protected from drying and overheating until it is installed. The prepared materials can be stored in water or moist soil (healed in) for a maximum of 2 days. Outside storage locations should be continually shaded and protected from the wind. If the ambient temperature is 50°F or greater, the dormant plant material shall not be stored on site, but installed the day it is removed from refrigeration and prepared. If the plant material is harvested on-site in warmer than 50-degree conditions, the plant material shall be installed the same day.

## 2.0 VEGETATIVE RESTORATION TECHNIQUES

### 2.1 LIVE STAKING/JOINT PLANTING

#### 2.1.1 Narrative Description

Live staking and joint planting involves the insertion of prepared cuttings (live stakes) from dormant woody plants (trees and/or shrubs) into the ground so they root and grow. Joint planting is a common variation of live staking; the live stakes are inserted through openings of revetments (e.g., rip rap) and then into the soil underneath them.

Live stakes do not provide much initial reinforcement of the soil because they do not normally extend beyond a slope failure plane. Over time however, the stakes take root and the roots help bind the soil together. The above-ground growth provides surface protection which can prevent surface erosion (e.g., rills, gullies). The growth also adds roughness to the stream bank, reducing the velocity of stream flow. Live stakes, alone or as joint plantings, are useful on wet slopes because they absorb water from the soil, control internal seepage, and allow the slope to dry out and stabilize. Live stakes and joint plantings assist in quickly reestablishing riparian vegetation (NRCS 2007a). Joint planting provides a more natural appearance to stream banks stabilized with rip rap and other flexible and hard revetments.

Installing live stakes on an existing slope, as well as joint planting through existing rip rap, can be undertaken by landowners. Often however, a lack of vegetation on stream banks is due to unstable conditions; analysis and design by a professional may be required to stabilize the stream bank and reestablish vegetation.

#### 2.1.2 Technique Information

- **Use:** Live staking and joint planting is used to quickly establish roots (below ground) and plant growth (above ground) along a stream bank. This helps reduce surface erosion, slow flow velocity by adding surface roughness, reinforce the soil, and reduce soil moisture and seepage.
- **Other uses:** The growth of the stake can improve aesthetics, riparian habitat, and water quality. The roots of woody plants provide a means of uptake of excess nutrients (especially nitrogen) in storm water runoff. The above-ground growth can shade the stream and reduce water temperatures. During high flows, the vegetation can provide refuge for fish and other aquatic living organisms. Live stakes can also be used to repair shallow soil slips, slumps, and gullies.
- **Best applications:**
  - Sites with adequate supply of woody plant species suitable for cuttings

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- Bare areas on existing stable slopes and stream banks, or slopes and banks recently graded to a stable angle (e.g., as part of a stream restoration project)
- **Variations:**
  - Combining live staking with other measures capable of providing initial stability (e.g., cover crop, erosion control matting, rip rap, other revetments). Joint planting is a common variation of live staking.
  - Using large (length and diameter cuttings). Live posts, dormant post planting, willow posts, etc. all generally refer to live staking and/or joint planting with a large (3-8" diameter, 3-20' long) dormant live cutting (NRCS 2007a). Bigger diameters and longer lengths are best suited for heavily eroded areas and varying water levels. They can provide more initial stabilization than live stakes if they extend beyond a slope failure plane.
- **Computations:** Computations are generally not necessary for landowners using live staking and/or joint planting to revegetate bare areas on otherwise stable stream banks. For stream restoration projects, live staking and joint planting require design by a professional.

Hydrologic and hydraulic computations aid in verifying that the appropriate conditions exist for use of live staking or joint planting. Geometric calculations are required to properly size and situate the vegetative structure within the context of its individual location. Hydraulic analysis is required to determine where to place live stakes on the slope, how the above-ground growth will distribute energy at various flow stages, and to verify that the velocities and shear stresses generated by streamflow do not exceed the permissible velocity and tensile strength of the vegetative structure.

Live stake properties: Depending on length of prepared cuttings and soil condition, live staking is cited in NRCS 2007a as having an initial permissible velocity of 1-2.5 ft/s; permissible velocity increases to 3-10 ft/s once vegetation is established. NRCS also cites initial permissible shear stress of 0.5-2 lbs/ft<sup>2</sup>; permissible shear stress increases to 2 lbs/ft<sup>2</sup> to over 5 lbs/ft<sup>2</sup> once vegetation is established.

Joint planting properties: Joint planting is cited in NRCS 2007a as having an initial permissible velocity of 5 ft/s to over 10 ft/s; permissible velocity increases to over 12 ft/s once vegetation is established. NRCS also cites initial permissible shear stress of over 3 lbs/ft<sup>2</sup>; permissible shear stress increases to over 8 lbs/ft<sup>2</sup> once vegetation is established.

- **Key Feature:** Live staking and joint planting require the use of woody riparian plant species that root easily from dormant live cuttings.



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- **Cautions:**
  - Planting vegetation adjacent to streams can adversely impact the local hydraulics, sometimes deflecting currents, catching debris and causing blockages, or increasing roughness and causing increases in flood stage.
  - Vegetation alone will likely be unsuccessful on steep bank slopes without sufficient shaping. No more than 50% Sycamore, river birch and dogwood in any single area.

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### 2.1.3 Detail Drawings and Data Table

The following drawings and data table depict information that should be included in construction plans for live staking and joint planting. The data table includes design guidelines and sources, where applicable.

**Table 1. Required Design Data for Live Staking/Joint Planting<sup>1</sup>**

Dimension <sup>2</sup>	Name	Typical Unit	Guidelines <sup>3</sup>	Description
A	Live stake spacing	Feet	2-4' (NRCS 2007a)	Spacing between individually installed live stakes. Stakes can be placed in a triangular grid (NRCS 2007a) or randomly (NRCS 2007a, Iowa DNR 2006). Recommend species diversity throughout project area.
B	Live stake – top of slope placement	Feet	N/A	Position of live stake relative to the top of a slope
C	Live stake – toe of slope placement	Feet	N/A	Position of live stake relative to the toe of a slope
D	Live stake – base flow relationship	Feet	N/A	Placement of lower row of live stakes relative to the approximate base flow water level with consideration given to duration of inundation during bankfull and other high flow events.
E	Live stake length	Feet	3' (Iowa DNR 2006); 3-10' (NRCS 2007a)	Length of prepared dormant live cutting from woody plant to be used

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**Table 1. Required Design Data for Live Staking/Joint Planting<sup>1</sup>**

Dimension <sup>2</sup>	Name	Typical Unit	Guidelines <sup>3</sup>	Description
				as live stake. Length should be sufficient to reach low-flow water table elevation.
F	Live stake protrusion	Feet	1/5 x live stake length (Iowa DNR 2006); taller than surrounding vegetation (NRCS 2007a)	Distance installed live stake should protrude about 20% from the ground. At least two buds or bud scars should be present above the ground in the final installation, depending on the surrounding vegetation height.
G	Live stake diameter	Inches	1/2 – 2" (Iowa DNR 2006); 3/4-3" (NRCS 2007a)	Diameter of prepared dormant live cutting from woody plant to be used as live stake – typically cite a permissible minimum and maximum diameter.

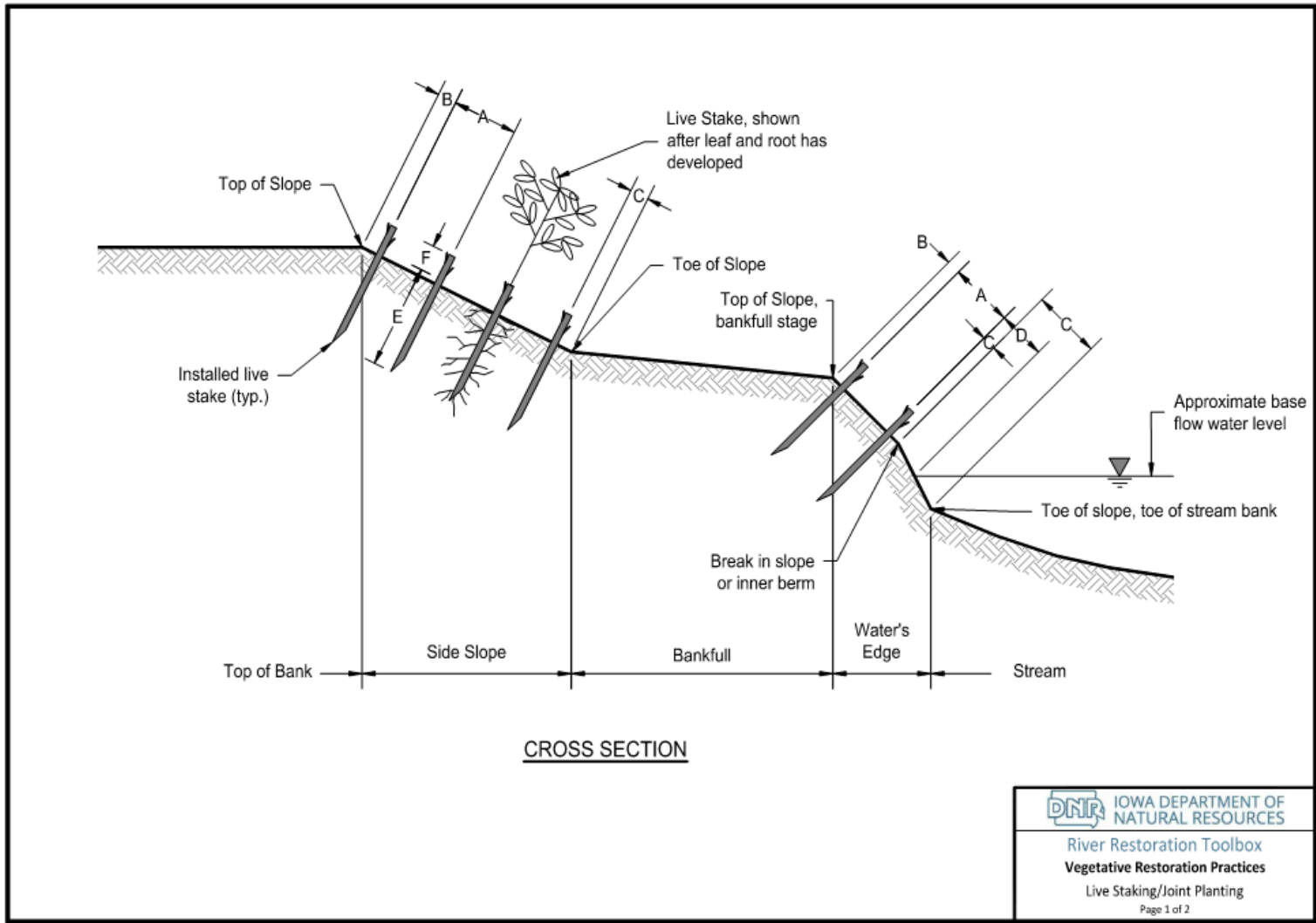
Notes:

1. Data are for live staking in bare soil, in soil covered with erosion control matting, and/or in soil covered with rip rap or other revetment (joint planting).
2. Dimension labels are referenced in the detail drawings.
3. Common guidance, values, or ranges are given unless they require computation using site-specific input.

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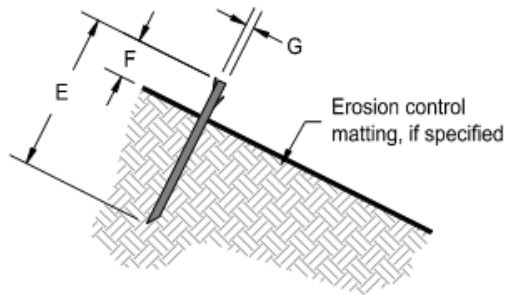
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## Drawing 1. Live Staking/Joint Planting

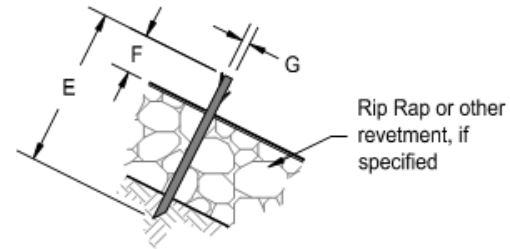


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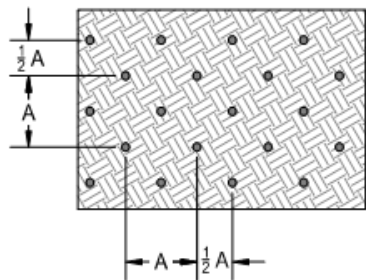
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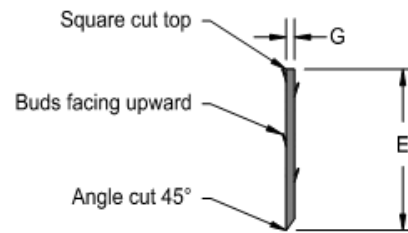
INSTALLED LIVE STAKE DETAIL



INSTALLED JOINT PLANTING DETAIL



LIVE STAKE PATTERN DETAIL



LIVE STAKE DETAIL

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### 2.1.4 Specifications

In addition to the information presented in Section 1.0 Introduction, the following information should be developed into specifications to accompany the use of live staking and joint planting:

- Materials:
  - Prepared live stakes of acceptable species and size.
  - Fertilizers and/or other soil amendments as required based on site conditions.
- Equipment/Tools:
  - Rubber mallet or dead blow hammer
  - Hand pruners, loppers, hand saw, and/or chain saw
  - Punch bar or hand auger used to create pilot holes
  - Stinger (hydraulic injector to create pilot hole)
  - Metal cap (if using the post planting variation these can be used to push in the larger diameter cuttings)
  - Excavator (if using the post planting variation these can be used to push in the larger diameter cuttings)
- Sequence:
  - Cleanly remove all side branches and the top growth, and fashion the cuttings into live stakes as depicted in the detail drawing. An option during preparation is to paint and seal the top of the live stake by dipping the top 1-2 inches into a 50-50 mix of light colored latex paint and water. Sealing the top of stake will reduce the possibility of desiccation, assure the stakes are planted with the top up, and makes the stakes more visible for subsequent planting evaluations.
  - Use a punch bar or hand auger to create a narrow pilot hole, perpendicular to the slope, through any erosion control matting, rip rap, or other revetment, filter fabric, etc., if present, and deep enough to intercept the water table. The hole should be only as large as necessary to install the live stake without damage while ensuring the highest amount of stake-soil contact.
  - Insert the pointed end of the live stake into the pilot hole. Tamp into the ground with a dead blow hammer taking care not to split or otherwise damage the live

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stake. Use water, soil backfill, tamping, etc. to achieve good soil-to-stem contact and remove air pockets.

- Workmanship:
  - All cuts should be clean and smooth.
  - No cracked or split live stakes should be used. If they split during tamping, they should be replaced.
  - The specified number of live stakes should be installed into the soil and protrude above the soil and any erosion control matting, rip rap, or other revetment.
  - The live stake should not move after installation; ensuring it is in firm contact with the soil.
  - It is important to ensure that the upstream and downstream ends of the live staking and joint planting merge smoothly into the undisturbed bank beyond the project area. The rate of installing live stakes and joint plantings should taper off gradually to blend in with the existing vegetation.
- Maintenance: Cuttings may require initial protection from beaver, deer, cattle, or other predators. Various types of deer-proof fencing or fine wire screen or mesh can be secured around the cuttings to offer protection. If the area is grazed, restrict livestock from the project site.



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### 2.1.5 Photographs



**Photo 1.** Dormant live cuttings prepared as live stakes. Source: Bio Draw-a product of Salix Applied Earth Care



**Photo 2.** Installed live stakes prior to trimming. Source: Bio Draw-a product of Salix Applied Earth Care, 1996



**Photo 3.** Live stake test plots. Source: Charlotte-Mecklenburg Storm Water Services



**Photo 4.** On-site live cutting refrigeration. Source: Charlotte-Mecklenburg Storm Water Services



**Photo 5.** Hydraulic stinger live stake installation. Source: Lake Superior Tree Farm



**Photo 6.** Live stakes in bankfull flow. Source: Charlotte-Mecklenburg Storm Water Services



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**Photo 7.** Joint planting. Source: Charlotte-Mecklenburg Storm Water Services



**Photo 8.** Joint planting with new growth. Source: Charlotte-Mecklenburg Storm Water Services



**Photo 9.** Joint planted rip rap. Source: Charlotte-Mecklenburg Storm Water Services



**Photo 10.** Prepared live stakes. Source: Lake Superior Tree Farm



**Photo 11.** Live stakes in erosion control matting. Source: Collins & Baker Engineering



**Photo 12.** Live stakes installed in late autumn on Dead River, MI. Source: Collins & Baker Engineering

## 2.2 LIVE FASCINES

### 2.2.1 Narrative Description

A live fascine is a long bundle of live cuttings tied together and then installed into a shallow trench on the stream bank to reduce erosion and stabilize the soil. They can be placed along the toe of the stream bank, as toe protection, or elsewhere on the bank along the contours or at angles.

Live fascines provide immediate protection against surface erosion of the stream toe or bank. Their placement along the stream bank contour can break a long slope into a series of shorter slopes, thus slowing overland flow. Fascine placement on an angle can capture and direct drainage advantageously down a slope. Fascines may even provide immediate protection against shallow slope failures if the stakes fastening them into the trench extend past a failure plane.

Over the long-term, the cuttings comprising the fascine root and grow. The above-ground growth provides surface protection which continues to prevent surface erosion (e.g., rills, gullies). The growth also adds roughness to the stream bank, reducing the velocity of stream flow. The roots bind soil particles together and reinforce the soil mantle (NRCS 2007a).

Installing live fascines on an existing slope can be undertaken by landowners. Often however, a lack of vegetation on stream banks is due to unstable conditions; analysis and design by a professional may be required to stabilize the stream bank and reestablish vegetation.

### 2.2.2 Technique Information

- **Use:** Live fascines protect the stream bank toe and stream bank slopes from shallow slides, seepage, and surface erosion, and re-establishes native vegetation.
- **Other uses:** In addition to short- and long-term erosion control and slope stability, live fascines will mature into streamside vegetation and provide numerous other benefits including improved aesthetics, riparian habitat, and water quality. For example, fascine growth increases the amount and quality of riparian habitat for birds, mammals, and other terrestrial animals by providing food and cover, and improves in-stream habitat and water quality for fish and other aquatic organisms through reducing water temperatures by providing shade. During high flows, the vegetation also provides refuge to fish and other aquatic organism from high velocities.
- **Best applications:**
  - Sites with a large supply of long live cuttings
  - Recently graded slopes (e.g., as part of a stream restoration project)

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- The toe of a stream bank requiring protection from high velocity and/or shear stress.
- To control overland flow by breaking up long banks into a series of shorter banks
- **Variations:**
  - Substituting live stakes for one or both dead stout stakes fastening the fascine into the trench
  - Combining a live fascine with another type of toe protection such as rip rap
  - Lining the trench and slope with erosion control matting and staking the fascine into the trench on top of the matting.
  - Orienting fascines vertically, up the stream bank. Called the vertical bundle method, the fascines are assembled with the basal ends of the cutting all on one end and placed in the water.
- **Computations:** Computations are generally not necessary for landowners using live fascines to revegetate bare areas on otherwise stable stream banks. However, planting vegetation adjacent to streams can adversely impact the local hydraulics, sometimes deflecting currents adversely, catching debris and causing blockages, or increasing roughness and causing increases in flood stage.

For stream restoration projects, live fascines require design by a professional.

Hydrologic and hydraulic computations aid in verifying that the appropriate conditions exist for use of live fascines. Geometric calculations are required to properly size and situate the vegetative structure within the context of its individual location. Hydraulic analysis is required to determine where to place live fascines on the slope, how the above-ground growth will distribute energy at various flow stages, and to verify that the velocities and shear stresses generated by streamflow do not exceed the permissible velocity and tensile strength of the vegetative structure.

Live fascine properties: Depending on adequate anchoring, live fascine is cited in NRCS 2007a as having an initial permissible velocity of 5-8 ft/s; permissible velocity increases to 8 ft/s to over 10 ft/s once vegetation is established. NRCS also cites initial permissible shear stress of 1.2 – 3.1 lbs/ft<sup>2</sup>; permissible shear stress increases to 1.4 lbs/ft<sup>2</sup> to over 3 lbs/ft<sup>2</sup> once vegetation is established.

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- **Key Features:**
  - Live fascines require the use of woody riparian plant species that root easily from dormant live cuttings.
  - Dormant live cuttings are assembled into bundles and bound together with biodegradable twine
  - Fascines are placed along contours (horizontally), on angles, and in a variation vertically.
- **Cautions:**
  - Planting vegetation adjacent to streams can adversely impact the local hydraulics, sometimes deflecting currents, catching debris and causing blockages, or increasing roughness and causing increases in flood stage.
  - Vegetation alone will likely be unsuccessful on steep bank slopes without sufficient shaping.

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**2.2.3 Detail Drawings and Data Table**

The following drawings and data table depict information that should be included in construction plans for live fascine. The data table includes design guidelines and sources, where applicable.

**Table 2. Required Design Data for Live Fascine<sup>1</sup>**

Dimension <sup>2</sup>	Name	Typical Unit	Guidelines <sup>3</sup>	Description
A	Fascine spacing	Feet	3-10' depending on slope (NRCS 2007a)	Spacing between installed live fascines. Spacing varies based on slope (NRCS 2007a). Recommend species diversity throughout project area.
B	Upper fascine - slope limit	Feet	N/A	Placement of upper installed live fascine relative to the top of a slope.
C	Lower fascine - slope limit	Feet	N/A	Placement of lower installed fascine relative to the toe of a slope.
D	Lower fascine – base flow limit	Feet	N/A	Placement of lower installed fascine relative to the approximate base flow water level with consideration given to duration of inundation during bankfull and other high flow events.
E	Fascine length	Feet	8' – 10' (NRCS 2007a)	Length of assembled fascine.
F	Live cutting length	Feet	5' – 15' (NRCS 2007a)	Length of dormant live cutting from woody plant to be assembled into a

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**Table 2. Required Design Data for Live Fascine<sup>1</sup>**

Dimension <sup>2</sup>	Name	Typical Unit	Guidelines <sup>3</sup>	Description
				fascine. Length should be sufficient to reach low-flow water table elevation.
G	Live cutting diameter	Inches	3/4" – 2" (NRCS 2007a)	Diameter of dormant live cutting from woody plant to be assembled into a fascine – typically cite a permissible minimum and maximum diameter
H	Fascine twine fastening spacing	Feet	2' (NRCS 2007a)	Spacing between twine fastening used to hold the assembled fascine together
I	Fascine diameter	Feet	0.5' – 2' (NRCS 2007a)	Diameter of assembled fascine
J1	Trench depth	Feet	½ fascine diameter – ¾ diameter (NRCS 2007a)	Depth of trench into which the assembled fascine is installed. Trenches should be excavated as deep as practicable to facilitate the maximum amount of soil/live cutting contact.
J2	Trench width	Feet	Fascine diameter	Width of trench into which the fascine is installed should be approximately equal to the diameter of the fascine to facilitate good soil/cutting contact

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**Table 2. Required Design Data for Live Fascine<sup>1</sup>**

Dimension <sup>2</sup>	Name	Typical Unit	Guidelines <sup>3</sup>	Description
K	Dead stout stake spacing	Feet	3' (NRCS 2007a)	Spacing of wooden, wedge-shaped stakes used to fasten the assembled fascine into the trench
L	Dead stout stake length	Feet	2' - 3' (NRCS 2007a)	Length of wooden, wedge-shaped stakes used to fasten the assembled fascine into the trench
M	Fascine angle (optional)	Degrees	30° - 60° (NRCS 2007a)	Angle of assembled fascine installation. On upper banks adjacent to a stream and along outside meanders, it may be useful to align the fascines at an angle to reduce the likelihood of scour and rill erosion around installed bundles.

Notes:

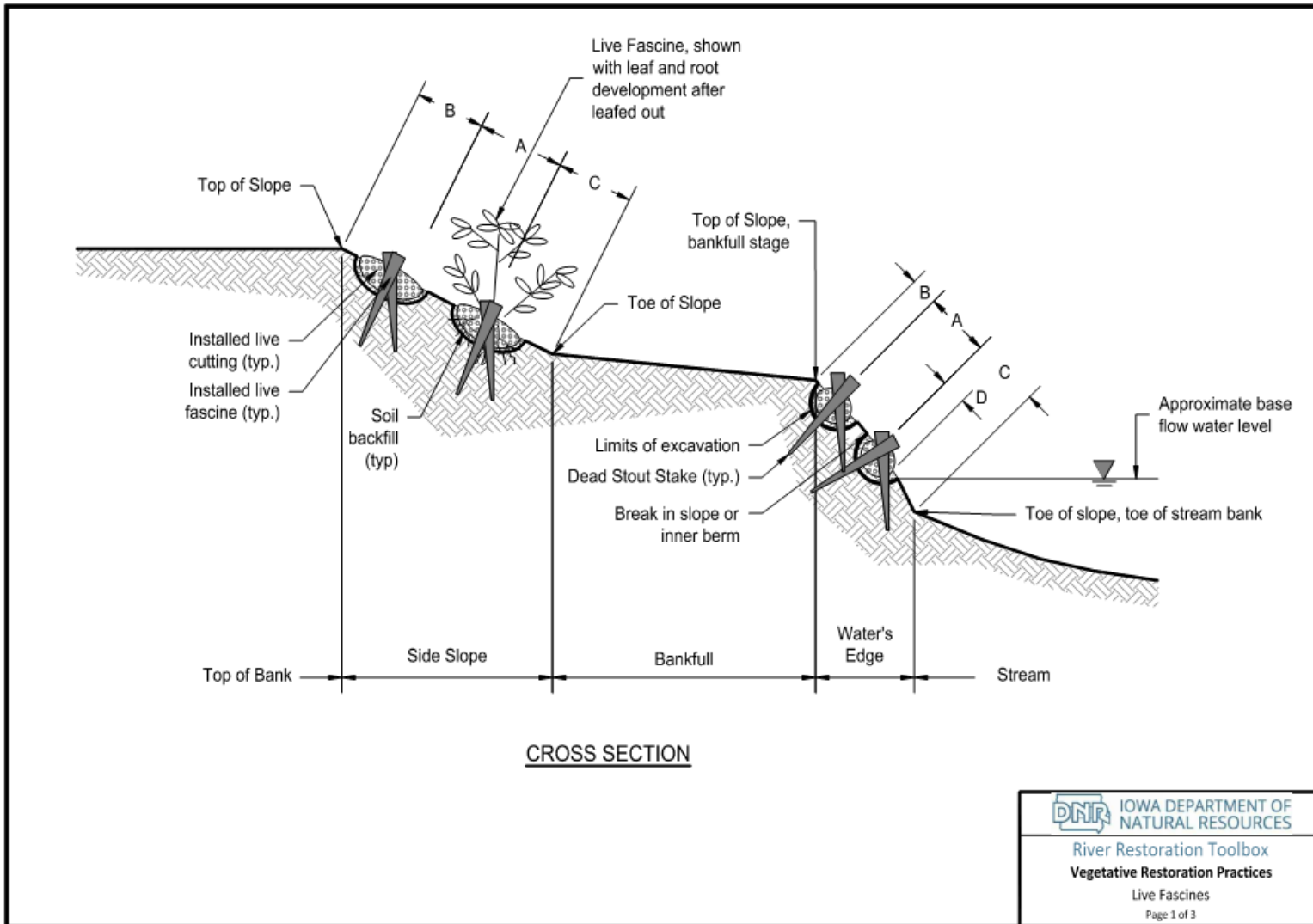
1. Data are for live fascines in bare soil and in soil covered with erosion control matting.
2. Dimension labels are referenced in the detail drawings.
3. Common guidance, values, or ranges are given unless they require computation using site-specific input.



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## Drawing 2. Live Fascine

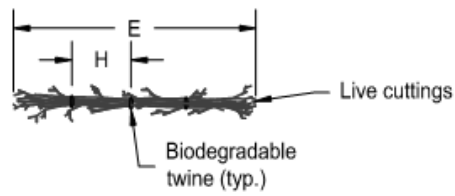


Version 1.0 5/24/2017

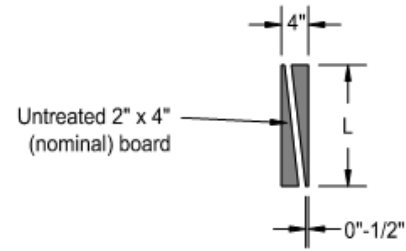


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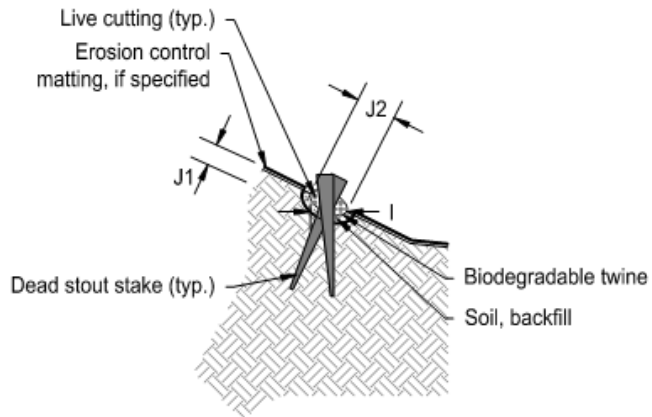
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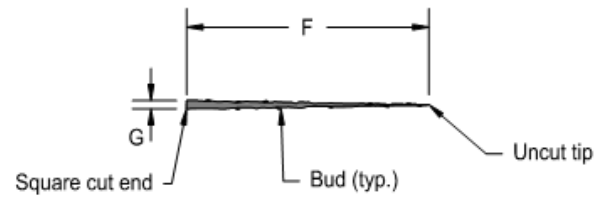
LIVE FASCINE DETAIL



DEAD STOUT STAKE DETAIL



INSTALLED LIVE FASCINE DETAIL



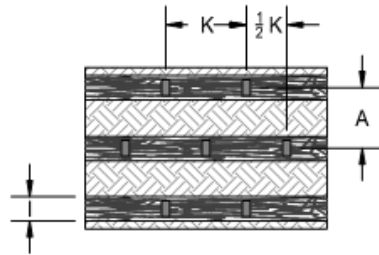
LIVE CUTTING DETAIL

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Vegetative Restoration Practices  
Live Fascines  
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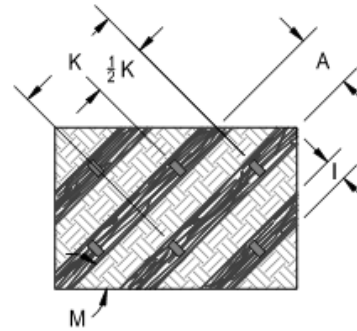
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LIVE FASCINE ON CONTOUR  
PATTERN DETAIL



LIVE FASCINE ON ANGLE  
PATTERN DETAIL



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### 2.2.4 Specifications

In addition to the information presented in Section 1.0 Introduction, the following information should be developed into specifications to accompany the use of live fascines:

- Materials:
  - Dormant live cuttings of acceptable species and size. Cuttings should be straight, long, and slender branches. Dead branches may be combined into the bundle if they are not brittle.
  - Dead stout stakes - Wooden 2" x 4" boards, cut on a diagonal, to firmly anchor the bundle into the trench. As a variation, live stakes can be used in combination with dead stout stakes to help secure the live fascines
  - Biodegradable twine
  - Fertilizers and/or other soil amendments as required based on site conditions.
- Equipment/Tools:
  - While the installation of live fascines is typically accomplished by handwork, a small backhoe may be used to dig the required trenches, depending upon the size and scale of the project and the required diameter of the live fascine.
  - Scissors, machete, hand pruners, loppers, hand saw, or other cutting tools
  - Round tip shovel
  - Hammer and/or sledge hammer
- Sequence:
  - Prepare fascines:
    - Leave side branches intact. Stagger the live cuttings in a uniform bundle built to a diameter specified. Vary the orientation of the cuttings. 8- to 10-foot-long bundles can be prepared for ease of moving from the preparation area to the installation site. They can be spliced together to create a fascine long enough to fit the project site.
    - In the vertical bundle variation of a live fascine the cuttings are oriented in one direction so the cut ends can be placed in the water.
    - Tie bundles with twine at specified intervals.

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- Toe protection installation:
  - For toe protection on contour:
    - Start installation from a stable point at the upstream end of the unstable stream bank toe.
    - Excavate a trench at the toe of bank.
    - Align the fascine along the toe of the bank and place it into the trench.
    - Fasten the fascine into the trench with dead stout stakes pushed directly through the bundle at the spacing specified. Allow the stake to protrude 2 inches above the top of the bundle. A variation to improve depth of reinforcement and rooting, involves installing live stakes just below (downslope) and in between the previously installed dead stout stakes, leaving approximately 3 feet protruding from the finished ground.
    - Cover the fascine with soil, ensuring good soil-to-stem contact. Wash it with water to get soil around the inner stems of the bundle. Some of the bundle should remain exposed to sunlight to promote sprouting.
    - When using erosion control matting between the fascine bundles, the matting is first placed in the bottom of the trench, an inch of soil is placed on top and up the sides of the trench and erosion control matting, and the fascine bundle is then placed in the trench and staked down (NRCS 2007a).
  - For toe protection with vertical bundles: Fascines can be oriented perpendicular to the stream bank contours with the cut ends in the water. This practice is often called the “vertical bundle method.”
- Slope protection installation:
  - Start installation at the toe of the bank and proceeds towards the top of bank.
  - Remove loose, failed, or failing soil from surface of the bank and smooth.

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- Align the fascine along the contour for dry banks. Place the fascine bundle at angle specified along wet slopes to facilitate (capture and direct) drainage.
  - Excavate a trench to the width and depth specified.
  - Place the bundle in the trench and fasten with dead stout stakes. Install dead stout stakes directly through the bundle at the specified spacing. The top of the stakes should protrude 2 inches above the top of the bundle. A variation to improve depth of reinforcement and rooting involves installing live stakes just below (downslope) and in between the previously installed dead stout stakes, leaving approximately 3 feet protruding from the finished ground.
  - Cover the fascine with soil, ensuring good soil-to-stem contact. Wash it with water to get soil around the inner stems of the bundle. Some of the bundle should remain exposed to sunlight to promote sprouting.
  - When using erosion control matting between the fascine bundles, the matting is first placed in the bottom of the trench, an inch of soil is placed on top and up the sides of the trench and erosion control matting, and the fascine bundle is then placed in the trench and staked down (NRCS 2007a).
- Workmanship:
    - All cuts should be clean and smooth.
    - No cracked or split live stakes should be used.
    - The fascines and/or dead stout stakes should not protrude from the banks to a degree such that they reduce the cross-sectional area of the stream.
    - Some of the fascine should be exposed to sunlight to promote sprouting.
    - It is important to ensure that the upstream and downstream ends of the live fascine installed tie-in smoothly into the undisturbed bank outside of the project area.
  - Equipment:
    - Sledge hammer or a rubber mallet or dead blow hammer if lives stakes are used as anchors.

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- Hand pruners, loppers, hand saw, and/or chain saw
  - Shovel
- Maintenance: Fascine growth may require protection from beaver, deer, cattle, or other predators. Various types of deer-proof fencing or fine wire screen or mesh can be secured around the cuttings to offer protection. If the area is grazed, restrict livestock from the project site.

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### 2.2.5 Photographs



**Photo 13.** Prepared fascines. Source: Unknown



**Photo 14.** Prepared fascine. Source: Unknown



**Photo 15.** Cuttings stored in water before made into fascines. Source: Charlotte-Mecklenburg Storm Water Services



**Photo 16.** Fascines placed at angles and on contours. Source: Charlotte-Mecklenburg Storm Water Services



**Photo 17.** Fascines with new growth. Source: Charlotte-Mecklenburg Storm Water Services



**Photo 18.** Installed fascine. Source: Stantec



### 2.3 BRUSH LAYERING

#### 2.3.1 Narrative Description

Brush layering is a soil bioengineering technique that consists of alternating layers of dormant live cuttings (brush) and soil, and can be used to rebuild or to stabilize a stream bank. The brush provides internal slope stabilization to counter shallow soil slides and frictional resistance to shear stress generated by water flowing against the slope like conventional geotextile slope reinforcement products and erosion control matting. Brush layering provides short-term protection against surface erosion and slope failure; in the long-term, roots grow along the stems of the material and help bind the soil together. In addition, the protruding cuttings reduce the lengths of long slopes, helping to reduce erosion due to surface runoff. Furthermore, the brush layers act as horizontal slope drains, helping to stabilize saturated slopes.

Brush layering on an existing slope can be undertaken by landowners. Often however, a lack of vegetation on stream banks is due to unstable conditions; analysis and design by a professional may be required to stabilize the stream bank and reestablish vegetation.

#### 2.3.2 Technique Information

- **Use:** Brush layering protects slopes from shallow slides and surface erosion, and re-establishes native vegetation.
- **Other uses:** In addition to short- and long-term erosion control and slope stability, brush layering will mature into streamside vegetation and provides numerous other benefits. For example, the vegetative growth from brush layering increases the amount and quality of riparian habitat for birds, mammals, and other terrestrial animals by providing food and cover, and improves in-stream habitat and water quality for fish and other aquatic organisms through reducing water temperatures by providing shade. The roots of woody plants also aid with the uptake of excess nutrients in storm water runoff, especially nitrogen. During high flows, the vegetation also provides fish and other aquatic organisms with refuge from high velocities.
- **Best applications:**
  - Brush layering requires large amounts of live cuttings and is best undertaken at sites with an adequate supply of suitable species for on-site harvesting.
  - Brush layering is limited to shallow bank slope excavations and should be constructed on a stable foundation (NRCS 2007a); toe protection may be required at a brush layering site.
  - Bare areas on stable slopes.



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- **Variations:**
  - A variation of brush layering is branch packing. Branch packing adds a matrix of vertical posts in the brush layers. Branch packing is typically used to repair small, scoured-out stream banks and slope failures only.
  - Brush layers separated by geotextile-wrapped soil lifts is called vegetated geogrid. Vegetated geogrids are suitable in high shear stress, outside bend, steep stream banks.
- **Computations:** Computations are generally not necessary for landowners using brush layering to revegetate bare areas on otherwise stable stream banks. However, planting vegetation adjacent to streams can adversely impact the local hydraulics, sometimes deflecting currents adversely, catching debris and causing blockages, or increasing roughness and causing increases in flood stage.

For stream restoration projects, brush layering requires design by a professional.

Hydrologic and hydraulic computations aid in verifying that the appropriate conditions exist for use of brush layering. Geometric calculations are required to properly size and situate the vegetative structure within the context of its individual location. Hydraulic analysis is required to determine where to place brush layering on the slope, how the above-ground growth will distribute energy at various flow stages, and to verify that the velocities and shear stresses generated by streamflow do not exceed the permissible velocity and tensile strength of the vegetative structure.

Brush layering properties: Depending on adequate anchoring, brush layering is cited in NRCS 2007a as having an initial permissible velocity of 2-4 ft/s; permissible velocity increases to over 10 ft/s once vegetation is established. NRCS also cites initial permissible shear stress of 0.2 – 1 lbs/ft<sup>2</sup>; permissible shear stress increases to 2.6 lbs/ft<sup>2</sup> to over 6 lbs/ft<sup>2</sup> once vegetation is established.

- **Key Features:**
  - Brush layering requires the use of woody riparian plant species that root easily from dormant live cuttings.
  - Dormant live cuttings are layered in a crisscross pattern in three courses on one or more benches excavated in the stream bank.
- **Cautions:**
  - Planting vegetation adjacent to streams can adversely impact the local hydraulics, sometimes deflecting currents, catching debris and causing blockages, or increasing roughness and causing increases in flood stage.

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- o Vegetation alone will likely be unsuccessful on steep bank slopes without sufficient shaping.

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### 2.3.3 Detail Drawings and Data Table

The following drawings and data table depict information that should be included in construction plans for brush layering. The data table includes design guidelines and sources, where applicable.

**Table 3. Required Design Data for Brush Layering<sup>1</sup>**

Dimension <sup>2</sup>	Name	Typical Unit	Guidelines <sup>3</sup>	Description
A	Brush layer course spacing	Inches	3-5" (NRCS 2007a)	Amount of soil between each of three courses of brush and live cuttings that form the brush layer
B	Brush layer – top of slope placement	Feet, inches	--	Position of brush layer bench relative to the top of a slope.
C	Brush layer – toe of slope placement	Feet, inches	--	Placement of brush layer bench relative to the toe of a slope.
D	Brush layer – base flow relationship	Feet, inches	--	Position of brush layer bench relative to the approximate base flow water level with consideration given to duration of inundation during bankfull and other high flow events.
E	Bench excavation width	Feet	2-3' (NRCS 2007a)	Width of excavation of bench onto which the layers of brush and live cuttings and soil will be layered. Square-cut end (not the uncut growing tip) of the live cuttings should touch the back of the excavation.

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**Table 3. Required Design Data for Brush Layering<sup>1</sup>**

Dimension <sup>2</sup>	Name	Typical Unit	Guidelines <sup>3</sup>	Description
F	Brush and live cutting diameter	Inches	3/4" – 3" (NRCS 2007a)	Diameter of brush and live cutting from woody plant to be used in brush layer – typically cite a permissible minimum and maximum diameter
G	Brush and live cutting length	Feet	3' – 6' (NRCS 2007a)	Length of brush and live cutting from woody plant to be used in brush layering
H	Brush and live cutting protrusion	Inches	6" – 18" (NRCS 2007a)	Distance installed brush and live cuttings should protrude from the slope.
I	Brush and live cutting density	Branches per linear foot	15-45 branches per foot (NRCS 2007a)	Install the brush layer in three courses with the first layer oriented to the right, the second layer oriented to the left, and the third layer pointing straight out of the slope. The finished brush layer has 15-45 branches per linear foot; 5-15 should be live cuttings.
J	Bench excavation slope	Degrees	15-25° (NRCS 2007a)	Slope of bench excavation down from the front outer edge to the back of the excavation.

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**Table 3. Required Design Data for Brush Layering<sup>1</sup>**

<b>Dimension<sup>2</sup></b>	<b>Name</b>	<b>Typical Unit</b>	<b>Guidelines<sup>3</sup></b>	<b>Description</b>
K	Bench spacing	Feet	3-5' (NRCS 2007a)	Bench spacing is the distance between benches on which the brush is layered. Bench spacing varies based on slope and whether soil conditions are wet or dry.

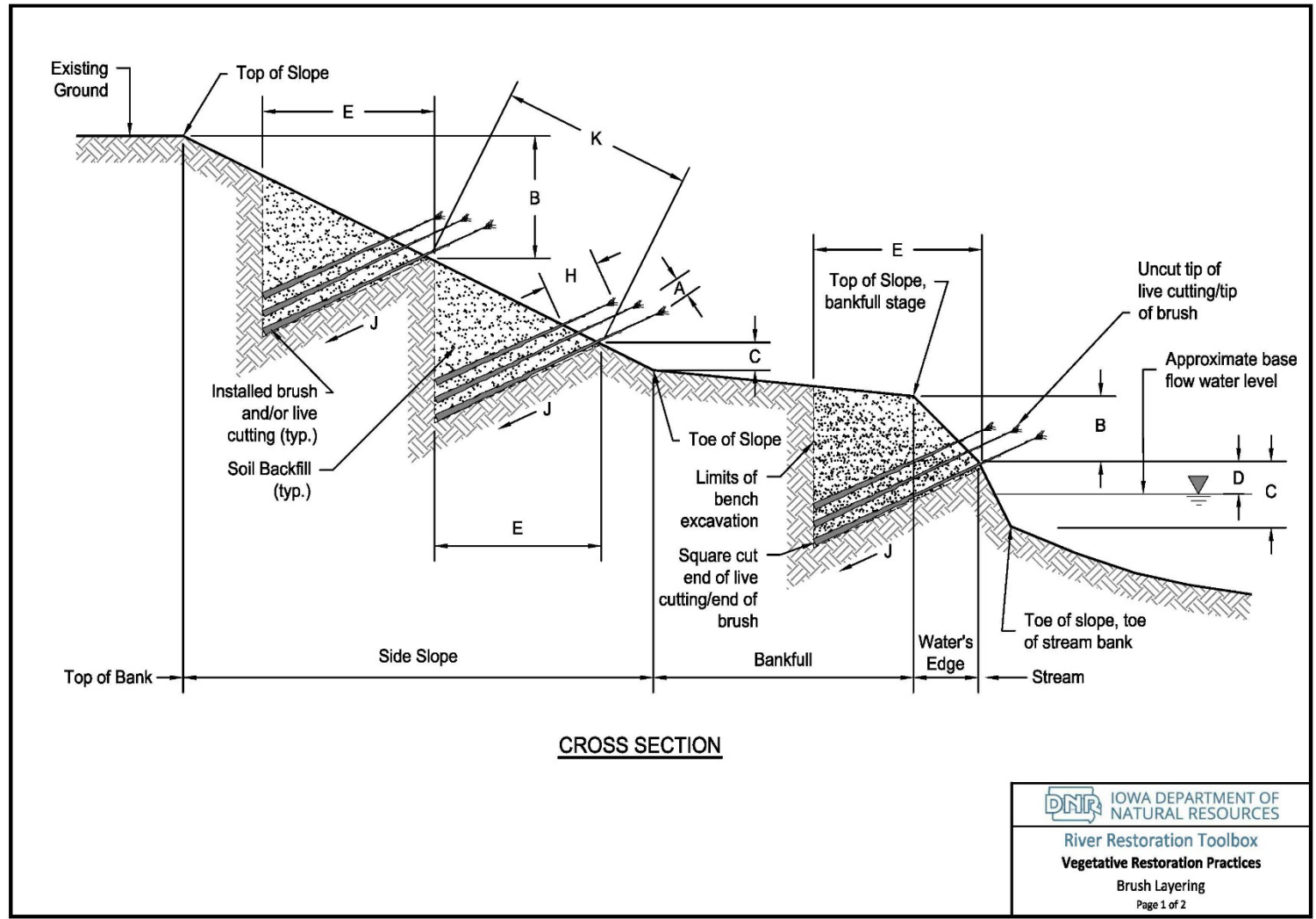
Notes:

1. Data are for brush layering in bare soil.
2. Dimension labels are referenced in the detail drawings.
3. Common guidance, values, or ranges are given unless they require computation using site-specific input.

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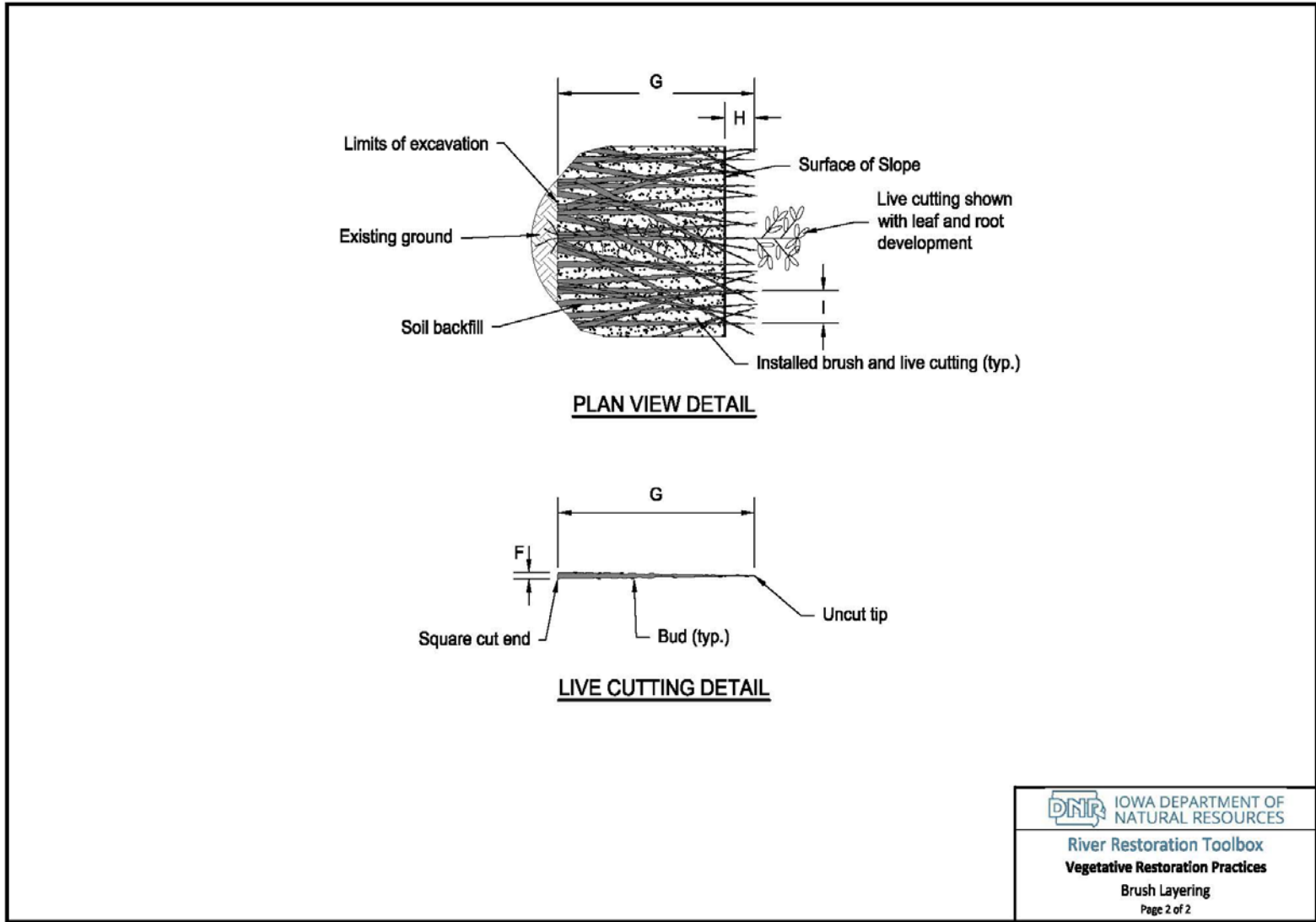
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## Drawing 3. Brush Layering



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### 2.3.4 Specifications

In addition to the information presented in Section 1.0 Introduction, the following information should be developed into specifications to accompany the use of brush layering:

- Materials:
  - Brush
  - Dormant live cuttings from acceptable species and cut to size
- Equipment/Tools:
  - Machete, clippers, saw, hammers, chainsaw, and/or loppers
  - Shovel and/or machinery to excavate and level benches
- Sequence:
  - Prepare live cuttings to the size specified.
  - Remove loose soil from face of the slope.
  - Start installation from the toe of the slope while working upslope along the bank.
  - Excavate benches.
  - Place branches in overlapping and crisscross configuration in three courses, separated by soil. Repeat until desired thickness is reached. Compact backfill to remove air pockets.
  - Orient the stems such that the basal ends touch the back of the undisturbed slope. Approximately  $\frac{1}{4}$  of the branch stem should extend beyond outside of each brush layer.
  - Trim the terminal bud so that stem energy will be routed to the lateral buds for more rapid root and stem sprouting.
- Workmanship:
  - All cuts should be clean and smooth.
  - No cracked or split live stakes should be used.
  - The finished surface of the brush layering should be generally in accordance with the lines, grades, cross sections, and elevations of the design.



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- It is important to ensure that the upstream and downstream ends of the brush layering tie-in smoothly into the undisturbed bank outside of the project area.
- Maintenance: Brush layering growth may require protection from beaver, deer, cattle, or other predators. Various types of deer-proof fencing or fine wire screen or mesh can be secured around the cuttings to offer protection. If the area is grazed, restrict livestock from the project site.

2.3.5 Photographs



**Photo 19.** Brush Layering with soil wrap used to stabilize a stream bank. Source: Salix Applied Earth Care



**Photo 20.** Brush layering, including soil wrap, Whiskeytown Lake, CA. Source: Salix Applied Earth Care



**Photo 21.** Brush layering, including soil wrap, Whiskeytown Lake, CA. Source: Salix Applied Earth Care



**Photo 22.** Brush layering, including soil wrap, Whiskeytown Lake, CA. Source: Salix Applied Earth Care



**Photo 23.** Bench excavation for brush layering. Source: Stantec



**Photo 24.** Brush layering with soil wrap, Raleigh, NC. Source: KCI

## 2.4 EROSION CONTROL MATTING

### 2.4.1 Narrative Description

Erosion control matting is used to temporarily stabilize and protect disturbed soil from erosion due to surface water runoff, to improve moisture retention, and protect newly planted seed from washing away and being consumed by animals. The mattings are manufactured from a variety of biodegradable and/or non-biodegradable materials, including coconut fiber (coir), jute, hemp, wood excelsior (shavings), and/or straw mulch. Natural, biodegradable materials are preferred in stream restoration applications.

Erosion control matting is typically placed on the surface of soil slopes and fastened with biodegradable stakes, preferably wood. Woody cuttings and herbaceous plants can be planted through the matting; seed and topsoil can be placed underneath. Erosion control matting stabilizes stream banks and other slopes until vegetation takes root.

Lack of vegetation on stream banks is often due to unstable conditions; analysis and design by a professional may be required to stabilize the stream bank and select and design appropriate erosion control matting.

### 2.4.2 Technique Information

- **Use:** Intended to temporarily stabilize and protect disturbed soil from erosion due to surface water runoff until vegetation can be established.
- **Other uses:** Creates advantageous microclimate and protects newly planted seeds from washing away and being consumed by animals. In addition, covering seeded areas with erosion control matting can increase the germination rates for grasses and legumes, and assist vegetation establishment. Erosion control matting can also reduce desiccation and evaporation by insulating the soil.
- **Best applications:** Erosion control matting should be used in areas where the risk of soil loss exists due to earth-disturbing activities. Application should adhere to the slope and shear stress constraints published by the product manufacturer. Erosion control blankets are not intended for use in low-flow channels.
- **Computations:** Hydrologic and hydraulic computations aid in verifying that the appropriate conditions exist for use of erosion control matting. Geometric calculations are required to properly size and situate the matting within the context of its individual location. Hydraulic analysis is required to determine where to place erosion control matting on the slope, how the matting and the intended vegetative growth will distribute energy at various flow stages, and to verify that the velocities and shear stresses generated by streamflow do not exceed the permissible velocity and tensile strength of

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the product used. Erosion control matting manufacturers provide permissible velocity and allowable shear stress information for their products.

- **Key Features:**

- A manufactured matting (e.g., a spun or woven fabric typically supplied in rolls) is used to cover soil.
- Erosion control matting is fastened into trenches at the top and bottom of slopes and is also fastened throughout with stakes.
- Erosion control matting can be placed over seeded and mulched soil. Live stakes can be installed through erosion control matting.

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### 2.4.3 Detail Drawings and Data Table

The following drawings and data table depict information that should be included in construction plans for erosion control matting. The data table includes design guidelines and sources, where applicable.

**Table 4. Required Design Data for Erosion Control Matting<sup>1</sup>**

Dimension <sup>2</sup>	Name	Typical Unit	Guidelines <sup>3</sup>	Description
A	Matting stake spacing	Feet, inches	Varies; typically, 6-12", maximum spacing of 18"; based on manufacturer's specification for site conditions (SUDAS 2017).	Spacing between erosion control matting stakes used to fasten the matting to the soil
B	Matting overlap	Feet, inches	Varies; typically, 3-8", based on manufacturer's specification for site conditions (SUDAS 2017)	Amount of erosion control matting overlap if multiple pieces and/or rolls of matting are used. Overlap varies depending on the location of the overlap with respect to position on the slope, location of the matting (edge or end), and product specifications.
C	Matting anchor trench depth	Feet, inches	Varies; 4" minimum, based on manufacturer's specification for site conditions (SUDAS 2017)	Depth of trench into which edge of erosion control matting is anchored at the top and/or toe of a slope.
D	Matting anchor trench width	Feet, inches	Varies; 4" minimum, based on manufacturer's specification for site conditions (SUDAS 2017)	Width of trench into which edge of erosion control matting is anchored at the top and/or toe of a slope.

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**Table 4. Required Design Data for Erosion Control Matting<sup>1</sup>**

Dimension <sup>2</sup>	Name	Typical Unit	Guidelines <sup>3</sup>	Description
E	Top of slope anchor trench setback	Feet, inches	--	Top of slope anchor trench distance from the top of slope. Top of slope refers to top of side slope, bank slope, terrace slope, bankfull, etc.
F	Matting stake length	Inches	Varies; typically, a minimum of 6", based on manufacturer's specification for site conditions (SUDAS 2017)	Length of erosion control matting stakes or staples used to fasten the matting to the soil

Notes:

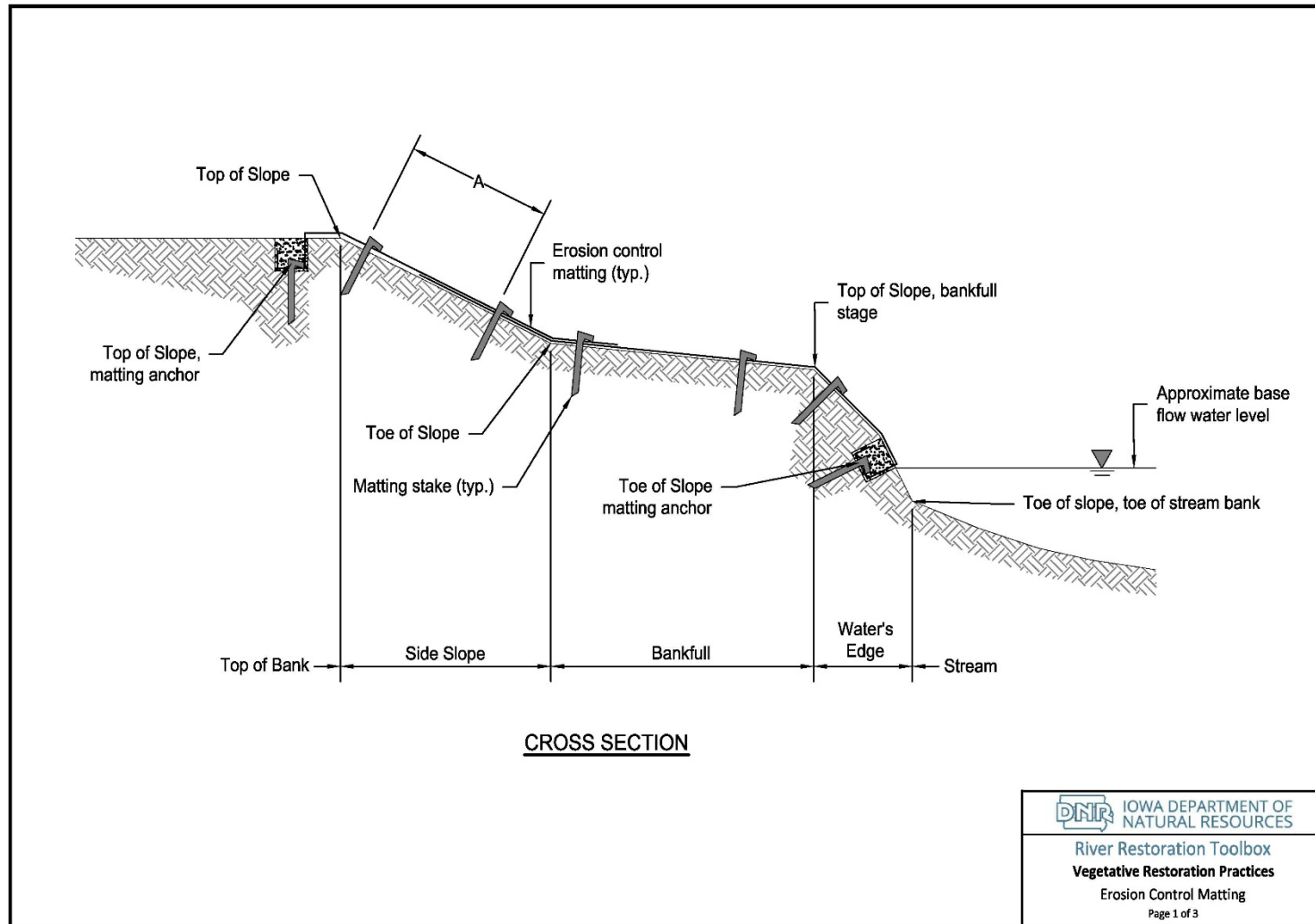
1. Data are for erosion control matting applied to stream bank slopes.
2. Dimension labels are referenced in the detail drawings.
3. Erosion control manufacturer's guidelines should be followed, based on type of matting used and conditions at the site.



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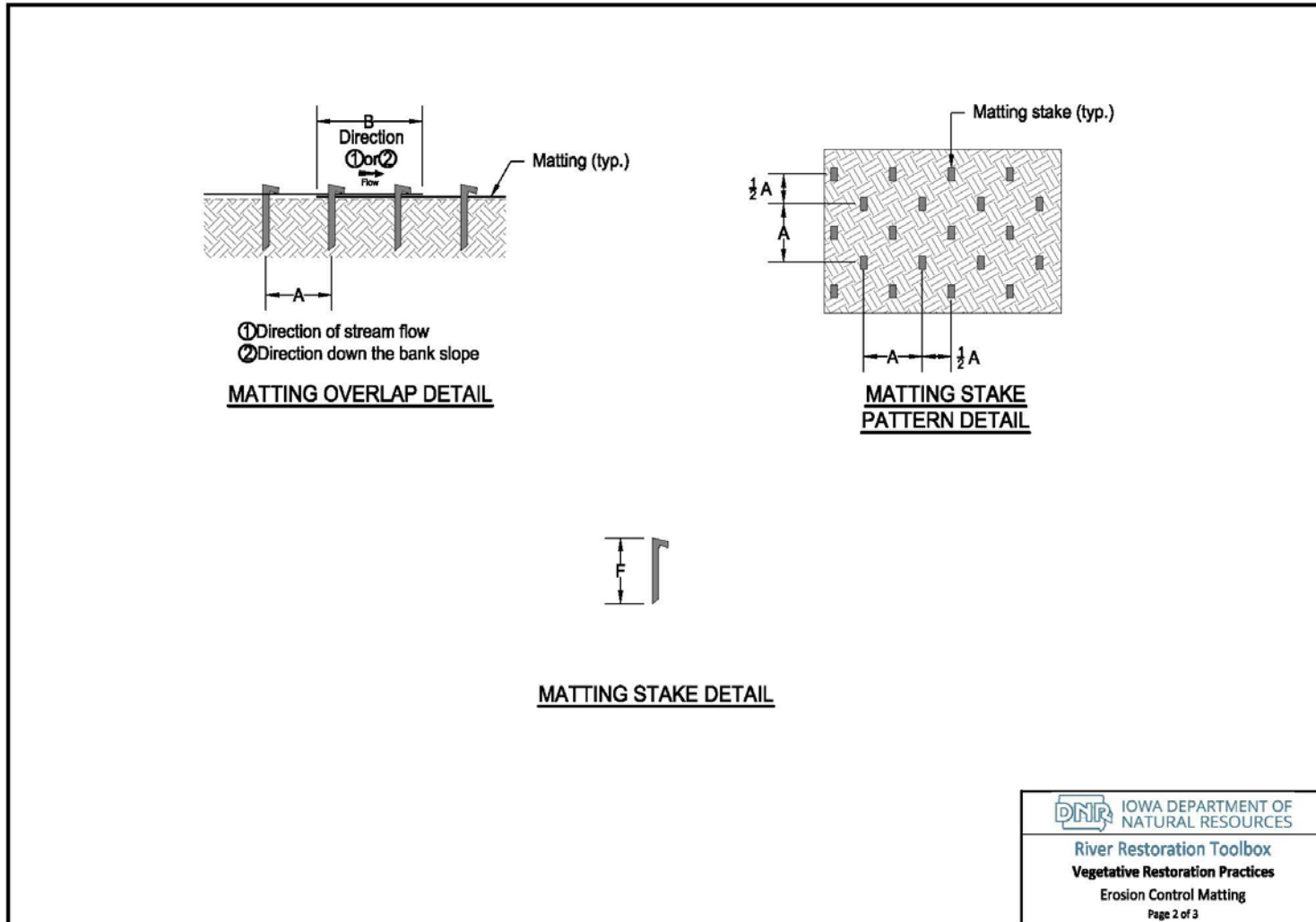
## Drawing 4. Erosion Control Matting



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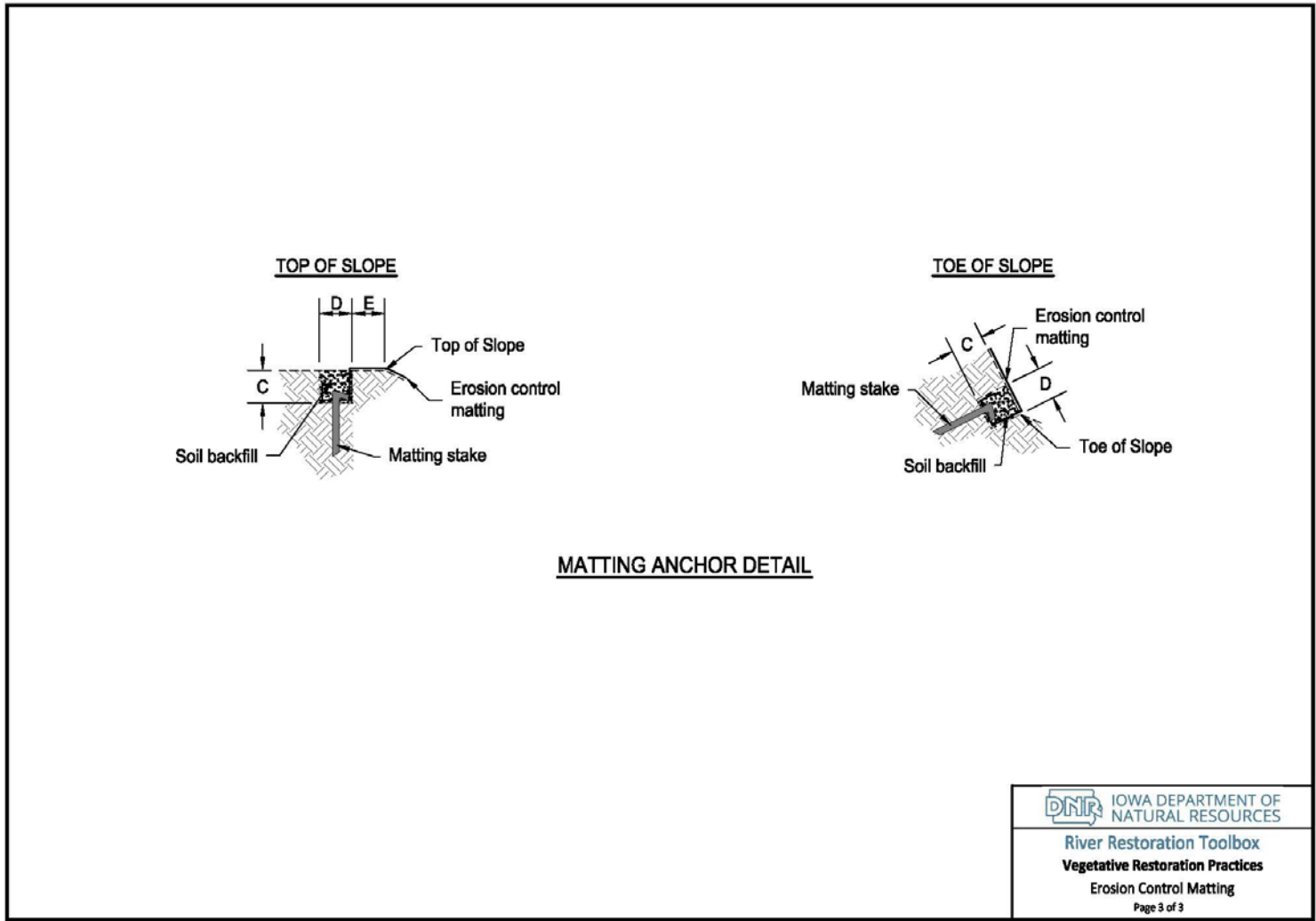
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### 2.4.4 Specifications

In addition to the information presented in Section 1.0 Introduction, the following information should be developed into specifications to accompany the use of erosion control matting:

- Materials:
  - Erosion control matting
  - Wedge-shaped wooden stakes and/or metal or biodegradable staples, depending on the manufacturer's specifications
- Equipment/Tools:
  - Heavy equipment is typically unnecessary when installing erosion control matting.
  - Shovel
  - Rubber mallet or hammer
  - Scissors, boxcutter, or other cutting tool
- Sequence:
  - Grade the exposed earthen surface and remove all debris.
  - Compact the exposed earthen surface to the desired amount.
  - Amend soils as necessary.
  - Seed the exposed surface with native herbaceous seed and rake to ensure good seed-soil contact.
  - Excavate a trench along the toe of the slope and along the top of the bank.
  - Excavate a trench at the upstream end that is perpendicular to the flow (key trench) and connect to the ends of the other trenches.
  - Place the ends of the matting on the stream bank with the ends of the matting in the trench so that the matting is touching the three sides of the trench. Secure the matting to the bottom of the trench by using a wedge-shaped wooden stake.
  - Cover the rest of the stream bank with the matting, making sure that the edges of each mat overlap and are shingled away from the direction of flow. Each

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overlap should be secured with wedge-shaped wooden stakes or staples, depending upon the manufacturer's specifications. In addition, secure the blanket to the slope according to the manufacturer's specifications. It is important to secure the upstream end of the mat by keying it into the final trench.

- Backfill the trenches with excavated soil or small cobble and compact it.
- Workmanship:
  - The finished surface of the erosion control matting should not have any voids, or matting that has not been properly anchored into the stream bank.
  - All trenches need to be compacted, especially the trenches that are perpendicular to the flows along the upstream and downstream edges of the project site.
  - There should be no loose ends of erosion control matting.
  - It is important to ensure that the upstream and downstream ends of the erosion control matting are keyed into the bank to prevent the matting from becoming unraveled during high flows.
  - It is critical that the matting maintain contact with the soil during a high flow event. If the matting separates from the soil by more than an inch under a reasonable tug additional staking is necessary.
  - If possible, avoid disturbing installed erosion control matting.

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### 2.4.5 Photographs



**Photo 25.** Top of slope trench for erosion control matting anchor. Source: Collins & Baker Engineering



**Photo 26.** Erosion control matting installed on a slope. Source: Salix Applied Earthcare



**Photo 28.** Erosion control matting. Source: Salix Applied Earthcare



**Photo 29.** Erosion control matting installed on slope. Source: Iowa DNR



**Photo 27.** Erosion control matting with seed growing through. Source: Charlotte-Mecklenburg Storm Water Services



**Photo 30.** Erosion control matting being rolled onto a stream bank. Source: Collins & Baker Engineering

### 2.5 SOD MATTING

#### 2.5.1 Narrative Description

Sod matting consists of large pieces of intact wetland soil and vegetation that has been removed from a donor site. Pieces of sod matting can be harvested from areas scheduled for demolition or other areas where material is available. Sod matting is used to provide channel bank stabilization where rock and/or logs are either not available or within context of the existing watershed conditions. The sod mats themselves provide initial channel bank stabilization, and the stabilization benefit is increased as the root systems grow deeper and denser. Sod matting is typically used in low-gradient stream systems where cohesive soils are present.

Installing sod mats on an existing slope can be undertaken by landowners. Often however, a lack of vegetation on stream banks is due to unstable conditions; analysis and design by a professional may be required to stabilize the stream bank and reestablish vegetation.

#### 2.5.2 Technique Information

- **Use:** Sod matting can be used for both immediate and long-term bank stabilization. Immediate stabilization is provided by the mass of the harvested sod mats and the vegetation growth already present. Long-term stability is increased when rooting depth increases and becomes denser.
- **Other uses:** Sod matting can be used in combination with other bank protection measures such as toe wood, root wads; stacking sod mats on top of these and other types of toe protection provides a natural transition between the toe protection structure and the stream bank slope. Vegetative cover can improve wildlife habitat along the stream corridor while also improving the aesthetics of a project site. Sod mats prevent erosion from storm water runoff and reduce sheet and rill erosion.
- **Best applications:**
  - Sites with an adequate supply of sod with suitable species for sod mats
  - Transitions between in-stream and/or toe protection structures and stream banks.
  - Bare areas on existing stable slopes and stream banks or slopes and banks recently graded to a stable angle (e.g. - as part of a stream restoration project)
  - Areas on the floodplain where restoration activities are proposed
- **Computations:** Computations are generally not necessary for using sod mats to revegetate bare areas on otherwise stable stream banks. However, hydrologic and hydraulic computations can aid in verifying that the appropriate conditions exist for use

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of sod mats and whether a combination of other bank protection methods may be necessary.

- **Key Feature:** Sod mats are harvested at a site, usually in a proximity to the work, and placed on stream banks providing immediate vegetative cover of bare soils.

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### 2.5.3 Detail Drawings and Data Table

The following drawings and data table depict information that should be included in construction plans for sod matting. The data table includes design guidelines and sources, where applicable.

**Table 5. Required Design Data for Sod Matting<sup>1</sup>**

Dimension <sup>2</sup>	Name	Typical Unit	Guidelines <sup>3</sup>	Description
A	Sod mat width	Feet	Sod mats should generally be about 8 sq. ft and 6-8" thick, depending on the type of equipment used to excavate them (NRCS 2008).	Width of individual sod mat.
B	Sod mat length	Feet	Sod mats should generally be about 8 sq. ft and 6-8" thick, depending on the type of equipment used to excavate them (NRCS 2008).	Length of individual sod mat.
C	Sod mat thickness	Inches	6" – 8" (NRCS 2008)	Thickness of individual sod mat.
D	Stacked sod mat setback	Feet, inches	--	The distance between the edges of sod mats stacked to form a slope
E	Width of stacked sod mats	Feet, inches	--	Width of a bank created by stacked sod mats



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Dimension <sup>2</sup>	Name	Typical Unit	Guidelines <sup>3</sup>	Description
F	Height of stacked sod mats	Feet, inches	Harvested sod mats should be placed in a matching hydrological zone similar to the donor site.	Height of a slope created by stacked sod mats
G	Width of surface-applied sod mats	Feet, inches	--	Width of a slope stabilized with surface-applied sod mats
H	Top of bank sod matting distance	Feet	Harvested sod mats should be placed in a matching hydrological zone similar to the donor site.	Distance sod matting is installed on the top of bank

Notes:

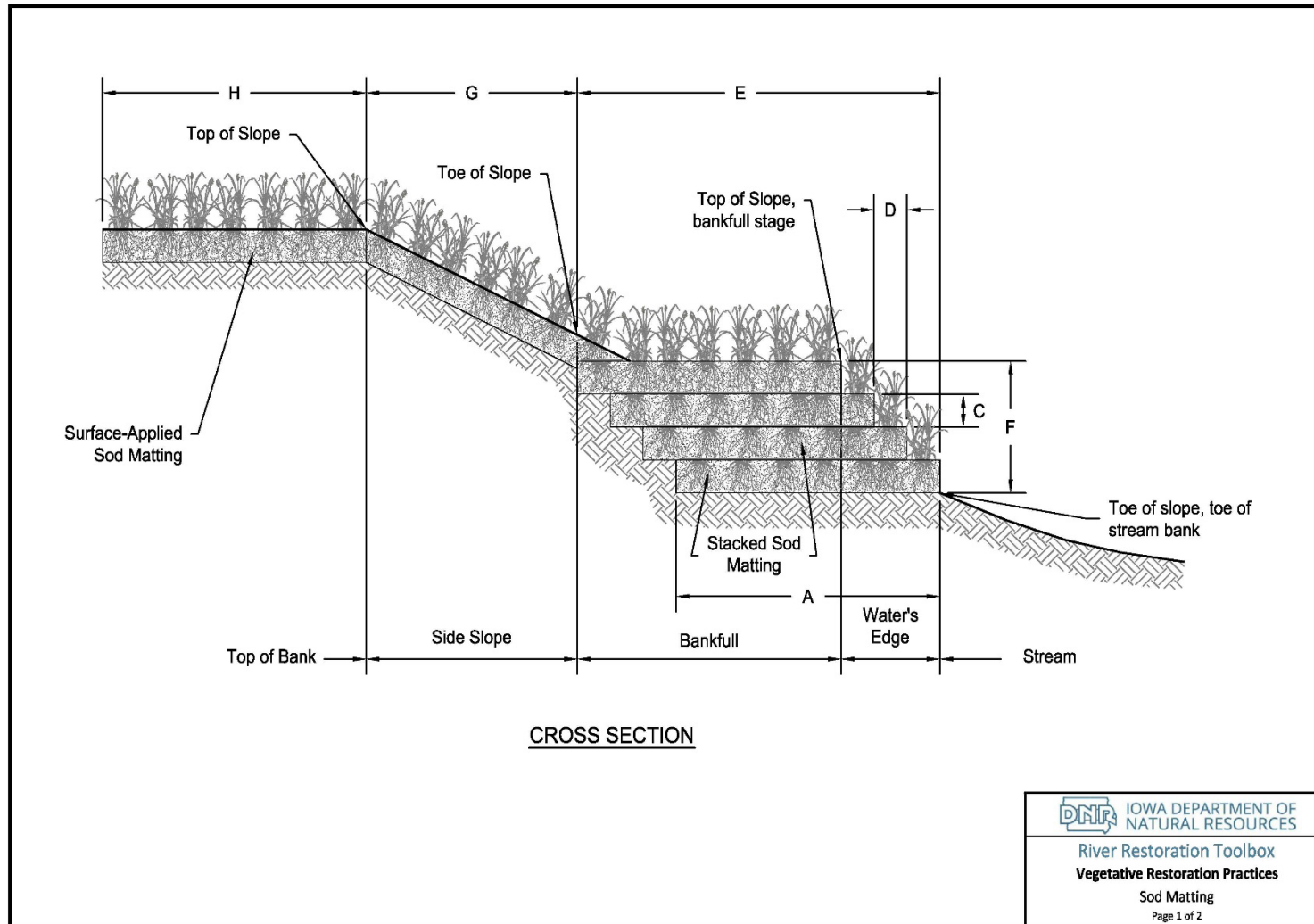
1. Data are for sod matting that is stacked to form a slope or surface-applied to a slope.
2. Dimension labels are referenced in the detail drawings.
3. Common guidance, values, or ranges are given unless they require computation using site-specific input.



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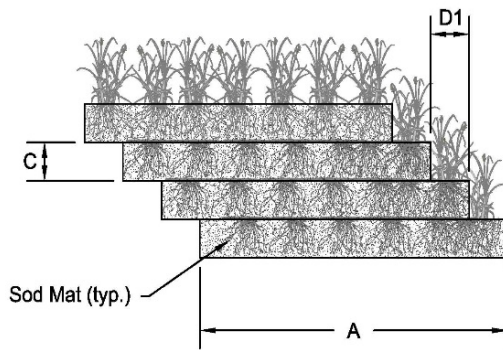
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## Drawing 5. Sod Matting

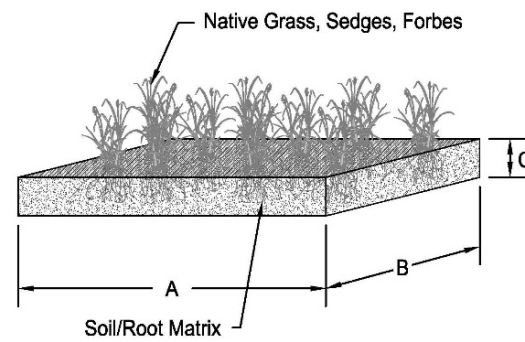


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STACKED SOD MATTING DETAIL



SOD MAT DETAIL

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### 2.5.4 Specifications

In addition to the information presented in Section 1.0 Introduction, the following information should be developed into specifications to accompany the use of sod matting:

- Materials
  - Donor site that contains an adequate supply of sod mats
  - Backhoe or front-end loader, wheel barrow, flatbed truck or trailer
  - Round and/or square tipped shovels
  - Wooden stakes
- Equipment:
  - A backhoe or front-end loader with a sharp-edged steel plate. A front-end loader can harvest uniform sod squares. The backhoe can harvest quickly, but yields uneven-edged mats.
- Sequence:
  - Identify location of sod mats to be harvested
  - Harvest sod mats from donor site with shovels, backhoe, or a modified front-end loader that contains a sharp-edged steel plate that undercuts the sod for safe and effective removal.
  - Depending upon the project size, load sod mats into a wheel barrow or onto a flatbed truck, or trailer and transport them to the work site.
  - Place the sod mat within the proper hydrologic zone, fitting them tightly against one another.
  - The top mat and/or other mats can be anchored with a live and/or dead stout stake to ensure that it does not mobilize during a flood event before the roots have established.
- Workmanship:
  - It is easiest to harvest sod mats when the soils are moist, yet well drained at the time of the cutting.
  - Sod mats can be stored on site if they are kept moist.

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- When transporting sod mats long distances, maintain moisture levels so that they do not become dried out.
- The sod mat should be placed into the same hydrologic zone as where it was harvested.
- When placing sod mats, do not leave large gaps between each sod mat as non-native vegetation will quickly attempt to colonize these voids.
- Sod mats can be transplanted during any season if there is sufficient moisture in the soil where they will be placed.

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### 2.5.5 Photographs



**Photo 31.** Sod mat harvest with a front-end loader. Source: Buck Engineering



**Photo 32.** Sod mat placed to form stream bank. Source: Buck Engineering



**Photo 33.** Sod mat stacked over toe wood. Source: Stantec



**Photo 34.** Sod matting on outside of a meander bend. Source: Stantec



**Photo 35.** Sod matting on stream banks. Source: Stantec



**Photo 36.** Excavator placing sod matting. Source: Bluegrass Streams, LLC



## 2.6 SEEDING

### 2.6.1 Narrative Description

Seeding is a low cost, low labor method to stabilize soils that involves the establishment of permanent, perennial vegetative cover consisting of grass or forb seed mixes. Seeding can be used as a single approach to stabilize stream banks where erosion is minor, or used in combination with other erosion control techniques such as erosion control matting and soil bioengineering where erosion is moderate to severe. The use of native, indigenous grasses and forbs is required as these species have evolved in a manner that will allow the recruitment of naturally-occurring woody vegetation.

Seeding provides rapid stabilization of stream banks by producing a mass of fibrous roots in the upper soil layer; this mass of roots bind the soil together and serve as a barrier, protecting the soil surface from wind and water erosion. In addition, grass roots help to improve soil structure by increasing soil porosity and increasing organic material that helps bind soil particles.

Seeding on an existing slope can be undertaken by landowners. Often however, a lack of vegetation on stream banks is due to unstable conditions; analysis and design by a professional may be required to stabilize the stream bank and reestablish vegetation.

### 2.6.2 Technique Information

- **Use:** Seeding is used to quickly establish plant growth along a stream bank. This helps reduce surface erosion, slow flow velocities, and reinforce the soil. Seeding may be used as both temporary and permanent vegetative cover during a stream restoration.
- **Other uses:** Vegetative cover will improve wildlife habitat along the stream corridor, as well as the aesthetics of the project site. Seeding will also prevent erosion from storm flow and reduce sheet and rill erosion. Seeding can be used to increase organic matter on a site and improve existing soil conditions.
- **Best applications:**
  - Bare areas on existing stable slopes and stream banks or slopes and banks recently graded to a stable angle (e.g. - as part of a stream restoration project)
  - Seeding is best used when rich topsoil is readily available and the seedbed has been properly prepared. Restoration projects should include seeding to reduce construction and post-construction erosion rates.
  - While seeding should be used along areas typically experiencing low to moderate stream bank erosion rates, it can be used along the entire riparian corridor.

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- **Computations:** Computations are generally not necessary for using seeding to revegetate bare areas on otherwise stable stream banks. However, hydrologic and hydraulic computations can aid in verifying that the appropriate conditions exist for use of seeding and whether a combination of other bank protection methods may be necessary.
- **Key Features:**
  - Seeding can be used alone in cases of low flows, or in combination with other vegetative practices in cases of moderate to severe flows.
  - Native forb and/or grass seed mixes should be used.

### 2.6.3 Design Guidelines

- Proper seed selection can play a vital role in determining the success of this type of erosion control method. Choose local and climatically adapted perennial species that are long-lived, hearty, and require low inputs of fertilizer, irrigation, and mowing. Seed blends or mixtures should always be considered as they are more adaptable (Iowa DNR 2016).
- Use seeds that are appropriate to the season (i.e., warm-season plantings or cool-season plantings) and site conditions (Iowa Riverside Plant Selection 2016).
- Topsoil may be needed if the soil on the bank is not adequate.
- Use of mulch to cover seeds will prevent seeds from being blown or washed away and keep the soil surface moist.
- Native seed can be sown in the autumn directly into a cover crop of an annual grass. The annual grass provides a “living mulch” and will not out-compete the new growth of native grasses and forbs the following growing season.
- When deployed as a single technique, seeding alone will not stabilize the toe of a stream bank and it may not be an adequate approach to reduce existing stream bank erosion rates.

### 2.6.4 Specifications

In addition to the information presented in Section 1.0 Introduction, the following information should be developed into specifications to accompany the use of seeding:

- **Materials:**
  - Seed mix

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- Organic fertilizer, inoculant, and/or nitrogen, if needed.
- Hydraulic mulch, tackifier, dye, if needed.
- Equipment/Tools:
  - Heavy equipment used to prepare the seedbed include chisel plows, discs, and rototillers. Application of seed mixes can be accomplished using seed drills or hydroseeders, if compatible with site conditions.
  - Rakes and shovels can be used to prepare the seed bed of smaller sites.
  - Broadcast spreader
  - Buckets for hand seeding
- Sequence:
  - Examine the site's soil conditions to determine whether the soil fertility and pH levels needs to be amended to satisfy the needs of the specific plant species that was selected.
  - Select proper seed mix, depending upon the conditions of the project site and time of year the site will be planted. Factors may include shade vs. sunlight, habitat values, rooting depths, etc. (Iowa DNR 2016).
    - Any Time of Year: Ready-sprouting mix (Iowa DNR)
      - ½ Virginia Wild Rye
      - ½ Annual Rye Grass if planted between March – September
      - ½ Oat Grain or Winter Wheat if planted between October – February
  - Fall/Spring Planting: Incorporate Diversity Mix (Iowa DNR) into above application guidelines.
  - Determine seeding rates and density
  - Depending upon the site's soil conditions, till existing site, apply topsoil, inoculant, compost, etc.
  - Apply the seeding mix to the project site by applying a liquid seed mix that can mechanically be blown (hydroseeded) onto the site, or by hand-broadcasting the seed mix. Till or rake seeds to the depth required for each seed species.



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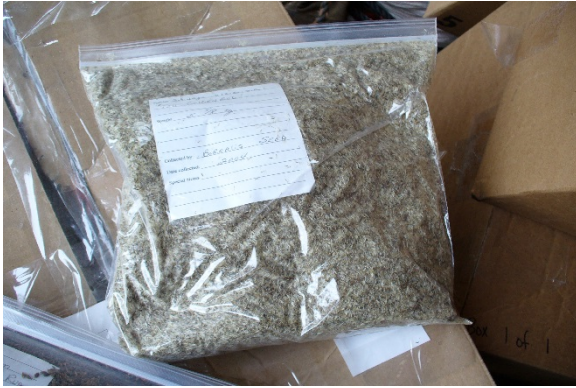
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- Apply a thin layer of mulch or install an erosion control mat over the newly seeded area, if possible. Erosion mats should form well to the banks to prevent loosening and floatation, consist of biodegradable woven material, and consist of a material opening to allow for sprouts to emerge.
- Workmanship:
  - Seeding should be done during low flow conditions.
  - Vegetation must have enough time to adequately root and grow before high flows occur on the project site.

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### 2.6.5 Photographs



**Photo 37.** Native seed. Source: Lake Superior Tree Farm



**Photo 38.** New growth of native grass stream buffer. Source: Charlotte-Mecklenburg Storm Water Services



**Photo 39.** Testing soil pH and moisture. Source: Collins & Baker Engineering



**Photo 40.** Apply mulch to seeded stream banks. Source: Buck Engineering



**Photo 41.** Cover crop on the Dead River, MI. Source: Collins & Baker Engineering



**Photo 42.** Native forb seed. Source: Lake Superior Tree Farm

### 2.7 NURSERY STOCK, BARE ROOT, VEGETATIVE PLUG, AND TRANSPLANTING

#### 2.7.1 Narrative Description

Nursery stock, bare roots, vegetative plugs, and the transplanting of carefully selected native plant material can provide immediate stream bank protection to an area of concern. The above-ground growth provides surface protection which continues to prevent surface erosion (e.g., rills, gullies). The growth also adds roughness to the stream bank, reducing the velocity of stream flow. The roots bind soil particles together and reinforce the soil mantle (NRCS 2007a). To assist with specific species selection for a project site, an Iowa Riverside Plant Selection guidance can be found online on the DNR website at <http://www.iowadnr.gov/Environmental-Protection/Water-Quality/River-Restoration>.

Nursery stock, bare root seedlings and vegetative plugs of varying native species can be obtained from local and regional nurseries (NRCS 2007b, 2011). Existing native vegetation can be typically be found on-site of the stream restoration project and marked for excavation so they can be salvaged and stored until they can be transplanted.

Installing nursery stock, bare roots, vegetative plugs, or the transplanting of carefully selected native plant material on a project site can be undertaken by landowners. Often however, a lack of vegetation on stream banks is due to unstable conditions; analysis and design by a professional may be required to stabilize the stream bank and reestablish vegetation.

#### 2.7.2 Technique Information

- **Use:** Nursery stock, bare roots, vegetative plugs, and the transplanting of carefully selected native plant material protects the stream bank toe and slope from shallow slides, seepage and surface erosion, and re-established native vegetation.
- **Other uses:** In addition to short- and long-term erosion control and slope stability, nursery stock, bare roots, vegetative plugs, and the transplanting of carefully selected native plant material provides numerous other benefits including improved aesthetics, riparian habitat, and water quality. For example, vegetation growth increases the amount and quality of riparian habitat for birds, mammals, and other terrestrial animals by providing food and cover and improves in-stream habitat and water quality for fish and other aquatic organisms by reducing water temperatures by providing shade.
- **Best applications:**
  - This form of vegetative reestablishment is best used when combined with other erosion control methods, depending upon the site and the project's goals and objectives.

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- On its own, native riparian vegetation is typically installed along areas experiencing low to moderate stream bank erosion rates. When combined with other erosion control techniques, native riparian vegetation can be installed along the entire riparian corridor.
- **Computations:** Hydrologic and hydraulic computations aid in verifying that the appropriate conditions exist for installation of native riparian plants. Special consideration needs to be given to the frequency and duration of flows along the stream for proper plant selection.

Computations are generally not necessary for landowners using nursery stock, bare roots, vegetative plugs, and the transplanting of carefully selected native plant material to revegetate bare areas on otherwise stable stream banks. However, planting vegetation adjacent to streams can adversely impact the local hydraulics, sometimes deflecting currents adversely, catching debris and causing blockages, or increasing roughness and causing increases in flood stage.

As part of a stream restoration project, the design of a planting plan for nursery stock, bare roots, vegetative plugs, or the transplanting of native plant material requires design by a professional.

- **Key Feature:** The most important consideration when choosing where to plant a specific species is where to place it within the stream's cross-section, including along the water's edge, near the bankfull elevation, along the side slope, or on the top of bank, per the Iowa Riverside Plant Selection guidance (Iowa DNR 2016).

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### 2.7.3 Detail Drawings and Data Table

The following drawings and data table depict information that should be included in construction plans for planting nursery stock, bare roots, and vegetative plugs, and transplanting. The data table includes design guidelines and sources, where applicable.

**Table 6. Required Design Data for Transplanting<sup>1</sup>**

Dimension <sup>2</sup>	Name	Typical Unit	Guidelines <sup>3</sup>	Description
A	Planting depth	Varies	Depth as required based on dimension of excavated soil and roots. Transplant should be planted at the same depth prior to harvest.	Planting depth of the transplant.
B	Height of mounded soil backfill	Inches	--	Height of mounded loose soil placed into over-excavated planting pit.
C	Depth of planting pit	Varies	Depth as required based on dimension of excavated soil and roots.	Depth of the planting pit; accommodates dimension of soil and excavated roots as well as mounded loose soil at bottom of pit.
D	Width of planting pit	Varies	1 ½ to 2 times the width of the excavated soil and roots	Over-excavated width of the planting pit; accommodates the width of the excavated soil and roots.
E	Height of mounded soil perimeter	Inches	3"	Height of soil berm constructed along the perimeter of the planting pit; helps retain water.

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**Table 6. Required Design Data for Transplanting<sup>1</sup>**

<b>Dimension<sup>2</sup></b>	<b>Name</b>	<b>Typical Unit</b>	<b>Guidelines<sup>3</sup></b>	<b>Description</b>
F	Width of mounded soil perimeter	Inches	8"	Width of soil berm constructed along the perimeter of the planting pit; helps retain water.
G	Width of weed barrier fabric (optional)	Inches	--	Width of fabric placed on surface to control weeds within the mounded soil perimeter; transplants typically have grasses, leaf matter, etc. attached and do not require weed barrier fabric.
H	Fabric stake length (optional)	Inches	4"-6"	Length of staples/spikes used to secure weed barrier fabric
I	Thickness of mulch (optional)	Inches	3"	Thickness of mulch, if necessary. Transplants typically have grasses, leaf matter, etc. attached and do not require mulch.
J	Gap between mulch and plant stem/trunk (optional)	Inches	2"	Room between plant stem/trunk and mulch. Transplants typically have grasses, leaf matter, etc. attached and do not require mulch.

Notes:

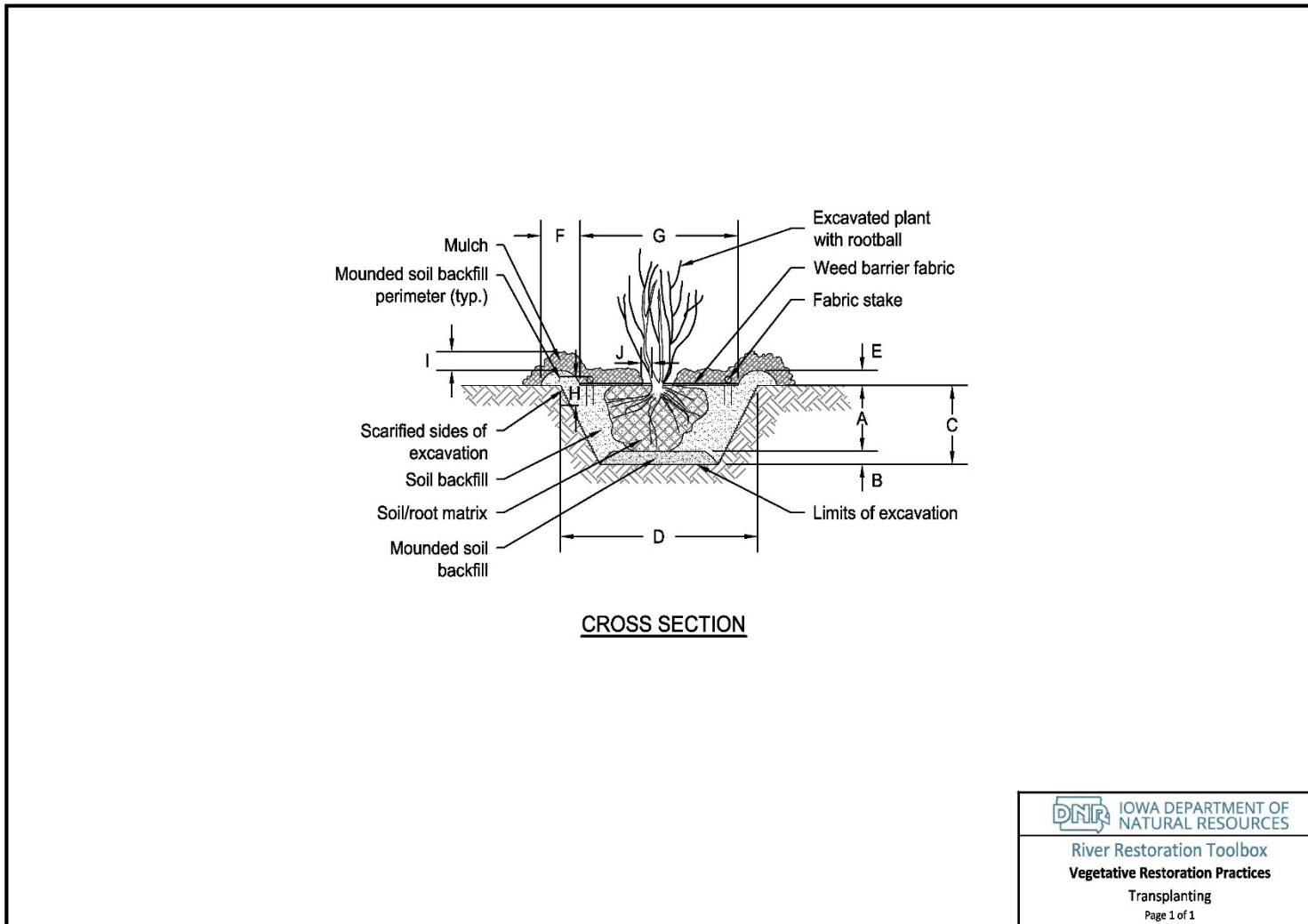
1. Data are for transplanted vegetation.
2. Dimension labels are referenced in the detail drawings.
3. Common guidance, values, or ranges are given unless they require computation using site-specific input.



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## Drawing 6. Transplanting



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**Table 7. Required Design Data for Bare Root Plants<sup>1</sup>**

Dimension <sup>2</sup>	Name	Typical Unit	Guidelines <sup>3</sup>	Description
A	Planting depth	Varies	Depth as required based on dimension of rootstock (SUDAS 2011). Root flare should be at or slightly above finished grade.	Planting depth of the bare root plant.
B	Height of mounded soil backfill	Inches	6" (SUDAS 2011)	Height of mounded loose soil placed into over-excavated planting pit.
C	Depth of planting pit	Varies	Depth as required based on dimension of rootstock (SUDAS 2011)	Depth of the planting pit; accommodates dimension of rootstock as well as mounded loose soil at bottom of pit.
D	Width of planting pit	Varies	1 ½ to 2 times the width of the rootstock (SUDAS 2011)	Over-excavated width of the planting pit; accommodates the width of the rootstock.
E	Height of mounded soil perimeter	Inches	3" (SUDAS 2011)	Height of berm constructed along the perimeter of the planting hole using soil backfill material; helps retain water.
F	Width of mounded soil perimeter	Inches	8" (ISA 2014)	Width of berm constructed along the perimeter of the planting hole using soil backfill material; helps retain water.



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**Table 7. Required Design Data for Bare Root Plants<sup>1</sup>**

Dimension <sup>2</sup>	Name	Typical Unit	Guidelines <sup>3</sup>	Description
G	Width of weed barrier fabric	Varies	--	Width of fabric placed on surface to control weeds within the mounded soil backfill perimeter
H	Fabric stake length	Inches	4"-6"	Length of steel staples or degradable resin spikes used to secure weed barrier fabric
I	Thickness of mulch	Inches	3" (SUDAS 2011)	Thickness of mulch
J	Gap between mulch and plant stem/trunk	Inches	2"	Room between plant stem/trunk and mulch.

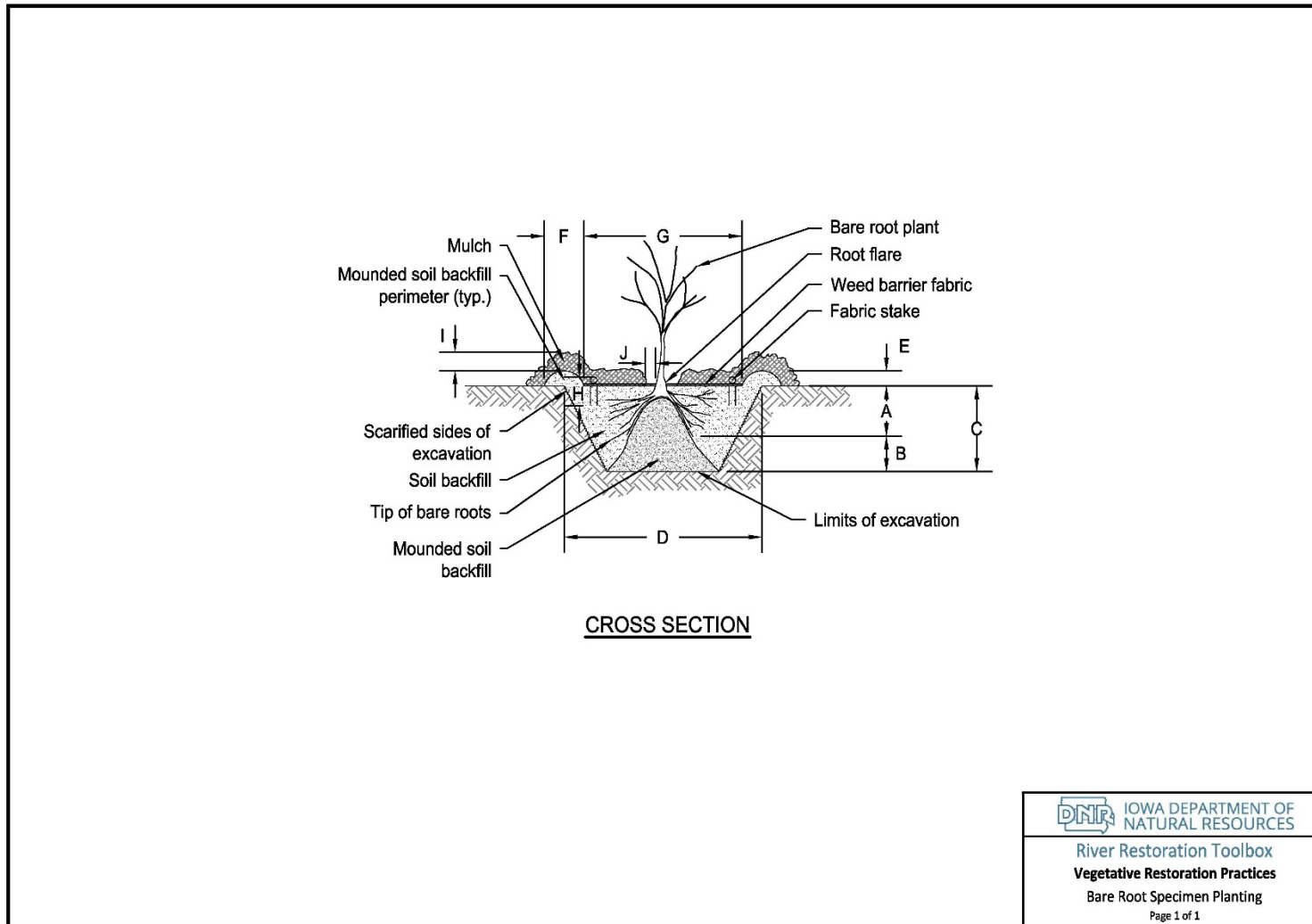
Notes:

1. Data are for bare root plants.
2. Dimension labels are referenced in the detail drawings.
3. Common guidance, values, or ranges are given unless they require computation using site-specific input.

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### Drawing 7. Bare Root Plants



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**Table 8. Required Design Data for Container Grown Nursery Stock<sup>1</sup>**

<b>Dimension<sup>2</sup></b>	<b>Name</b>	<b>Typical Unit</b>	<b>Guidelines<sup>3</sup></b>	<b>Description</b>
A	Planting depth	Varies	Plant at same depth as in container (SUDAS 2011)	Planting depth of the container plant.
B	Height of mounded soil backfill	Inches	6" (SUDAS 2011)	Height of mounded loose soil placed into over-excavated planting pit.
C	Depth of planting pit	Varies	Plant at same depth as in container (SUDAS 2011)	Depth of the planting pit; accommodates dimension of container as well as mounded loose soil at bottom of pit.
D	Width of planting pit	Varies	1 ½ to 2 times the width of the container (SUDAS 2011)	Over-excavated width of the planting pit; accommodates the width of the container.
E	Height of mounded soil perimeter	Inches	3" (SUDAS 2011)	Height of berm constructed along the perimeter of the planting hole using soil backfill material; helps retain water.
F	Width of mounded soil perimeter	Inches	8" (ISA 2014)	Width of berm constructed along the perimeter of the planting hole using soil backfill material; helps retain water.

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**Table 8. Required Design Data for Container Grown Nursery Stock<sup>1</sup>**

Dimension <sup>2</sup>	Name	Typical Unit	Guidelines <sup>3</sup>	Description
G	Width of weed barrier fabric	Inches		Width of fabric placed on surface to control weeds within the mounded soil backfill perimeter
H	Fabric stake length	Inches	4"-6"	Length of steel staples or degradable resin spikes used to secure weed barrier fabric
I	Thickness of mulch	Inches	3" (SUDAS 2011)	Thickness of mulch
J	Gap between mulch and plant stem/trunk			Room between plant stem/trunk and mulch.

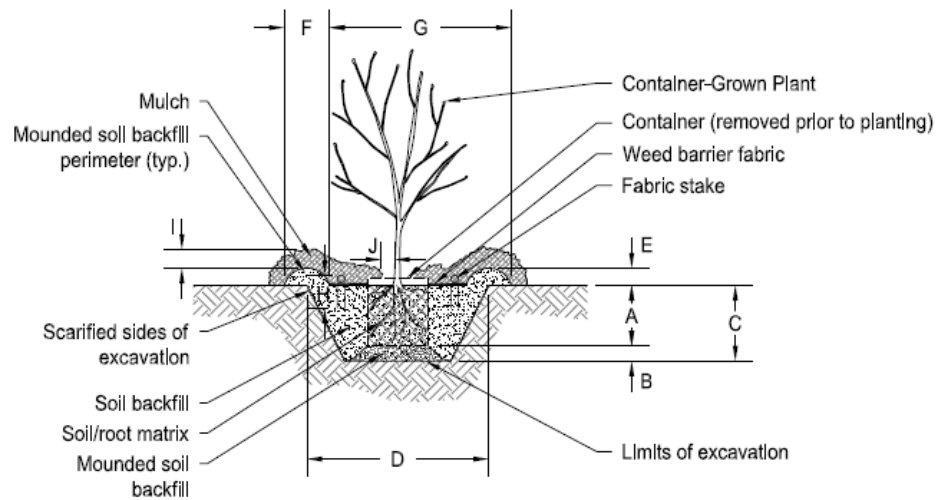
Notes:

1. Data are for container-grown nursery stock.
2. Dimension labels are referenced in the detail drawings.
3. Common guidance, values, or ranges are given unless they require computation using site-specific input.

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### Drawing 8. Container-Grown Nursery Stock



Note: If necessary for protection against beaver/deer, cage protection should be installed on container stock above areas receiving frequent flow.

#### CROSS SECTION

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**Table 9. Required Design Data for Vegetative Plugs<sup>1</sup>**

Dimension <sup>2</sup>	Name	Typical Unit	Guidelines <sup>3</sup>	Description
A	Planting depth	Inches	Plug should be easily placed into soil opening and not crushed or pressed.	Depth of planting to accommodate plug
B	Planting tool blade length	Inches	At least equal to planting depth	Length of planting tool blade
C	Planting tool blade width	Inches	Wide enough to accommodate plug	Width of planting tool blade

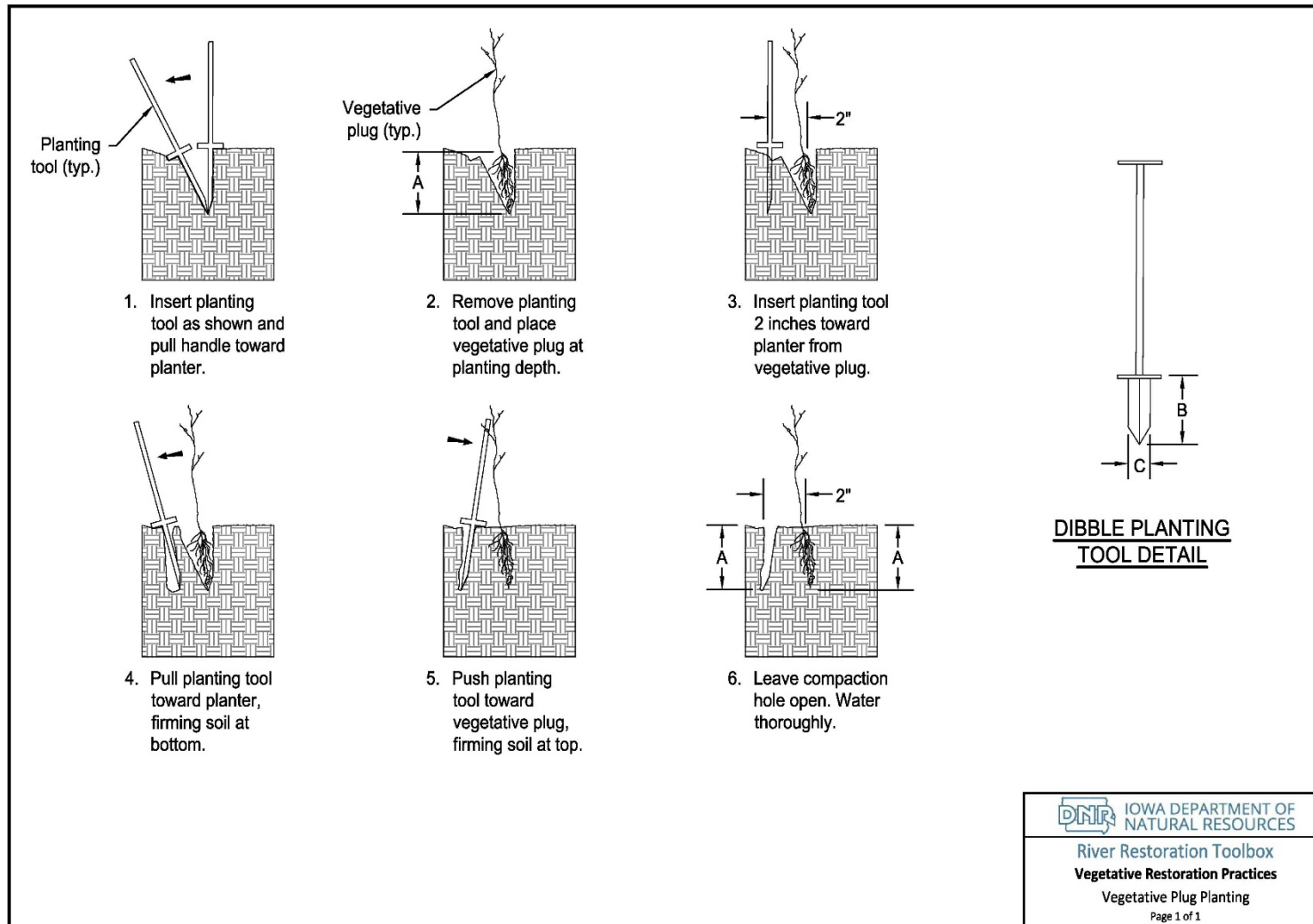
Notes:

1. Data are for vegetative plugs.
2. Dimension labels are referenced in the detail drawings.
3. Common guidance, values, or ranges are given unless they require computation using site-specific input.

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## Drawing 9. Vegetative Plugs



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### 2.7.4 Specifications

In addition to the information presented in Section 1.0 Introduction, the following information should be developed into specifications to accompany the use of nursery stock, bare roots, vegetative plugs, or the transplanting of native plant material:

- Materials:
  - Chosen nursery stock, vegetative plugs, and transplants
- Equipment/Tools:
  - When safe and feasible, a back hoe should be used when placing very large plants.
  - Round tip shovels
  - Soil tamping hand tool
  - Vertical support stakes, if required
  - Sledge hammer
  - Anti-predation fencing, if required
- Sequence:
  - Provide storage of plants on site or have only as many plants delivered as can be planted in a day.
  - Layout plants along the project per the project's specifications. Protect plants from direct sun, drying of the root stock, and freezing prior to planting.
  - Except for vegetative plugs, holes for individual plantings should be excavated to produce nearly vertical sides and flat bottoms. Planting pits should be excavated by-hand, using a mattock, pick, iron bar, etc. The planting pits should be excavated to a depth and diameter suitable for the form of plant (e.g., transplant, bare root, or containerized). All planting holes should have roughed, scarified sides and bottoms.
  - Determine whether soil amendment is required and apply, if needed.
  - Remove any container and score root ball before planting.
  - Backfill all plants with soil excavated from the planting pit and tamp lightly to remove any voids. Plug openings are closed by inserting planting tools next to the



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planted opening and pressing adjacent soil toward plug and closing the gap around the plug.

- Water all vegetation immediately following planting.
- Apply vertical support stakes or anti-predation fencing if needed.
- Workmanship:
  - All plant material needs to be fresh, free from transplant shock or visible wilt.
  - All container plants need to have been propagated in a container long enough for the root system to have developed sufficiently to hold its soil.
  - Prior to installation, inspect the plant material to make sure there is a vigorous root system, and the plants are healthy, free from defects, decay, diseases, insect pest eggs, and all other forms of infestation.
  - If stored on site, plants need to be protected and from the wind, sun, and freezing. If practical, the roots can be covered with moist sawdust, wet burlap, wood chips, shredded bark, peat moss, or other similar material.
  - Do not plant when the soil is frozen.
  - Plants are ideally installed during their dormancy period.
  - Planting hole should be sufficient as not to cramp the roots.
- Maintenance: Plants may require initial protection from beaver, deer, cattle, or other predators. Various types of deer-proof fencing or fine wire screen or mesh can be secured around the plants and beds of plants, etc., to offer protection. If the area is grazed, restrict livestock from the planting site.

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### 2.7.5 Photographs



**Photo 43.** Bare root trees. Source: Lake Superior Tree Farm



**Photo 44.** Vegetative plugs. Source: Collins & Baker Engineering



**Photo 45.** Bare root trees. Source: Lake Superior Tree Farm



**Photo 46.** Planting vegetative plugs. Source: Iowa DNR



**Photo 47.** Trees planted on Edwards Branch. Source: Charlotte-Mecklenburg Storm Water Services



**Photo 48.** Vegetative plugs at Edwards Branch, NC. Source: Charlotte-Mecklenburg Storm Water Services

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