# Work Plan – Final Revision

Schuster Slope Management Area - Unit 1
Tacoma, Washington

*for*
**City of Tacoma – Environmental Services**

December 23, 2015

GeoEngineers
Earth Science + Technology

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# Tacoma, Washington

**File No. 0570-140-04**

**December 23, 2015**

Prepared for:

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## INTRODUCTION

GeoEngineers, Inc. (GeoEngineers) was contracted by the City of Tacoma (City) to prepare a Work Plan for vegetation management activities planned to be completed within the Schuster Slope Management Area by City-managed work crews during fall 2015 through winter 2016. This Work Plan was prepared in general accordance with Task 1 of GeoEngineers' contract with the City, dated September 22, 2015.

The Schuster Slope Management Area is located in Tacoma, Washington, north of downtown (Figure 1). The Schuster Slope Management Plan was developed by the City of Tacoma in cooperation with Metro Parks Tacoma (City of Tacoma, 2015). This management plan provides general recommendations and guidance for vegetation management activities, such as removal of invasive species and re-establishment of native vegetation, on steep slopes.

Vegetation management activities are proposed within Unit 1 of the Management Area (Figure 1). Unit 1 is one of nine Management Units (MUs) defined in the Management Plan (City of Tacoma, 2015). The MUs are arranged sequentially from south to north across the Management Area. Unit 1 is the southern-most MU. MU-1 extends from the southern limit of the Management Area at the Stadium Way off-ramp overpass from I-705 north to South 4$^{th}$ Street.

The Management Plan requires that site-specific Work Plans be developed for vegetation management activities in areas with slopes greater than 67 percent. A significant portion of Unit 1 contains slopes greater than 67 percent and some slopes exceed 100 percent (Figure 2). The purpose of this Work Plan is therefore to provide site-specific guidance for work crews to implement the general provisions of the Management Plan within Unit 1. This Work Plan presents our opinion of what vegetation management activities are feasible and should be implemented within Unit 1 during fall 2015 and winter 2016. We also provide recommendations for activities occurring on steep slopes.

### Goals and Objectives

The Management Plan identifies actions that should generally be implemented throughout the Management Area, including removal of invasive species, installation of native plant species, and potential slope stability treatments. This Work Plan addresses site-specific recommendations that apply to Unit 1 by identifying: 1) areas that are feasible to treat and that can be managed within a 24-hour period to reduce the potential for erosion and maintain slope stability; 2) specific types, quantities and locations of invasive species that will be removed and native species that will be installed (based on general provisions of the Management Plan); and 3) recommended erosion protection options prior to, during, and following work activities.

To address the project goals and provide context for our recommendations, we have identified specific treatment plots for implementation of vegetation management activities within Unit 1. The treatment plots are based on: our review of existing baseline information; standards and specifications presented in the Management Plan; meetings and discussions with City project management and work crew personnel regarding goals, objectives and work crew capabilities; and our site reconnaissance. These proposed treatment plots are illustrated on Figure 3.

General considerations that apply across all treatment plots are presented in this Work Plan. For example, general considerations include recommended timing of work actions, identification of work sections, plant availability and requirements, and a general strategy for erosion control and containment. Specific recommendations are also provided on a plot-by-plot basis. These provisions apply specifically to each treatment plot, including identification of the type, amount, and nature of invasive species present that will be removed, type of plants and installation methods for re-vegetation, and recommended erosion control and containment practices/methods.

We understand that permits for this project do not allow for permanent slope stabilization measures. The proposed vegetation management activities have been reviewed by our geotechnical engineers and have been determined to not present a significant risk of inducing global slope instability. Any action on a steep slope, even as part of an effort to improve the long-term stability, will increase the potential for instability in the short term. Our recommendations are intended to reduce the potential for instability but it is not possible to eliminate this risk. All recommendations provided in this Work Plan are preliminary and may be modified during implementation and our on-site visits to account for changes in site conditions.

### Unit 1 Description

In the Baseline Conditions Assessment Report (GeoEngineers, 2014), the majority of Unit 1 was considered part of "Geologic Hazard Zone A," indicating high landslide susceptibility as evidenced by active soil creep, limited groundcover vegetation and loose surficial soils. As shown in Figure 2 (LiDAR Slope Gradient and Topography), slopes within the project area range from approximately 60 percent to over 100 percent. The area below the slope crest, as delineated on Figure 3 (Treatment Plots), is considered a high risk area due to the presence of steep slopes. Direct observations indicate actual slope conditions are more steeply inclined and include vertical bluffs, landslide scarps and overhangs.

The Baseline Conditions Assessment Report (GeoEngineers, 2014) indicates the geologic setting of Unit 1 as undifferentiated pre-Vashon Deposits. The glacial deposits are referred as the Kitsap formation in the Baseline Conditions Assessment Report. The Kitsap formation is described as consisting of dense, glacially overridden deposits including till, pebbly mud, and associated silt, sand, gravel and conglomerate.

Vegetation within Unit 1 includes a mature deciduous canopy throughout most of the unit, with heavy Himalayan blackberry infestations in the understory in some locations and sparse understory vegetation in others. Heavy infestations of English ivy (*Hedera helix*) and Old-man's beard (*Clematis vitalba*) were also noted in some locations. The top section of slope, where there is a less steeply sloped bench adjacent to Stadium Way, was characterized by young tree stands or invasive species monocultures without overstory forest canopy; some of the invasive monocultures extended down the slope over steep terrain as well.

Specific vegetation parameters were mapped in further detail by the City during 2015. Spatial geographic information system (GIS) and computer-aided design (CAD) data were provided to GeoEngineers for our use in developing this Work Plan. The City obtained a wetland delineation covering the entire slope (Grette Associates, 2015); one wetland unit is present within Unit 1, near the base of the slope at the northeastern corner of the unit (Figure 3). This wetland appears to originate from seepage discharge near the toe of the slope, which accumulates in a "ditch" adjacent to the sidewalk and then flows northerly along the roadway and sidewalk. The City also collected global positioning system (GPS) data for trees and invasive species on the slope. Tree point data identifies the tree species, size, number of stems, and notes regarding condition. Invasive species data identifies general locations where invasive species are dominant. GPS data

had low accuracy and precision; our understanding of actual vegetation conditions and distribution was further refined using direct observations during development of this Work Plan.

## GENERAL CONSIDERATIONS

### Timing/Work Crews

We understand that the City has two work crews available for work beginning in middle to late October. Each work crew consists of six (6) workers plus one crew leader. Work crews have basic training in site safety and vegetation management methods, and will be directed by a crew leader with experience in vegetation management.

Beginning of work should be coordinated with construction observation personnel. These personnel will work with crew leaders to schedule and coordinate construction observation field visits. Recommendations will be provided to the work crew leader during field visits after conditions are observed and evaluated, and will be documented in a field report that will be provided to the City project manager.

Because of the sensitive nature of the slope and high potential for erosion, work activities should be contingent on weather patterns. We recommend checking the weather forecast on a daily basis and limiting starting new work during inclement wet weather. Working in sections is a fundamental component of this Work Plan with the aim of limiting erosion resulting from inclement weather; see the subsequent discussion below. By limiting the amount of exposed soil at a given time, it should be feasible to complete work within a work section in advance of major precipitation events, and to delay starting a new work section until the weather has passed. Construction observation personnel may provide additional guidance as to what kind of weather events may preclude specific work activities.

We understand the City is currently waiting on review and approval of the Management Plan for activities proposed within wetland habitats potentially under the regulatory jurisdiction of the U.S, Army Corps of Engineers (USACE). Therefore, it is likely that implementation of actions proposed in this Work Plan that apply to the wetland area may be performed later in the season.

### Site Safety

We understand that work crews are trained to safely work on the steep slopes that are present within Unit 1, and that work crew leaders have the necessary expertise and judgement to curtail operations if conditions become hazardous. We understand that use of rope systems, personal harnesses, and/or other anchoring mechanisms may be employed by work crews under the supervision of the crew leader. We would also caution workers to minimize prolonged exposure at the base of slopes that have been denuded as a result of invasive species removal activities, particularly during or immediately after precipitation events. This Work Plan is not intended to address site safety and GeoEngineers cannot take responsibility for the safety of field crews, even when we are present on site during construction observations activities. All safety equipment and procedures remain the responsibility of the City of Tacoma. Activities within the high risk areas shown on Figure 3 should be avoided due to the potential for slope destabilization. Any proposed activities within these areas should be communicated to the observing geotechnical engineer for evaluation prior to the commencement of the proposed activities.

## Work Sections

A fundamental provision of this Work Plan is that work "sections" be identified by crew leaders before beginning work. The goal of establishing work sections is to identify an area within a Treatment Plot that can be fully managed by a single work crew within a relatively short period of time. The purpose of this provision is to limit the amount of slope that is denuded of vegetation at any given point in time with the goal that adequate erosion control and containment measures, and replacement vegetation plantings, can be installed quickly in the event of inclement wet weather.

Our recommended time period for completion of all management activities within a work section is 24 hours. We recommend starting off the work season conservatively to allow work crews to come "up to speed" on methods and procedures and to allow for a period of adjustment after which crew leaders may be allowed latitude to increase the size of work sections at their discretion. For difficult sections at the beginning of the work season, we recommend starting conservatively with 400 $ft^2$ work sections for each six-person work crew. Increasing work sections should be based on competency of the crew, terrain, site access, and difficulty of the management tasks to be performed, as identified by the crew leaders. For example, in difficult, steep or more heavily infested areas, such as TP-1, TP-2 and TP-5, work sections may not be able to be safely increased. However, we anticipate that the size of work sections can be increased substantially as the work season progresses, as crews become more proficient, and crew leaders are able to accurately identify the amount of progress that can be made per unit time. This is especially true in less steep or less heavily infested areas, such as TP-3, TP-4 and TP-6.

## Construction Sequencing

The anticipated sequence for construction activities is outlined below. Activities 1 through 3 can be completed at the beginning of the field season. It is possible that one work crew might proceed to Activity 4 in locations where Activity 3 is already complete while the other work crew continues with Activity 3. Activities 4 through 10 should be completed on a daily or near-daily basis in accordance with the provisions described under "Timing/Work Crews" and "Work Sections", above.

1. **Construction kick-off meeting.** This meeting should be held prior to start of construction to provide for an overview of the proposed activities and sequence, an opportunity to pose and answer questions, and to encourage open communication among all parties involved in development and implementation of this Work Plan. Attendees at this meeting should include project managers from the City and construction observation consultant(s), City work crew leaders, and construction observation personnel.
2. **Safety briefing.** Site safety is not addressed in this Work Plan. We note that the City is responsible for arranging equipment, practices and training as needed to ensure employee safety. Construction observation staff that will be on site during construction observation activities may attend and participate in this meeting at the City's request. In addition, daily site briefings may be called by construction observation consultant staff on days they are present at the site.
3. **Install containment.** Containment devices to be installed at the toe of the slope should be installed prior to any invasive species removal or other management activities within each TP. Type of device and methods of installation are discussed in further detail below. The construction observation consultant should be available to provide installation recommendations and/or to verify installation as part of the construction observation contract.

4. **Identify work section.** Work crew leaders should clearly identify the work section to be addressed for the day, and the day's goals and objectives. Daily briefings with work crews are appropriate. It is recommended to identify and work in work sections at higher elevations first and then identify and work in subsequent work sections located at lower elevations.
5. **Identify means of access.** To minimize compaction and erosion effects on soil due to accessing work sections a single means of ingress and egress, located in an area that is less susceptible to erosion or compaction, should be established accessing one work section or multiple work sections adjacent to each other. Trips through the access routes should be kept to a minimum by identifying the necessary work and equipment needed to complete the activities planned within the work section. A single access route is preferred for work sections that are in close proximity to each other.
6. **Invasive species removal.** In work sections with invasive species, removal is the first task for vegetation management.
7. **Install erosion control.** Following satisfactory removal of invasive species, as needed, the ground surface of the work section should be inspected for signs of erosion that may have been previously hidden by invasive vegetation and to identify if standard erosion control methods will be adequate or if additional consultation or alternate methods may be warranted. If standard erosion controls appear adequate, they should be installed at this time. If additional consultation is warranted, it should be requested immediately and a solution identified and implemented expediently. In the case that consultation is not available immediately, standard erosion control should be placed in the interim until consultation is provided.
8. **Install plantings.** Plants and other planting materials should be staged in advance at a convenient location for the day's work activities. Plants should be installed as soon as possible following completion of Activities 5 and 6. Soil amendments and/or additives, if planned, should be installed concurrently with plantings. To improve efficiency, it may be possible to complete Activities 6 and 7 for multiple work sections prior to installing plantings throughout a larger area. This possibility is contingent on further evaluation based on work crew ability/efficiency, specific terrain in each TP, and extended weather forecasts. Extending plant installation across multiple work sections to improve efficiency should be evaluated as part of the contracted construction observation services.
9. **Work section close-out.** Prior to moving on to the next work section, crews should verify activities in the current work section are completed satisfactorily. This may be as simple as a check by the crew leader, or it may be identified to require additional consultation with a geotechnical engineer or third-party biologist as part of the construction observation contract.
10. **Access route restoration.** After work is closed out of the work section(s), the access route(s) should be restored to a condition similar to that observed prior to the start of work. If the means of ingress and egress will be used over subsequent days to access unfinished work sections the pathway should be covered with biodegradable/photodegradable netting and secured with temporary weighting mechanisms (i.e., large rocks, sand bags, cinder blocks, etc.).

### Planting Materials and Methods

The Management Plan recommends plant selections based on the location on the slope (top of slope, slope face/toe), observed moisture regime, and amount of light/shading. Unit 1 spans the slope from top to toe, includes one wetland and associated buffer area, and is consistently oriented with an east-by-northeast

aspect. Canopy cover varies across the unit, contributing to variation in light/shading at the understory level.

### Installation

Fall and winter are ideal times of year for installation of native plant materials because plants are in growth dormancy and the climate is likely to provide naturally abundant water. The Management Plan includes general and some specific recommendations for selection of plant materials and installation methods. In general, use of smaller plant material stock is recommended to reduce the amount of soil disturbance necessary to correctly install plantings.

The following recommendations have been developed to address site-specific issues with regard to plant material installation. These recommendations are not intended to supersede the provisions of the Management Plan, nor do they provide comprehensive instruction for plant installation. Rather, these recommendations should supplement information that has already been prepared and is available for the project as well as the technical expertise of work crew leaders.

Installation of new plantings through erosion control nets and blankets should conform to installation requirements provided in Appendix D of the Management Plan.

#### *Soil Amendments*

New plantings will likely benefit from soil amendments to increase the nutrient content of soil at the planting location. We understand that broad-scale application of topsoil or other soil amendments is not allowable according to permit authorizations that the City currently holds. This strategy would also not likely be feasible due to the slope gradient. Instead, we recommend slight over-excavation of the planting hole for each plant, exceeding the size of the root ball of containerized plants; as the plant is inserted into the excavation, backfilling the hole with potting soil, topsoil or other nutrient-enriched soil is recommended to improve establishment success and survival.

DriWater™ CT is a slow-release soil moisture additive pre-packaged in a carton that the City has used in the past. We understand that the City intends to add these cartons to tree plantings in the spring to help newly installed trees cope with the summer drought period. DriWater can be installed relatively easily on steep slopes and in remote areas, making it well-suited to this project. This treatment is appropriate for all tree plantings described in this Work Plan. SoilMoist™ is a combined slow-release fertilizer and soil moisture enhancer proposed for experimental use in TP-3, as described more fully in the "Specific Recommendations" section of this Work Plan.

#### *Protective Devices*

Newly installed plantings should be protected with devices to discourage herbivory, which could result in plant mortality. Plant protection can be provided using Vexar™ tubes or other similar devices. Because of the large number of plantings that will be installed, installation of plant protective devices can be prioritized for high susceptibility areas and planting types to reduce cost. "Benched" portions of the slope that may be less steeply inclined than other areas are more likely to be subject to high levels of deer herbivory and, therefore, warrant higher priority for installation of protective devices. Benched areas occur in TP-3, TP-4, and portions of TP-5 and TP-6. Evergreen tree species, thorny species, other plants with natural resistance to herbivory, and rapidly growing plant species should receive lower priority for protective devices. Examples of species anticipated to be utilized in MU-1 that are less likely to be damaged by herbivory include: grand

fir, Western redcedar, Western hemlock, Sitka spruce, madrone, shore pine, Pacific wax-myrtle, evergreen huckleberry, salal, low/tall Oregon grape, devil's club, salmonberry, Nootka rose, and kinnikinnick.

### Plant Material Types

We recommend sourcing containerized or bare-root seedling plant materials for most planting areas in accordance with the Management Plan. Live stakes may be appropriate in particularly wet areas, such as the wetland that has been delineated within TP-6, as described more fully in the "Specific Recommendations" section below. At this time, we do not propose utilizing hydroseeding, live fascines, brush layering, or contour wattling within MU-1. In our experience, hydroseed is primarily used as erosion control in locations where a native tree/shrub community is not planned, for example roadside slopes, stormwater swales, et cetera. Aside from logistical considerations of installation and cost, our opinion is that installation of grass seed for the purpose of erosion control is likely to reduce survival of native plantings established in the same area due to competitive interactions. Use of live fascines, brush layering, or contour wattling is discussed in the "Erosion Control and Containment" section below.

### Plant Quantities

We have estimated the overall size of Unit 1 at 124,303 $ft^2$. The treatment plots identified on Figure 3 and discussed in this Work Plan total 89,470 $ft^2$ in plan view. These square footages were calculated in plan view using ESRI® ArcGIS; we did not adjust the area for the slope angle.

As identified on a plot-by-plot basis below in the "Specific Recommendations and Treatment Plots" section of this Work Plan, a total of 459 trees, 2,865 shrubs, and 4,030 groundcovers are estimated to be needed to complete vegetation management actions proposed in this Work Plan. Of these quantities, 260 shrubs and 910 groundcovers will be planted in subsequent years and will not be needed during the first year of implementation in accordance with the Treatment Plot details described in this Work Plan. Proposed plant quantities are based on recommended plant spacing as identified in Table 1, Appendix D of the Schuster Slope Management Plan, which appear adequate for the purposes of this Work Plan.

### Availability

The City provided a list of City-owned nursery plant stock available for use. Based on this list, additional plants will need to be acquired to complete vegetation maintenance in Unit 1. The City has excess stock of some species that could be substituted for a lack of other species. We suggest that some Douglas fir and Western hemlock, of which the City has excess stock, could be substituted for grand fir, which the City would otherwise need to purchase in substantial quantities, in areas of the slope face and toe with partial shade to full shade. The goal of species substitution is to reduce the financial and logistical burden of plant acquisition. However, species diversity should still be a consideration both from an ecological perspective as well as to "hedge bets" if for some reason one or more species fails to establish in a given area. Therefore, substitution of species should be limited in scope and quantity.

Our estimate for the quantity of groundcover plants that will be needed is lower than the City estimate, which should also help to reduce the burden of plant acquisition.

## Best Management Practices

A number of Best Management Practices (BMPs) are described in this document. A list of all BMPs approved by the City of Tacoma Surface Water Management Manual that may be implemented during activities discussed in this Work Plan are included as Appendix A.

## Erosion Control and Containment

In areas where freshly cleared, planted, or bare slopes are present there is a potential for excessive erosion, which should be controlled to the extent feasible. It is our understanding that erosion control measures for work activities addressed in this Work Plan must be temporary due to permit restrictions. Most slopes within Unit 1 exceed 60 percent slope (Figure 2) and will, therefore, require some form of erosion control. Slopes between 67 and 100 percent slope should have fixed erosion control measures (e.g., erosion mats or geogrid) to comply with specifications in the Management Plan. However, because fixed erosion control measures such as erosion mats or geogrids would not be temporary, we recommend using biodegradable/ photodegradable nets or blankets that are fixed to the slope using shallow staples or anchors (as described in and installed per the 2012 Tacoma Stormwater Management Manual Volume 2, Chapter 3 Best Management Practices [BMP] C122). Additionally, if erosion mats or geogrids are installed they would need to be removed after installed plantings become established. Removal of the mats or geogrids could damage established plants and root systems. Because of the potential for damaging the established plantings, we do not recommend erosion mats or geogrids as fixed erosion control. Erosion control measures placed on slopes should be installed immediately after work sections are cleared. For this Work Plan, management activities are restricted from slopes that exceed 100 percent slope, which in our opinion will require permanent engineered solutions in accordance with the Management Plan.

Activities resulting in steepening of slopes, such as regrading or removal of soil, are prohibited throughout Unit 1. Steepening slopes is likely to decrease the global stability of the hillside and could potentially cause or contribute to large slope failures. Actions that would steepen the slope of the hillside will require more detailed engineering analysis.

Recommended temporary fixed erosion control measures can include biodegradable/photodegradable nets or blankets (as described in and installed per the 2012 Tacoma Stormwater Management Manual Volume 2, Chapter 3 BMP C122), straw wattles (as described in and installed per the 2012 Tacoma Stormwater Management Manual Volume 2, Chapter 3 BMP C235), and temporary debris containment systems.

Biodegradable/photodegradable nets, or blankets would consist of jute, coir, or similar materials. Jute or coir nets or blankets that incorporate different materials in the weaving could include straw or other biodegradable/photodegradable materials. Nets or blankets that utilize straw could add additional organics to the ground cover providing beneficial conditions for establishing vegetation. The nets and blankets are intended to stay on the slope until they degrade. Biodegradable/photodegradable nets, or blankets are cheap in cost, easy to install, provide organic material to the ground cover once degraded and, unlike other nets or blankets made of plastics, would be temporary. Live fascines, brush layering, and contour wattling are forms of combined erosion control and plant establishment described in the Management Plan for use in limited areas addressing specific erosion control issues. In our opinion, there are currently no specific erosion control issues warranting these types of treatments that have been observed within MU-1, such as erosion gullies, stream banks, or other exposed soil areas highly susceptible to concentrated erosive forces.

These techniques are time-consuming to install and costly, and therefore not appropriate for broad application across the slope. However:

1. We have developed several alternative experimental treatments utilizing straw wattles for application in TP-6. Details are described more fully in the "Specific Recommendations" section below.
2. As invasive vegetation is removed from within the MU, conditions not previously observable may become exposed, warranting adaptive management solutions that could include one or more of these techniques. Selection and application of these solutions may be recommended during construction observation services that are planned during implementation of this Work Plan.

Debris containment systems should be implemented at the toe of the slopes for all treatment plot areas. The debris containment systems are not intended to arrest slope failures or protect workers. The debris containment systems are only intended to reduce the risk of loose debris (i.e., soil, cobbles, fallen trees, etc.) from sloughing onto Schuster Parkway during slope restoration activities. In areas where the slope is flatter or activities are near the toe of the slope, the debris containment system may consist of silt fencing (as described in and installed per the 2012 Tacoma Stormwater Management Manual Volume 2, Chapter 3 BMP C233). In areas where the slope is steep or otherwise poses a greater risk, the debris containment system should consist of a short wall constructed of ecology blocks or traffic/jersey barriers. All debris containment systems should be installed before the start of work within a treatment plot and should be left in place a minimum of two years and until plants have become established based on the results of vegetation monitoring. For example, if there is plant failure and re-planting is needed, the amount of time may need to be extended.

Straw wattles should generally be used in areas where erosional features such as gullies or rills are noted within the slope. Straw wattles will help deter and disperse channelized flow on the slope.

Areas near and below overhangs or bluffs (such as in steep areas at the upslope limits of TP-5 and TP-6, and the "high risk area" above) should be avoided until the area can be evaluated in more detail. Additional evaluation can be provided by the geotechnical engineer that is retained to perform construction observation services. Undermining or active denuding of the slope could potentially change and weaken the slope in these areas and destabilize the overhanging material or the bluff, causing a safety hazard for workers below. We recommend the crew leader or designated site safety officer visually inspect these slopes and bluffs for loose rocks or other objects that could fall and injure workers. This visual inspection should occur at the beginning of the work period prior to starting work and should continue periodically while workers are present. Full-time spotters may be required in some locations or during some activities.

Advantages and disadvantages of recommended erosion control are discussed in the 2012 Tacoma Stormwater Management Manual excerpts provided in Appendix A. An estimate of the anticipated quantities and cost of erosion control features is included as Appendix B.

## SPECIFIC RECOMMENDATIONS AND TREATMENT PLOT DETAILS

### Overview

Proposed treatment plots are identified on Figure 3. An area designated as "high risk area" is also shown on Figure 3, within which no management actions are proposed at this time. The high risk area is characterized by slopes that generally exceed 100 percent as indicated by LiDAR-derived slope data and

where direct observations indicate actual conditions may be more steeply inclined than the LiDAR data indicate. Portions of the high risk area are vertical or near-vertical. According to the Section 4.2.1 of the Management Plan, management actions on slopes greater than 67 percent require evaluation by a geotechnical engineer. According to Section 6-3 of Appendix D to the Management Plan, slopes exceeding 100 percent will require engineered solutions. For a solution to be considered "engineered", it must have a relatively high level of certainty that it will remain stable for an extended period of time. We understand these types of solutions are not authorized by the current permit held for vegetation management within Unit 1 at this time. Therefore, we are not proposing vegetation management activities on slopes exceeding 100 percent in this Work Plan.

The following sections identify site conditions within each treatment plot and specify the following for each treatment plot: types and extent of invasive species removals that will be necessary, appropriate replacement planting types and quantities (see Table 1, Appendix D, Schuster Slope Management Plan), and specific recommendations for erosion control and debris containment. The recommendations provided in these sections draw upon the guidance presented in the Management Plan, including technical specifications presented in Appendix D to the Management Plan, as well as our professional opinions resulting from review of available data and direct field observations.

## Treatment Plot 1

Treatment Plot 1 (TP-1) is proposed as an experimental treatment within a steep slope area where existing mature trees (maples) are present that may provide natural slope support and debris containment below the plot without the need for engineered solutions. TP-1 is approximately 160 $ft^2$ (estimate 10 feet high by 16 feet wide) and is located in an area of slopes exceeding 100 percent based on LiDAR data. The purpose of this experimental plot is to evaluate feasibility of vegetation management on a small scale where natural features, in this case a cluster of mature trees, may provide natural containment in an area that we would otherwise not propose management action at this time due to steepness. Because of the somewhat risky nature of proposed activity on this optional plot, we have strictly limited the size of the plot. Success of this experimental management area will not be measured strictly based on native plant cover or other typical measures of vegetation success. Instead, success should be evaluated based on no major signs of erosion such as development of erosion rills or other erosion features or exposure of newly installed plant roots due to soil erosion that results in plant mortality. This TP should be observed carefully after implementation, especially following precipitation events. If erosional features are observed, a geotechnical engineer should be consulted immediately to address a slope solution.

### Vegetation Management

The treatment plot (TP-1) is dominated by nearly 100 percent cover of dense Himalayan blackberry, with some Clematis. Although adjacent trees, combined with the slope aspect, result in a part shade condition in this plot, there are no trees within the plot. Dense invasive vegetation should be removed from throughout this small plot and then replanted with species selected from the list of Slope Face and Toe, Dry to Moist Soils, Shade to Part Shade species. We estimate one tree, five shrubs and twelve groundcovers will be required to replant this area.

Success of vegetation management actions in TP-1 may be improved through continued maintenance trimming of encroaching invasive species originating in surrounding areas that are not treated at this time.

### Erosion Control and Containment

Temporary erosion control in this plot would be provided by the following: Biodegradable/photodegradable nets, and blankets; and a concrete block or barrier debris containment system.

Due to the steep slopes in TP-1, freshly cleared, planted, or bare ground will be highly susceptible to erosion. Biodegradable/photodegradable nets, and blankets consisting of jute, coir, or other materials consistent with those described in Section 5.4.1 of the Schuster Slope Landscape Management Plan and as described in the 2012 Tacoma Stormwater Management Manual Volume 2, Chapter 3 BMP C122 are recommended for erosion control in TP-1. Areas where vegetation is being established should also be protected to impede erosion and sloughing of the hillside that could further destabilize the existing slopes. Once the existing vegetation is removed the slope surface should be inspected for gullies or rills that could collect or concentrate water. If these features are present, straw wattles or other diffusers may need to be installed.

We recommend installing debris containment systems consisting of concrete traffic barriers or ecology blocks as described in Section 5.4.5 of the Schuster Slope Landscape Management Plan. Debris containment systems would be installed along the toe of the slope below TP-1 and as shown in Figure 4. Recommended extents of the debris containment system is shown in Figure 4. In areas where traffic barriers or ecology blocks encroach upon the sidewalk, silt fencing (as described in the 2012 Tacoma Stormwater Management Manual Volume 2, Chapter 3 BMP C233) could be used for additional coverage. Activities in this area may weaken the surficial soils on the slope and cause surficial skin slides over the planted area. This debris containment system is intended to reduce the risk of potentially significant loose debris (i.e., soil, cobbles, fallen trees, etc.) from sloughing onto Schuster Parkway during or after slope restoration activities in TP-1. The debris containment system is not intended to resist the impact of major slope failures.

## Treatment Plot 2

Treatment Plot 2 (TP-2) is proposed as a first step in treating an area of dense Himalayan blackberry, with some Scotch broom, near the southern limit of the MU. TP-2 is approximately 4,500 $ft^2$ and includes slopes ranging from less than 60 to over 100 percent, although the majority of the plot is within the 67 to 100 percent range. The rationale behind this treatment plot is to complete partial treatment of the slope by addressing a lateral band across the base of the slope. Limiting the vertical extent of this band to an area approximately 20 feet across (in plan view) reduces the proportion of the slope that needs to be denuded of vegetation at one time. Once native vegetation becomes established on the first band, treatment may progress upwards in sequential lateral bands at a later time. It is anticipated that three separate treatment phases, each addressing a lateral band sequentially higher on the slope, would be required in this area to complete vegetation management objectives.

### Vegetation Management

Vegetation management within this plot (TP-2) is recommended based on the following rationale to manage risk of slope failure or excessive erosion resulting from management activities: the proposed cleared area during the first year of vegetation management is located at the base of the slope and time will be allowed for re-vegetation plantings to establish and contribute toward slope stabilization before management activities progress in upward bands in subsequent years.

TP-2 is dominated by nearly 100 percent cover of dense Himalayan blackberry, which will need to be cleared throughout the plot. Native plantings should utilize species selected from the list of Slope Face and Toe, Dry to Moist Soils, Full Sun species. We estimate 23 trees and 144 shrubs will be required to replant this area initially. Once groundcover species are planted to fill in the vegetation community, we estimate approximately 325 will be required in this plot.

Because of the nearly 100 percent dominance of Himalayan blackberry in this plot, it is likely that complete eradication will not be possible with a single treatment and repeat control efforts will be needed. Therefore, the proposed planting strategy for this plot is to install tree and shrub strata in the first year, immediately following clearing and installation of erosion control, but to delay installation of groundcover species until after several years of blackberry control can be completed. During the initial phase during which the blackberry infestation is being addressed, resources should be focused on maintaining survival of trees and shrubs, and eradicating invasive species. This is intended to reduce loss of plant material and labor resources that might otherwise occur as a result of groundcover plantings being adversely affected by continued blackberry control efforts, which may include additional clearing/trimming, grubbing, and/or use of herbicides. After blackberry control efforts have stabilized, as documented through ongoing vegetation monitoring activities, groundcover species should be installed to fill out the desired vegetation community.

#### Erosion Control and Containment

Temporary erosion control in this plot would be provided by the following: Biodegradable/photodegradable nets and blankets; and a silt fence debris containment system.

Due to the steep slopes in TP-2, freshly cleared, planted, or bare ground will be susceptible to erosion. Biodegradable/photodegradable nets and blankets consisting of jute, coir, or other materials consistent with those described in Section 5.4.1 of the Schuster Slope Landscape Management Plan and as described in the 2012 Tacoma Stormwater Management Manual Volume 2, Chapter 3 BMP C122 are recommended for erosion control in TP-2. These erosion control measures should stay in place until they naturally degrade. Maintenance or replacement of these erosion control measures may be required to maintain erosion protection while plantings mature.

We recommend installing debris containment systems consisting of silt fencing at the toe of the slope along the full extent of TP-2 with the exception of the area covered by the concrete debris containment system installed for TP-1. Silt fencing should be BMP C233 as described in the 2012 Tacoma Stormwater Management Manual Volume 2, Chapter 3. Activities in this area may weaken the surficial soils on the slope and cause skin slides over the planted area. The silt fencing would act as a debris containment system to reduce the risk of loose debris from sloughing onto Schuster Parkway during or after slope restoration activities in TP-2. The debris containment system is not intended to resist the impact of major slope failures.

Steepening of the slope caused by regrading or removal of soils should not be permitted in TP-2 due to the treatment plots location at the toe of the slope. Steepening the slope at the toe may decrease the global stability of the hillside and could potentially cause or contribute to slope failure. If erosion and/or surficial slides result in a loss of material from this area, the area must be refilled and erosion control measures re-established as soon as practical.

## Treatment Plots 3 and 4

Treatment Plots 3 and 4 (TP-3 and TP-4) occupy the continuous bench near the top of the slope, which is considerably less steep than most other portions of Unit 1. TP-3 is approximately 16,300 $ft^2$ and TP-4 is approximately 8,100 $ft^2$. Both plots include slopes generally less than 60 percent and are, therefore, considered lower risk for slope failure or excessive erosion due to the shallower slope angle. The goals for both of these units are similar; they are distinguished from each other only in the proposed methods for revegetation.

### Vegetation Management

**Treatment Plot 3:** The northern portion of TP-3 is dominated by dense Himalayan blackberry, with patchy and less dense areas of blackberry and Clematis extending southward along the narrow strip adjacent to Stadium Way. Overall, we estimate invasive species will need to be cleared throughout approximately 80 percent of this plot, or 13,000 $ft^2$. The entire plot, including cleared areas, will need to be planted utilizing species selected from the list of Top of Slope, Dry to Moist Soils, Full Sun species. TP-3 will be re-planted with a full suite of native vegetation species (e.g., trees, shrubs and groundcovers), in accordance with the Management Plan. We estimate approximately 84 trees, 523 shrubs and 588 groundcovers will be required to replant this area.

Use of SoilMoist™, a combined slow-release fertilizer and soil moisture additive, is also proposed experimentally in this plot. We recommend the plot be divided roughly in half and that SoilMoist be added to all installed plantings within the experimental half of the plot, and not to the control half. Plant survival and establishment, as documented through ongoing vegetation monitoring, will then be utilized to evaluate success of the method.

**Treatment Plot 4:** Approximately 80 percent of TP-4, or 6,500 $ft^2$, is dominated by invasive vegetation, predominantly dense Himalayan blackberry. Invasive species will need to be cleared throughout this area and then the entire plot will be planted with tree species selected from the list of Top of Slope, Dry to Moist Soils, Full Sun species. As an experimental plot, TP-4 will be re-planted initially only with tree species. Shrub and groundcover will then be added at a later time once the trees have an opportunity to establish and begin to form an overstory canopy. The potential benefit of this strategy is that 1) an overstory canopy will become partially developed prior to other plantings, resulting in shade conditions at ground level more appropriate for shrub and groundcover species; and 2) there may be lower potential for trees to become water-stressed as a result of competition with other plantings. Disadvantages or risks may include: 1) a need for maintenance to reduce competition from undesirable vegetation due to lower overall native vegetation cover at the outset; 2) reduced vegetation screening from unauthorized use and access; and 3) the need to return to the site at a later time to supplement the plantings with shrubs and groundcover. We estimate approximately 42 trees will be required to establish a forest canopy in this area at this time, and that follow-up plantings, once the trees have established, will require 260 shrubs and 585 groundcovers. Once overstory trees are established in this plot, it may be possible to utilize shrub and groundcover species from the Shade to Part Shade list.

### Erosion Control and Containment

Temporary erosion control in this plot would be provided by the following: Biodegradable/photodegradable nets and blankets.

To reduce the potential for erosion of freshly cleared, planted, or bare ground we recommend biodegradable/photodegradable nets and blankets consisting of jute, coir, or other materials consistent with those described in Section 5.4.1 of the Schuster Slope Landscape Management Plan and as described in the 2012 Tacoma Stormwater Management Manual Volume 2, Chapter 3 BMP C122 are recommended for erosion control in TP-3 and TP-4. These erosion control measures should stay in place until they naturally degrade. Maintenance or replacement of these erosion control measures may be required to maintain erosion protection while plantings mature.

## Treatment Plot 5

Treatment Plot 5 (TP-5) includes a portion of the lower half of the slope above the existing retaining wall that is located along an approximately 300-foot length of the base of the slope, above the Schuster Parkway road. TP-5 is approximately 14,400 $ft^2$ and includes slopes generally in the range of less than 60 to 100 percent. The LiDAR data doesn't distinguish between retaining walls and steep slopes. Accordingly, the retaining wall shows up as a slope exceeding 100 percent. This plot has reduced risk for slope failure and excessive erosion resulting from vegetation management activities because the retaining wall and gradual bench that exist above the retaining wall provide some slope support and debris catchment.

### Vegetation Management

Much, but not all, of this plot has a full overstory of mature bigleaf maple trees. Invasive species type and distribution vary substantially across the plot: Himalayan blackberry monocultures along the western margin on the highest portions of the slope within this plot lack overstory cover; the southern half of the plot on the lower portion of the slope is dominated by Himalayan blackberry as an understory to mature forest; and much of the northern half of the plot consists of a native forest canopy with a minimal understory that is characterized by a heavy infestation of creeping vines (English ivy and Clematis) as an invasive groundcover.

Overall, we estimate that approximately 60 percent of the plot, or 8,700 $ft^2$, contains dense Himalayan blackberry. Of the remaining area without blackberries, we estimate approximately 50 percent groundcover by invasive vines, or approximately 2,900 $ft^2$. Invasive species will need to be cleared throughout these areas. Native plantings in this plot should utilize species selected from the list of Slope Face and Toe, Dry to Moist Soils, Shade to Part Shade species. We estimate 74 trees, 461 shrubs and 600 groundcovers will be required to replant this area.

Success of vegetation management actions in TP-5 may be improved if invasive species on the steeper portion of the slope above this plot, where treatment is not proposed at this time, can be sprayed with an herbicide prior to vegetation management activities.

### Erosion Control and Containment

Temporary erosion control in this plot would be provided by the following: Biodegradable/photodegradable nets and blankets; and a silt fence debris containment system.

Due to the presence of steep slopes in TP-5, freshly cleared, planted, or bare ground will be susceptible to erosion. Biodegradable/photodegradable nets and blankets consisting of jute, coir, or other materials consistent with those described in Section 5.4.1 of the Schuster Slope Landscape Management Plan and as described in the 2012 Tacoma Stormwater Management Manual Volume 2, Chapter 3 BMP C122 are

recommended for erosion control in TP-5. These erosion control measures should stay in place until they naturally degrade. Maintenance or replacement of these erosion control measures may be required to maintain erosion protection while plantings mature.

We recommend installing debris containment systems consisting of silt fencing at the toe of the slope (immediately upslope of the retaining wall). The silt fence may be omitted where the top of the retaining wall extends at least 2 feet above grade and can act as debris containment. Silt fencing should be BMP C233 as described in the 2012 Tacoma Stormwater Management Manual Volume 2, Chapter 3. Activities in this area may weaken the surficial soils on the slope and cause skin slides over the planted area. The silt fencing would act as a debris containment system intended to reduce the risk of loose debris from sloughing onto Schuster Parkway during or after slope restoration activities in TP-5. The debris containment system is not intended to resist the impact of major slope failures.

Activities in areas below overhangs or bluffs located within the high risk area should be restricted until the area is evaluated. Undermining or active denuding of the slope could potentially weaken the slope in these areas and destabilize overhangs or bluffs, causing a safety hazard for workers below.

## Treatment Plot 6

Treatment Plot 6 (TP-6) includes a large portion of the lower half of the slope in the north half of Unit 1. TP-6 is approximately 45,900 $ft^2$ and includes slopes that range from less than 60 percent near the toe, progressively steepening up the slope to the western margin of the plot, where slopes top out near 100 percent below the high risk area identified on Figure 2. The up-slope limit of this treatment plot is defined by a dramatic scarp where the slope is over-steepened and vegetation is generally unable to establish; vegetation management activity in the high risk area of slope should be avoided. Below the scarp, this plot has reduced risk for slope failure and excessive erosion resulting from vegetation management activities because of the relatively shallow slope angles at the base of the slope and limited amount of invasive species removal that is needed or proposed within this plot.

### Vegetation Management

This plot has a full overstory of mature bigleaf maple trees with minimal understory, which is dominated in some places by ground-covering invasive vines. Removal of vines (English ivy and Clematis) in this area is low-risk, and plantings should be established as feasible. One medium-sized English holly (*Ilex aquifolium*) tree, less than 2 inches stem diameter, has also been identified, and should be removed. If digging out and removing the roots of the holly is likely to cause too much ground disturbance, alternatively the stem could be cut at ground level and then treated with herbicide. Overall, we estimate that approximately 30 percent of the plot, or 13,800 $ft^2$, contains invasive vine groundcover that should be removed. No native tree or shrubs should be removed from the wetland area.

Because native understory is lacking in areas both with and without invasive groundcover, the entire plot should be planted with native species. The majority of plantings should be selected from the list of Slope Face and Toe, Dry to Moist Soils, Shade to Part Shade species. One wetland is also located within this plot, Wetland A, which is 627 $ft^2$ in size. Plantings within the wetland should utilize species selected from the list of Wetland/Streams, Moist to Wet Soils, Shade to Part Shade species. In general, these species come in containerized or bare-root seedling forms; however, red-osier dogwood may be planted as live stakes instead, which may be significantly more economical. We estimate a total of 235 trees (including 3 from the wetland species list), 1,472 shrubs (including 20 from the wetland species list), and 1,920

groundcovers (including 80 from the wetland species list) will be required to replant this area. A very small proportion (approximately 5 percent) of these plants should be wetland-specific, and up to half of the wetland-specific shrub plantings could be sources as live stakes.

Several alternate experimental erosion control methods are also proposed in TP-6, some of which include integrated plantings. These alternate methods are described in more detail below. We recommend using containerized plantings for this purpose, although bare-root seedlings may also work.

### Erosion Control and Containment

Temporary erosion control in this plot would be provided by the following: biodegradable/photodegradable nets and blankets; and a silt fence debris containment system.

Due to the presence of steep slopes in TP-6, freshly cleared, planted, or bare ground will be susceptible to erosion. As a standard form of erosion control, biodegradable/photodegradable nets and blankets consisting of jute, coir, or other materials consistent with those described in Section 5.4.1 of the Schuster Slope Landscape Management Plan and as described in the 2012 Tacoma Stormwater Management Manual Volume 2, Chapter 3 BMP C122 are recommended for general erosion control in TP-6. These erosion control measures should stay in place until they naturally degrade. Maintenance or replacement of these erosion control measures may be required to maintain erosion protection while plantings mature.

In TP 6, where rocky/gravel surface cover is present, straw wattles should be employed in three experimental cases (see Figure 5) to test survivability of freshly planted vegetation and soil retention. The three alternate erosion control methods are proposed in this plot on an experimental basis. All three alternate methods include installation of straw wattles as described in the 2012 Tacoma Stormwater Management Manual Volume 2, Chapter 3 BMP C235, with differences as follows:

1. Straw wattles with integrated plantings.
2. Straw wattles with integrated plantings and fabric lining.
3. Straw wattles.

The three cases should be employed in staggered areas as shown on Figure 3. The three proposed experimental cases are illustrated on Figure 5 and described as follows:

#### *Experimental Case 1*

Case 1 employs straw wattles immediately downslope of freshly planted vegetation. Biodegradable/ photodegradable nets or blankets should cover the freshly planted and disturbed area. Excavated gravel from planting excavations should be piled up downslope of the straw wattle to add support to the straw wattle. This treatment is a medium-effort test case with respect to the levels of effort required for Cases 2 and 3. Soil surrounding the root ball could migrate away from the root system of the freshly planted vegetation and into the surrounding gravel that extends to an unknown depth. Compared to Case 2, Case 1 has a lower likelihood of successfully establishing vegetation along the rocky/gravel slope due to the potential for soils to migrate into the gravel.

#### *Experimental Case 2*

Case 2 also employs straw wattles immediately downslope of freshly planted vegetation. For this treatment, biodegradable/photodegradable nets or blankets line the bottom of the planting excavation to aid in

preventing soil within the planting excavation from migrating into the surrounding gravel. Biodegradable/ photodegradable nets or blankets should also cover the freshly planted and disturbed area. Excavated gravel from planting excavations should be piled up downslope of the straw wattle to add support to the straw wattle. This treatment is a high-effort test case with respect to the levels of effort required for Cases 1 and 3. Compared to Case 1, Case 2 has a higher likelihood of successfully establishing vegetation along the rocky/gravel slope due to the reduction in the potential for soils to migrate into the gravel.

***Experimental Case 3***

Case 3 employs straw wattles with no planted vegetation. Biodegradable/photodegradable nets or blankets should cover the disturbed area. Case 3 is intended to retain eroded soil on the slope with the goal of creating a soil bench that would be conducive to establishing planted vegetation. This option is a low-effort test case with respect to the levels of effort required for Cases 1 and 2. The likelihood of establishing vegetation along the rocky/gravel slope is dependent on the soil retained from installing the straw wattles within the area.

***Installation Considerations***

The three experimental cases employed in T-6 should generally adhere to the following sequencing:

1. Install biodegradable/photodegradable nets or blankets surrounding the area to be disturbed.
2. Install straw wattle per City of Tacoma 2012 SWMM "*BMP C235: Straw Wattles*" and details shown in Figure 5.
3. Install plantings (Cases 1 and 2 only):
    a. **Case 1:** Install plantings through the biodegradable/photodegradable nets or blankets per manufacturer's instructions for the net or blanket. Spoils from the excavation for the installation of new vegetation should be piled upslope of the straw wattles.
    b. **Case 2:** Install plantings through the biodegradable/photodegradable nets or blankets per manufacturer's instructions for the net or blanket. Line the excavation with biodegradable/ photodegradable net or blanket prior to placing new vegetation within the excavated planting hole. Spoils from the excavation for the installation of new vegetation should be piled up behind the straw wattle to help reinforce the straw wattle and biodegradable/photodegradable nets or blankets.

We recommend installing debris containment systems consisting of silt fencing at the toe of the slope. Silt fencing should be BMP C233 as described in the 2012 Tacoma Stormwater Management Manual Volume 2, Chapter 3. Silt fence installation is restricted to areas outside of the delineated wetland, but may be within the wetland buffer, below the wetland, at the toe of the slope. Activities in this area may disturb the surficial soils on the slope and cause skin slides over the planted area. The silt fencing would act as a debris containment system intended to reduce the risk of loose debris (i.e., soil, small shrubs, etc.) from sloughing onto Schuster Parkway during or after slope restoration activities in TP-6. The debris containment system is not intended to resist the impact of major slope failures.

Activities in areas below overhangs or bluffs located within the high risk area (such as in areas of TP-5 and TP-6) should be restricted until the area is evaluated. Undermining or active denuding of the slope could potentially weaken the slope in these areas and destabilize the overhang or bluff, causing a safety hazard for workers below.

## CLOSURE

We appreciate the opportunity to assist the City in developing this Work Plan in support of vegetation management activities proposed for Unit 1 of the Schuster Slope Management Area. We look forward to continuing working with you during project implementation over the next several months. Please do not hesitate to contact any of the authors of this document via email, or at 253.383.4940, if you have any questions regarding the recommendations discussed in this report.

## LIMITATIONS

We have prepared this report for the exclusive use of the City of Tacoma and their authorized agents for the Schuster Slope Management Area Unit 1 Work Plan.

Our services were provided to evaluate certain geologic risks for planned work located on sloping property. Our recommendations are intended to maintain the overall stability of the site and to reduce the potential for future property damage related to earth movements, drainage or erosion. However, all construction on slopes involves risk, only part of which can be mitigated through qualified engineering and construction practices. Favorable performance of structures in the near term does not imply a certainty of long-term performance, especially under conditions of adverse weather or seismic activity.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in the field of geotechnical engineering in this area at the time this report was prepared. No warranty or other conditions, express or implied, should be understood.

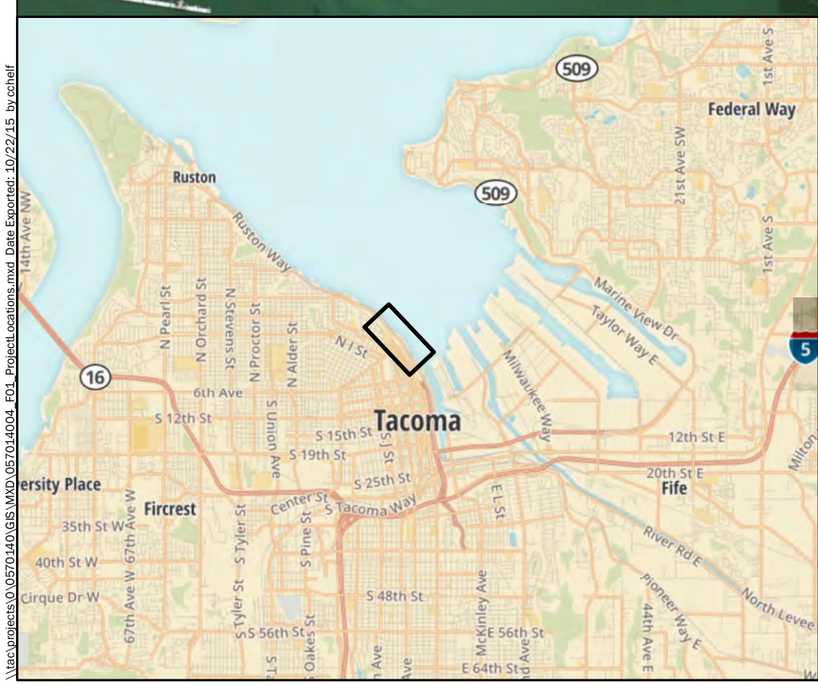
Please refer to Appendix C A titled “Report Limitations and Guidelines for Use” for additional information pertaining to use of this report.

## REFERENCES

City of Tacoma. 2015. Schuster Slope Landscape Management Plan. Developed in Cooperation with Metro Parks Tacoma. City of Tacoma, Environmental Services Department, May 15, 2015.

GeoEngineers, Inc. 2014. Baseline Conditions Assessment, Schuster Slope Management Area, Tacoma, Washington. Prepared for City of Tacoma on October 15, 2014.

Grette Associates. 2015. Schuster Slope Management Area Wetland and Stream Delineation and Analysis Report. Prepared for City of Tacoma – Center for Urban Waters, July 22, 2015.


Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Schuster Slope Management Plan, Figure 5A: City Prioritization Map – Management Units (City of Tacoma, 2015)
Mapbox Open Street Map, 2015

Not to Scale

**Project Location**

Schuster Slope Management Area - Unit 1
Tacoma, Washington

GEOENGINEERS

**Figure 1**

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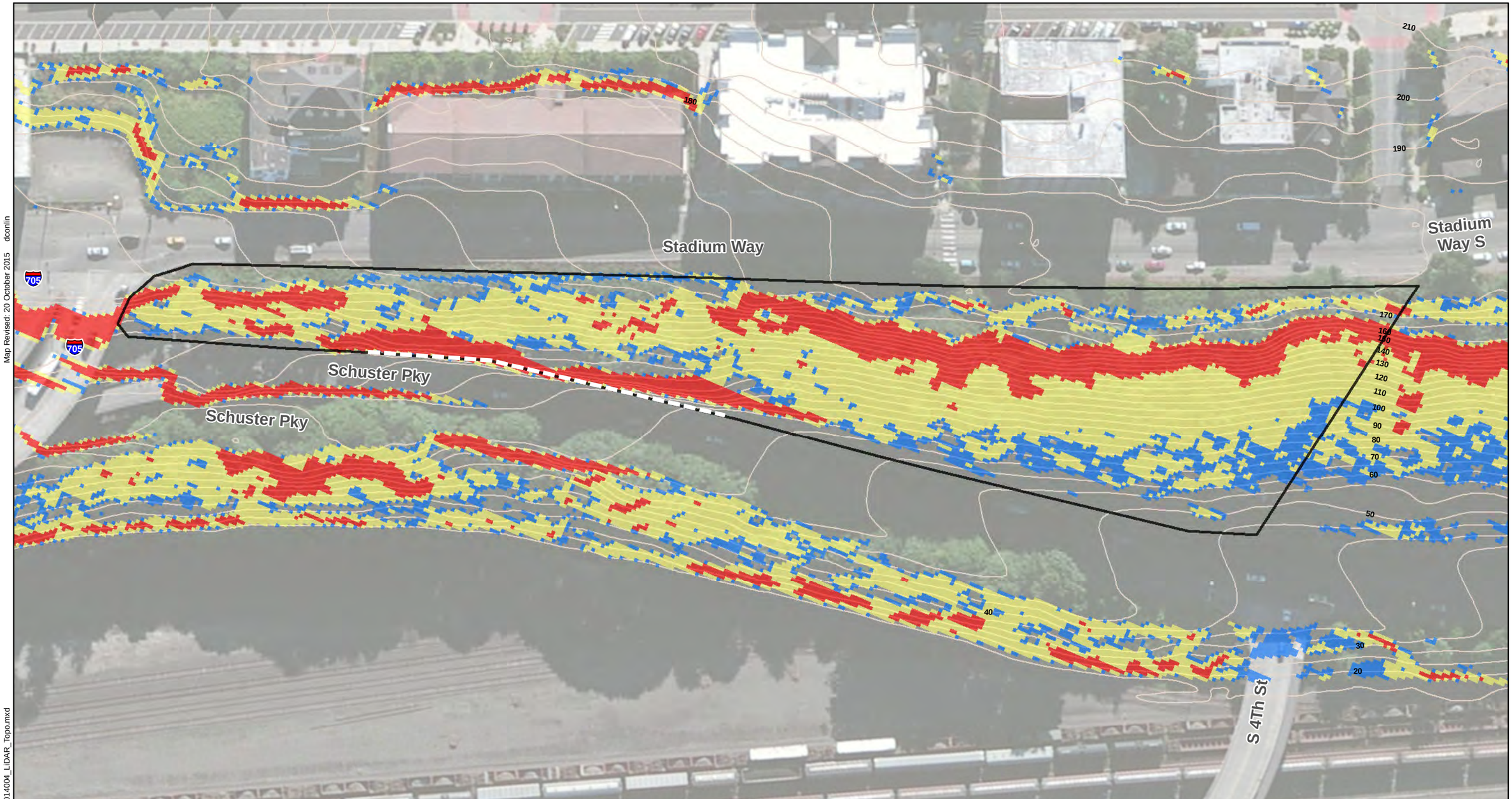


Map Revised: 20 October 2015 dconlin

Path: \\tacl\Projects\0\0570140\GIS\MXD\057014004_LiDAR_Topo.mxd

Data sources: 5-ft contours created from LiDAR data obtained from Puget Sound LiDAR Consortium

Notes:
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Management Unit 1

150 5-ft contours

Retaining Wall (Existing)

**Slope Gradient**

60-67%

67%-100%

100%+

80 0 80

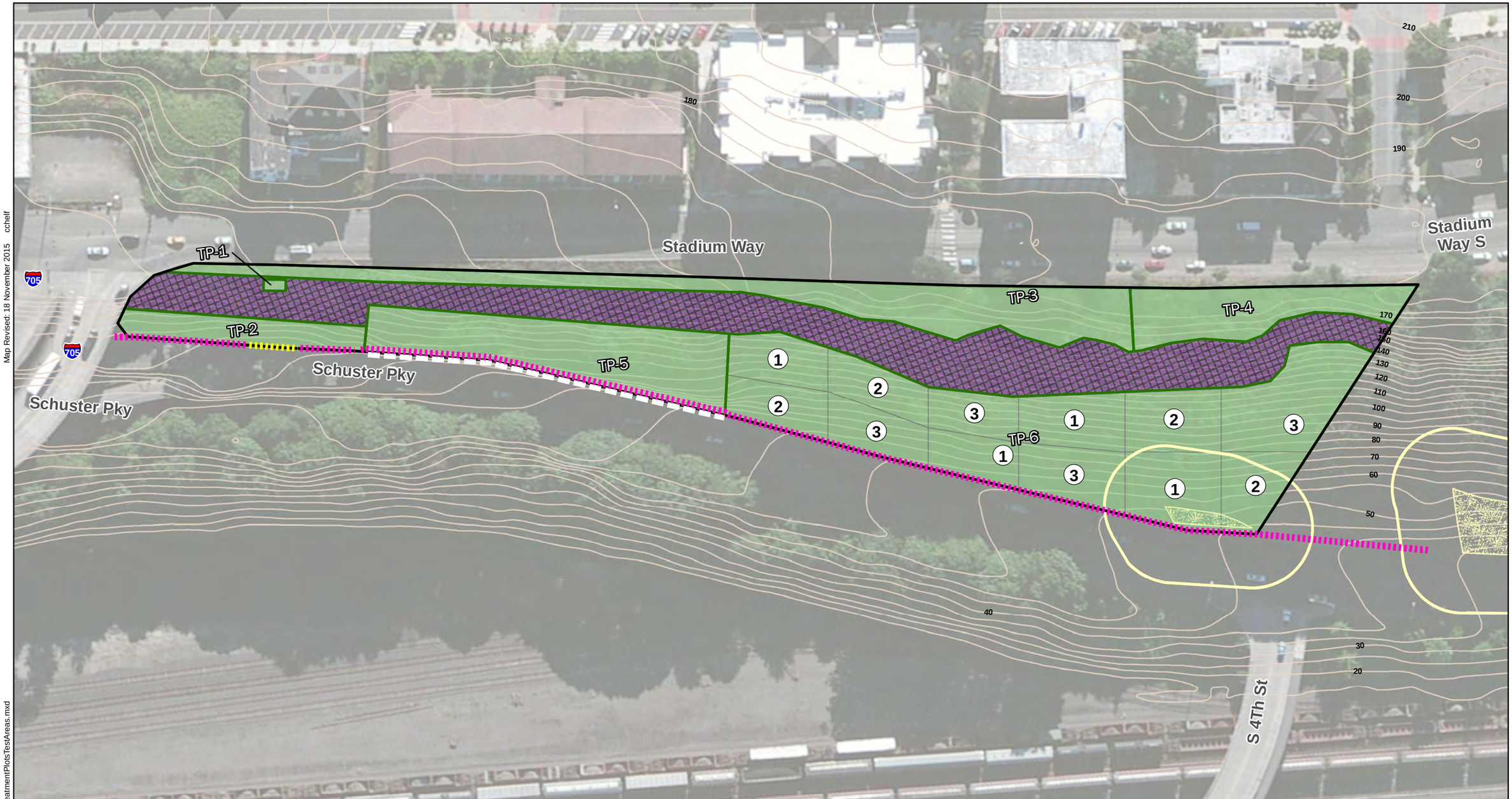
Feet

**LiDAR Slope Gradient and Topography**

Schuster Slope Management Area - Unit 1
Tacoma, Washington

GEOENGINEERS

**Figure 2**




Map Revised: 18 November 2015 cchelf

Path: P:\0\0570140\GIS\MXD\0570140004_TreatmentPlotsTestAreas.mxd

Data sources: 5-ft contours created from LiDAR data obtained from Puget Sound LiDAR Consortium

Notes:
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- Management Unit 1
- 5-ft contours
- Retaining Wall (Existing)
- Wetland
- Wetland Buffer
- Straw Wattle Test Case
- Treatment Plot
- High Risk Area - No Proposed Action
- Debris Containment (Proposed)
- Concrete Debris Containment (Proposed)

N W E S

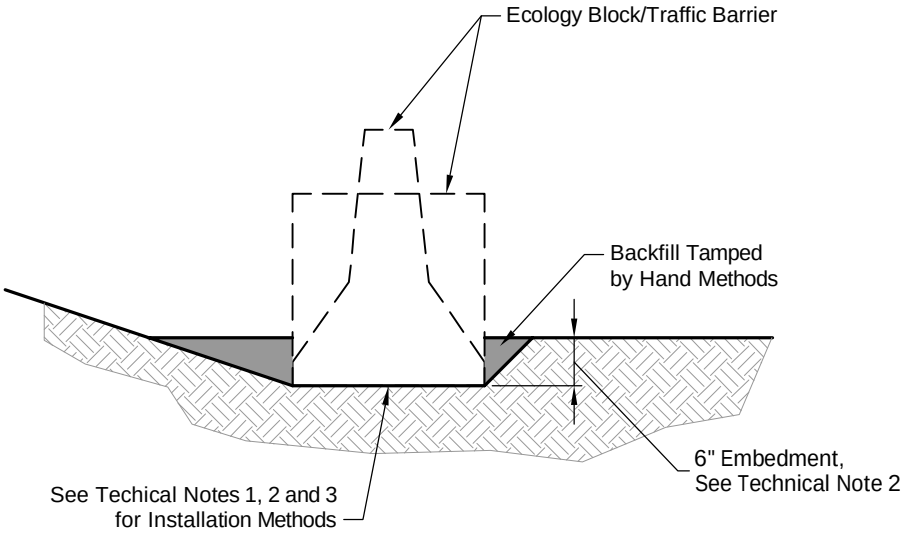
80 0 80
Feet

**Treatment Plots**

Schuster Slope Management Area - Unit 1
Tacoma, Washington

GEOENGINEERS

**Figure 3**




Not to Scale

Technical Notes:

1. Debris containment system should be placed on flat ground at the toe of the slope.

2. Embed debris containment system on firm ground.

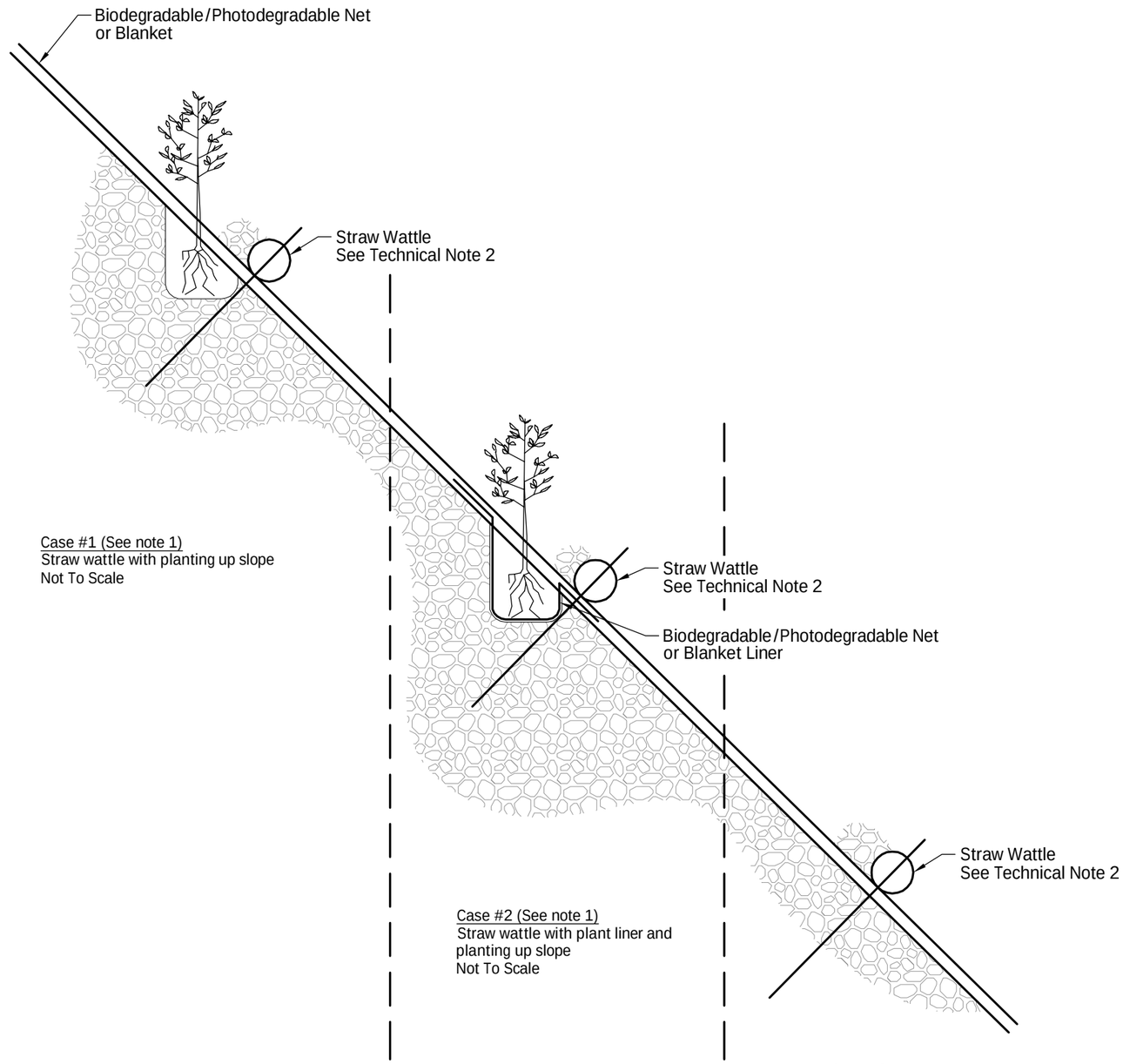
3. Excavation areas to embed the debris containment system should be kept as small as feasibly possible for installation and should not encroach upon or steepen the existing slope.

General Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: GeoEngineers, October 2015.

| TP-1 Debris Containment System Detail | |
|---|---|
| Schuster Slope Management Area - Unit 1<br>Tacoma, Washington | |
| GeoEngineers | Figure 4 |




Case #1 (See note 1)
Straw wattle with planting up slope
Not To Scale

Case #2 (See note 1)
Straw wattle with plant liner and
planting up slope
Not To Scale

Case #3
Straw wattle with no planting
Not To Scale

Technical Notes:

1. Depth and diameter of planting dependent on plant species used.

2. Straw wattles installed per City of Tacoma 2012 SWMM BMP C235: Straw Wattles.

General Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: GeoEngineers, October 2015.

| Straw Wattle Detail | |
|---|---|
| Schuster Slope Management Area - Unit 1<br>Tacoma, Washington | |
| GeoEngineers | Figure 5 |

# APPENDIX A

## Proposed BMPs Excerpted from City of Tacoma Surface Water Management Manual

## 3.1.9 BMP C121: Mulching

### 3.1.9.1 Purpose

The purpose of mulching soils is to provide immediate temporary protection from erosion. Mulch also enhances plant establishment by conserving moisture, holding fertilizer, seed, and topsoil in place, and moderating soil temperatures. There is an enormous variety of mulches that can be used. Only the most common types are discussed in this section.

### 3.1.9.2 Conditions of Use

As a temporary cover measure, mulch should be used:

- On disturbed areas that require cover measures for less than 30 days.
- As a cover for seed during the wet season and during the hot summer months.
- During the wet season on slopes steeper than 3H:1V with more than 10 feet of vertical relief.
- Mulch may be applied at any time of the year and must be refreshed periodically.

### 3.1.9.3 Design and Installation Specifications

For mulch materials, application rates, and specifications, see Table 2 - 7.

**NOTE:** Thicknesses may be increased for disturbed areas in or near sensitive areas or other areas highly susceptible to erosion.

Mulch used within the ordinary high-water mark of surface waters should be selected to minimize potential flotation of organic matter. Composted organic materials have higher specific gravities (densities) than straw, wood, or chipped material.

### 3.1.9.4 Maintenance Standards

- The thickness of the cover must be maintained.
- Remulch and/or protect with a net or blanket any areas that experience erosion. If the erosion problem is drainage related, then fix the problem and remulch the eroded area.

***Table 2 - 7: Mulch Standards and Guidelines***

| Mulch Material | Quality Standards | Application Rates | Remarks |
|---|---|---|---|
| Straw | Air-dried; free from undesirable seed and coarse material. | 3" thick; 5 bales per 1000 sf or 2 to 3 tons per acre. | Cost-effective protection when applied with adequate thickness. Hand-application generally requires greater thickness than blown straw. The thickness of straw may be reduced by half when used in conjunction with seeding. In windy areas, straw must be held in place by crimping, using a tackifier, or covering with netting. Blown straw always has to be held in place with a tackifier as even light winds will blow it away. Straw, however, has several deficiencies that should be considered when selecting mulch materials. If often introduces and/or encourages the propagation of weed species and it has no significant long-term benefits. Straw should be used only if mulches with long-term benefits are unavailable locally. It should also not be used within the ordinary high-water elevation of surface waters (due to flotation). |
| Hydro-mulch | No growth inhibiting factors. | Approx. 25-30 lbs per 1000 sf or 1500-2000 lbs per acre. | Shall be applied with hydromulcher. Shall not be used without seed and tackifier unless the application rate is at least doubled. Fibers longer than about ¾ - 1 inch clog hydromulch equipment. Fibers should be kept to less than ¾ inch. |
| Composted Mulch and Compost | No visible water or dust during handling. Must be purchased from supplier with a Solid Waste Handling permit (unless exempt) | 3" thick, min.; approx. 100 tons per acre (approx. 800 lbs. per yard). | Mulch is excellent for protecting final grades until landscaping because it can be directly seeded or tilled into soil as an amendment. Composted mulch has a coarser size gradation than compost. It is more stable and practical to use in wet areas and during rainy weather conditions. |
| Chipped Site Vegetation | Average size shall be several inches. Gradations from fine to 6-inches in length for texture, variation, and interlocking properties. | 3" minimum thickness | This is a cost-effective way to dispose of debris from clearing and grubbing, and it eliminates the problems associated with burning. Generally, it should not be used on slopes above approx. 10% because of its tendency to be transported by runoff. It is not recommended within 200 feet of surface waters. If seeding is expected shortly after mulch, the decomposition of the chipped vegetation may tie up nutrients important to grass establishment. |
| Wood-based mulch | No visible water or dust during handling. Must be purchased from a supplier with a Solid Waste Handling permit or one exempt from solid waste regulations. | 3" thick; approx. 100 tons per acre (approx. 800 lbs. per yard). | This material is often called "hog" or "hogged fuel". The use of mulch ultimately improves the organic matter in the soil. Special caution is advised regarding the source and composition of wood-based mulches. Its preparation typically does not provide any weed seed control, so evidence of residual vegetation in its composition or known inclusion of weed plants or seeds should be monitored and prevented (or minimized). |

## 3.1.10 BMP C122: Nets and Blankets

### 3.1.10.1 Purpose

Erosion control nets and blankets are intended to prevent erosion and hold seed and mulch in place on steep slopes and in channels so that vegetation can become well established. In addition, some nets and blankets can be used to permanently reinforce turf to protect drainage ways during high flows. Nets (commonly called matting) are strands of material woven into an open, but high-tensile strength net (for example, coconut fiber matting). Blankets are strands of material that are not tightly woven, but instead form a layer of interlocking fibers, typically held together by a biodegradable or photodegradable netting (for example, excelsior or straw blankets). They generally have lower tensile strength than nets, but cover the ground more completely. Coir (coconut fiber) fabric comes as both nets and blankets.

### 3.1.10.2 Conditions of Use

Erosion control nets and blankets should be used:

- To aid permanent vegetated stabilization of slopes 2H:1V or greater and with more than 10 feet of vertical relief.
- For drainage ditches and swales (highly recommended). The application of appropriate netting or blanket to drainage ditches and swales can protect bare soil from channelized runoff while vegetation is established. Nets and blankets also can capture a great deal of sediment due to their open, porous structure. Synthetic nets and blankets can be used to permanently stabilize channels and may provide a cost-effective, environmentally preferable alternative to riprap. 100 percent synthetic blankets manufactured for use in ditches may be easily reused as temporary ditch liners.
- Disadvantages of blankets include:
  - Surface preparation required;
  - On slopes steeper than 2.5:1, blanket installers may need to be roped and harnessed for safety;
- Advantages of blankets include:
  - Can be installed without mobilizing special equipment;
  - Can be installed by anyone with minimal training;
  - Can be installed in stages or phases as the project progresses;
  - Seed and fertilizer can be hand-placed by the installers as they progress down the slope;
  - Can be installed in any weather;
  - There are numerous types of blankets that can be designed with various parameters in mind. Those parameters include: fiber blend, mesh strength, longevity, biodegradability, cost, and availability.

### 3.1.10.3 Design and Installation Specifications

- See Figure 2 - 5 and Figure 2 - 6 for typical orientation and installation of blankets used in channels and as slope protection. Note: these are typical only; all blankets must be installed per manufacturer’s installation instructions.

- Installation is critical to the effectiveness of these products. If good ground contact is not achieved, runoff can concentrate under the product, resulting in significant erosion.

***Installation of Blankets on Slopes:***

- Complete final grade and track walk up and down the slope.
- Slope surface shall be free of rocks, clods, sticks and grass. Nets/blankets shall have good contact with the soil.
- Apply permanent seeding per BMP C120 or mulching per BMP C121 before placing net/ blanket.
- Dig a small trench, approximately 12 inches wide by 6 inches deep along the top of the slope. Cover with soil to secure.
- Install the leading edge of the blanket into the small trench, backfill the trench with soil and staple approximately every 18 inches.

**NOTE:** Staples are metal. ”U”-shaped, and a minimum of 6 inches long. Longer staples are used in sandy soils. Biodegradable stakes are also available and should be used where applicable.

- Roll the blanket slowly down the slope as the installer walks backwards.

**NOTE:** The blanket rests against the installer’s legs. Staples are installed as the blanket is unrolled. It is critical that the proper staple pattern in used for the blanket being installed. The blanket should not be allowed to roll down the slope on its own as this stretches the blanket, making it impossible to maintain soil contact. In addition, no one should be allowed to walk on the blanket after it is in place.

- If the blanket is not long enough to cover the entire slope length, the trailing edge of the upper blanket should overlap the leading edge of the lower blanket and be stapled. On steeper slopes, this overlap should be installed in a small trench, covered with soil and stapled.
- With the variety of products available, it is impossible to cover all the details of appropriate use and installation. Therefore, it is critical that the design engineer consults the manufacturer's information and that a site visit takes place in order to insure that the product specified is appropriate. Information is also available at the WSDOT website:

  http://www.wsdot.wa.gov/environment/

- Jute matting must be used in conjunction with mulch (BMP C121). Excelsior, woven straw blankets, and coir (coconut fiber) blankets may be installed without mulch. There are many other types of erosion control nets and blankets on the market that may be appropriate in certain circumstances.
- In general, most nets (e.g., jute matting) require mulch in order to prevent erosion because they have a fairly open structure. Blankets typically do not require mulch because they usually provide complete protection of the surface.
- Extremely steep, unstable, wet, or rocky slopes are often appropriate candidates for use of synthetic blankets, as are riverbanks, beaches, and other high-energy environments. If synthetic blankets are used, the soil should be hydromulched first.
- 100 percent biodegradable blankets are available for use in sensitive areas. These organic blankets are usually held together with a paper or fiber mesh and stitching which may last up to a year.

- Most netting used with blankets is photodegradable, meaning it will break down under sunlight (not UV stabilized). However, this process can take months or years even under bright sun. Once vegetation is established, sunlight does not reach the mesh. It is not uncommon to find non-degraded netting still in place several years after installation. This can be a problem if maintenance requires the use of mowers or ditch cleaning equipment. In addition, birds and small animals can become trapped in the netting.

#### 3.1.10.4 Maintenance Standards

- Good contact with the ground must be maintained, and erosion must not occur beneath the net or blanket.
- Repair or staple any areas of the net or blanket that are damaged or not in close contact with the ground.
- If erosion occurs due to poorly controlled drainage, fix the problem and protect the eroded area.

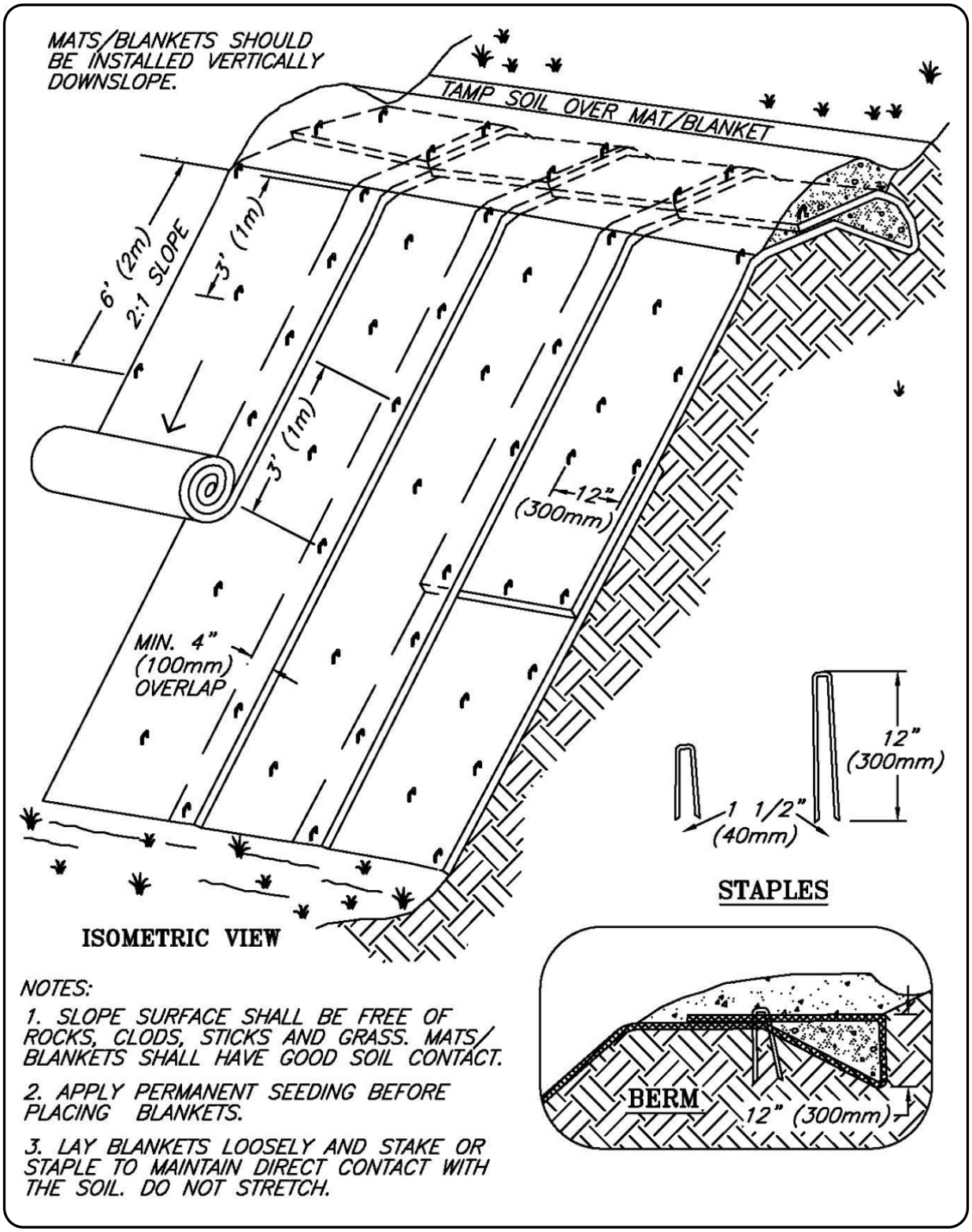



***Figure 2 - 5. Nets and Blankets – Slope Installation***

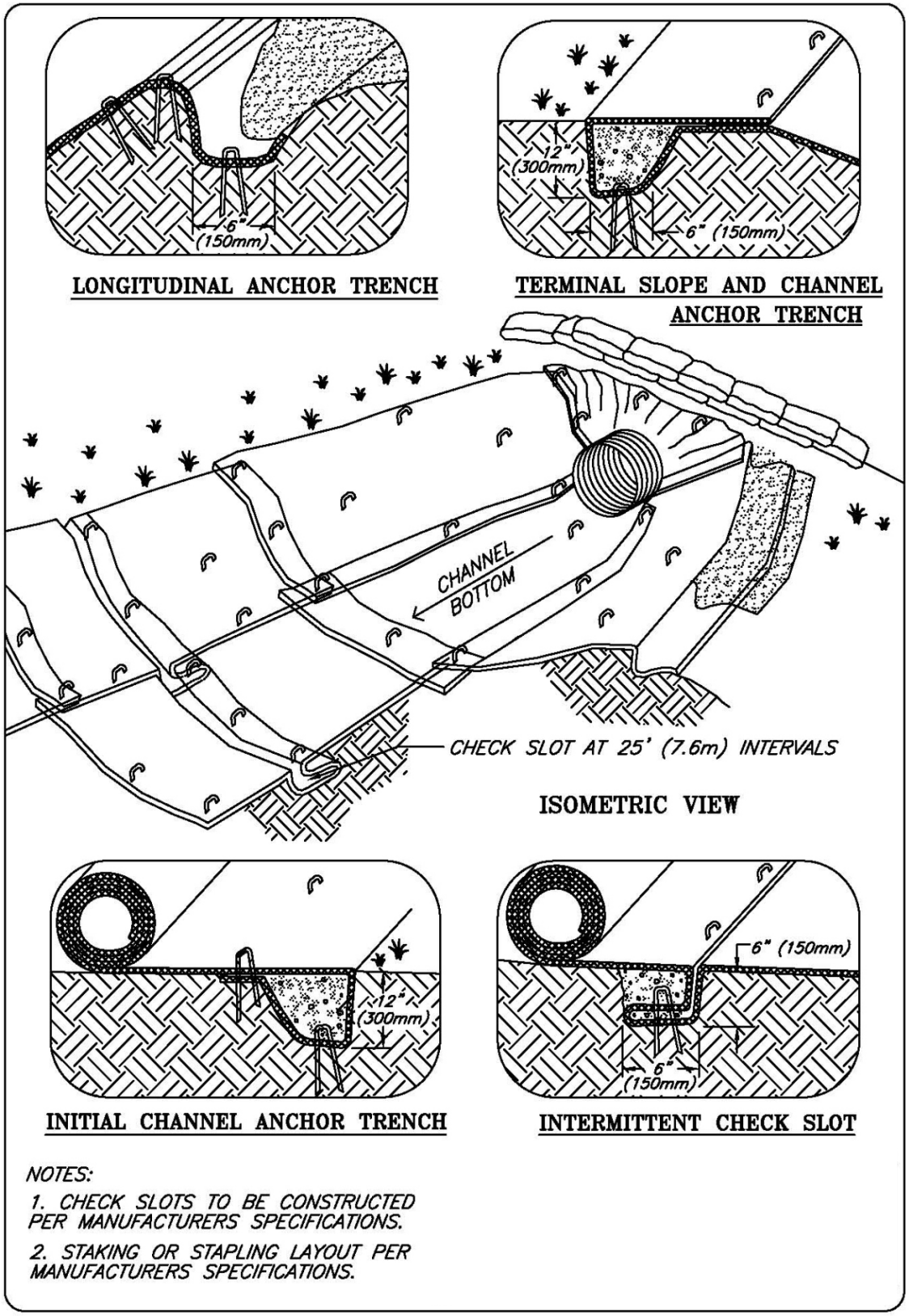



***Figure 2 - 6. Nets and Blankets – Channel Installation***

## 3.1.13 BMP C125: Compost

### 3.1.13.1 Purpose

The purpose of compost is to help establish vegetation and filter stormwater thus removing fine sediment and other contaminants. Compost can be used alone as a compost blanket, as a berm, or inside a sock.

### 3.1.13.2 Conditions of Use

- Do not use if stormwater will discharge to a nutrient sensitive waterbody.
- Do not use as a storm drain inlet protection measure.

### 3.1.13.3 Design and Installation Specifications

**Compost Blankets**

Compost blankets are simply compost blanketed over an area.

- Place compost 3" thick.
- Compost can be blown onto slopes up to 2:1 or spread by hand on shallower slopes.
- Compost must be ¾ to 1 inch-minus screened compost meeting Ecology's requirements for Grade A quality compost. See http://www.ecy.wa.gov/programs/swfa/compost for more information on compost quality.
- Compost can be mixed with a seed mix to ensure rapid vegetation.
- Compost does not need to be removed after construction phase unless required by the project engineer or geotechnical professional.

**Compost Berms**

Compost berms are a perimeter sediment control that can be used instead of silt fence.

- Do not use compost berms on steep slopes.
- Berm width shall be a minimum of 2 feet.
- Berm height shall be a minimum of 12 inches.
- Berm width shall be twice the berm height.

Compost can be blown in place or placed by front-end loader. Compost must be ¾ to 1 inch-minus screened compost meeting Ecology's requirements for Grade A quality compost. See http://www.ecy.wa.gov/programs/swfa/compost for more information on compost quality.

Compost should be spread over proposed landscaped section when construction is complete to aid in revegetation.

**Compost Socks**

Compost socks are similar to straw wattles.

- Sock material that is biodegradable will last up to 6 months and can be used for soil amendment after 6 months.
- Sock material that is non-biodegradable must be removed after construction is complete.
- Place socks perpendicular to flow.
- Walk socks in place to ensure good soil contact.
- Install wooden stakes every 12” on steep slopes or every 24” on shallow slopes

### 3.1.13.4 Maintenance Standards

**Compost Blankets**

- Inspect compost regularly.
- Ensure a 3” thick blanket.

**Compost Berms**

- Inspect compost berm regularly.
- Ensure vehicular traffic does not cross berm and track compost offsite. If this occurs, sweep compost immediately.

**Compost Socks**

- Do not allow erosion or concentrated runoff under or around the barrier.
- Inspect the socks after each rainfall and repair any socks that tear or are not abutting the ground.

## 3.1.14 BMP C126: Topsoiling

### 3.1.14.1 Purpose

To provide a suitable growth medium for final site stabilization with vegetation. While not a permanent cover practice in itself, topsoiling is an integral component of providing permanent cover in those areas where there is an unsuitable soil surface for plant growth. Native soils and disturbed soils that have been organically amended not only retain much more stormwater, but they also serve as effective biofilters for urban pollutants and, by supporting more vigorous plant growth, reduce the amount of water, fertilizer, and pesticides needed to support installed landscapes. Topsoil does not include any subsoils, only the material from the top several inches, including organic debris.

### 3.1.14.2 Conditions of Use

Native soils should be left undisturbed to the maximum extent practicable. Native soils disturbed during clearing and grading should be restored, to the maximum extent practicable, to a condition where moisture-holding capacity is equal to or better than the original site conditions. This criterion can be met by using onsite native topsoil, incorporating amendments into onsite soil, or importing blended topsoil.

- Topsoiling is a required procedure when establishing vegetation on shallow soils, and soils of critically low pH (high acid) levels.
- Stripping of the existing, properly functioning soil system and vegetation for the purpose of topsoiling during construction is not acceptable. If an existing soil system is functioning properly, it shall be preserved in its undisturbed and uncompacted condition.
- Depending on where the topsoil comes from, or what vegetation was on site before disturbance, invasive plant seeds may be included and could cause problems for establishing native plants, landscaped areas, or grasses.
- Topsoil from the site will contain mycorrhizal bacteria that are necessary for healthy root growth and nutrient transfer. These native mycorrhiza are acclimated to the site and will provide optimum conditions for establishing grasses. Commercially available mycorrhiza products should be used when topsoil is brought in from offsite.

### 3.1.14.3 Design and Installation Specifications

If topsoiling is to be done, the following items should be considered:

- Maximize the depth of the topsoil wherever possible to provide the maximum possible infiltration capacity and beneficial growth medium. Topsoil depth shall be at least 8 inches with a minimum organic content of 10 percent dry weight and pH between 6.0 and 8.0 or matching the pH of the undisturbed soil. This can be accomplished either by returning native topsoil to the site and/or incorporating organic amendments. Organic amendments should be incorporated to a minimum 8-inch depth except where tree roots or other natural features limit the depth of incorporation. Subsoils below the 12-inch depth should be scarified at least 4 inches to avoid stratified layers, where feasible. The decision to either layer topsoil over a subgrade or incorporate topsoil into the underlying layer may vary depending on the planting specified.
- If blended topsoil is imported, fines should be limited to 25 percent passing through a 200 sieve.
- The final composition and construction of the soil system will result in a natural selection or favoring of certain plant species over time. For example, recent practices have shown

that incorporation of topsoil may favor grasses, while layering with mildly acidic, high-carbon amendments may favor more woody vegetation.

- Locate the topsoil stockpile so it meets specifications and does not interfere with work on the site. It may be possible to locate more than one pile in proximity to areas where topsoil will be used.
- Allow sufficient time in scheduling for topsoil to be spread prior to seeding, sodding, or planting.
- Care must be taken not to apply topsoil over subsoil if the two soils have contrasting textures. Sandy topsoil over clayey subsoil is a particularly poor combination, as water creeps along the junction between the soil layers and causes the topsoil to slough.
- If topsoil and subsoil are not properly bonded, water will not infiltrate the soil profile evenly and it will be difficult to establish vegetation. The best method to prevent a lack of bonding is to work the topsoil into the layer below for a depth of at least 6 inches.
- Ripping or re-structuring the subgrade may also provide additional benefits regarding the overall infiltration and interflow dynamics of the soil system.
- Field exploration of the site shall be made to determine if there is surface soil of sufficient quantity and quality to justify stripping. Topsoil shall be friable and loamy (loam, sandy loam, silt loam, sandy clay loam, clay loam). Areas of natural groundwater recharge should be avoided.
- Confine stripping to the immediate construction area. A 4- to 6- inch stripping depth is common, but depth may vary depending on the particular soil. Place all surface runoff control structures in place prior to stripping.

Stockpile topsoil in the following manner:

- Side slopes of the stockpile shall not exceed 2:1.
- Surround all topsoil stockpiles between October 1 and April 30 with an interceptor dike with gravel outlet and silt fence. Between May 1 and September 30, install an interceptor dike with gravel outlet and silt fence if the stockpile will remain in place for a longer period of time than active construction grading.
- Complete erosion control seeding or covering with clear plastic or other mulching materials of stockpiles within 2 days (October 1 through April 30) or 7 days (May 1 through September 30) of the formation of the stockpile. Do not cover native topsoil stockpiles with plastic.
- Topsoil shall not be placed while in a frozen or muddy condition, when the subgrade is excessively wet, or when conditions exist that may otherwise be detrimental to proper grading or proposed sodding or seeding.
- Maintain previously established grades on the areas to be topsoiled according to the approved plan.
- When native topsoil is to be stockpiled and reused, the following should apply to ensure that the mycorrhizal bacterial, earthworms, and other beneficial organisms will not be destroyed:
    - Topsoil is to be re-installed within 4 to 6 weeks;
    - Topsoil is not to become saturated with water;
    - Plastic cover is not allowed.

#### 3.1.14.4 Maintenance Standards

Inspect stockpiles regularly, especially after large storm events. Stabilize any areas that have eroded.

## 3.1.24 BMP C160: Certified Erosion and Sediment Control Lead

### 3.1.24.1 Purpose

The project proponent designates at least one person as the responsible representative in charge of erosion and sediment control (ESC) and water quality protection. The designated person shall be the erosion and sediment control (ESC) lead, who is responsible for ensuring compliance with all local, state, and federal erosion and sediment control and water quality requirements.

### 3.1.24.2 Conditions of Use

An erosion and sediment control contact is required for all project sites. A certified erosion and sediment control lead (CESCL) or certified professional in erosion and sediment control (CPESC) is required on projects that include, but are not limited to:

- Construction activity that disturbs one acre of land or more.
- Construction activity that disturbs less than one acre of land, but is part of a larger common plan of development or sale that will ultimately disturb one acre of land or more.
- Heavy construction of roads, bridges, highways, airports, buildings.
- Projects near wetlands and sensitive or critical areas.
- Projects in or over water.

### 3.1.24.3 Specifications

The ESC lead shall:

- Have a current certified erosion and sediment control lead (CESCL) certificate proving attendance in an erosion and sediment control training course that meets the minimum ESC training and certification requirements established by Ecology. Ecology will maintain a list of ESC training and certification providers at: www.ecy.wa.gov/programs/wq/stormwater.

  OR

- Be a Certified Professional in Erosion and Sediment Control (CPESC). For additional information go to: www.cpesc.net

The ESC lead shall have authority to act on behalf of the contractor or developer and shall be available, on call, 24 hours per day throughout the period of construction.

The Construction SWPPP shall include the name, telephone number, fax number, and address of the designated ESC lead.

An ESC lead may provide inspection and compliance services for multiple construction projects in the same geographic region.

Duties and responsibilities of the ESC lead shall include, but are not limited to, the following:

- Maintaining a permit file on site at all times which includes the SWPPP and any associated permits and plans.
- Directing BMP installation, inspection, maintenance, modification, and removal.
- Updating all project drawings and the Construction SWPPP with changes made.
- Keeping daily logs and inspection reports. Inspection reports should include:

- Inspection date/time.
- Weather information, general conditions during inspection, and approximate amount of precipitation since the last inspection.
- A summary or list of all BMPs implemented, including observations of all erosion/ sediment control structures or practices. The following shall be noted:
  - Locations of BMPs inspected,
  - Locations of BMPs that need maintenance,
  - Locations of BMPs that failed to operate as designed or intended, and
  - Locations where additional or different BMPs are required.
- Visual monitoring results, including a description of discharged stormwater. The presence of suspended sediment, turbid water, discoloration, and oil sheen shall be noted, as applicable.
- Any water quality monitoring performed during inspection.
- General comments and notes, including a brief description of any BMP repairs, maintenance, or installations made as a result of the inspection.

- Facilitate, participate in, and take corrective actions resulting from inspections performed by outside agencies or the owner.
- Keep an inventory of equipment onsite.

## 3.1.26 BMP C162: Scheduling

### 3.1.26.1 Purpose

Sequencing a construction project reduces the amount and duration of soil exposed to erosion by wind, rain, runoff, and vehicle tracking.

### 3.1.26.2 Conditions of Use

The construction sequence schedule is an orderly listing of all major land-disturbing activities together with the necessary erosion and sedimentation control measures planned for the project. This type of schedule guides the contractor on work to be done before other work is started so serious erosion and sedimentation problems can be avoided.

Following a specified work schedule that coordinates the timing of land-disturbing activities and the installation of control measures is perhaps the most cost-effective way of controlling erosion during construction. The removal of surface ground cover leaves a site vulnerable to accelerated erosion. Construction procedures that limit land clearing, provide timely installation of erosion and sedimentation controls, and restore protective cover quickly can significantly reduce the erosion potential of a site.

### 3.1.26.3 Design Considerations

- Avoid rainy periods.
- Schedule projects to disturb only small portions of the site at any one time. Complete grading as soon as possible. Immediately stabilize the disturbed portion before grading the next portion. Practice staged seeding in order to revegetate cut and fill slopes as the work progresses.

## 3.2.11 BMP C220: Storm Drain Inlet Protection

### 3.2.11.1 Purpose

To prevent coarse sediment from entering drainage systems prior to permanent stabilization of the disturbed area.

### 3.2.11.2 Conditions of Use

Where storm drain inlets are to be made operational before permanent stabilization of the disturbed drainage area.

Provide protection for all storm drain inlets downslope and within 500 feet of a disturbed or construction area, unless the runoff that enters the catch basin will be conveyed to a sediment pond or trap. Inlet protection may be used anywhere to protect the drainage system. It is likely that the drainage system will still require cleaning.

Table 2 - 9 lists several options for inlet protection. All of the methods for storm drain inlet protection are prone to plugging and require a high frequency of maintenance. Drainage areas should be limited to 1 acre or less. Emergency overflows may be required where stormwater ponding would cause a hazard. If an emergency overflow is provided, additional end-of-pipe treatment may be required.

Only bag filter type catch basin filters (per Section 3.2.11.3) are allowed within the right of way.

***Table 2 - 9: Storm Drain Inlet Protection***

| Type of Inlet Protection | Emergency Overflow | Applicable for Paved/Earthen Surfaces | Conditions of Use |
|---|---|---|---|
| Excavated drop inlet protection | Yes, temporary flooding will occur | Earthen | Applicable for heavy flows. Easy to maintain. Large area requirement: 30’ x 30’ per acre. |
| Block and gravel drop filter | Yes | Paved or earthen | Applicable for heavy concentrated flows. Will not pond. |
| Gravel and mesh filter | No | Paved | Applicable for heavy concentrated flows. Will pond. Can withstand traffic. |
| Catch basin filters | Yes | Paved or earthen | Frequent maintenance required. |
| Curb inlet protection with a wooden weir | Small capacity overflow | Paved | Used for sturdy, more compact installation. |
| Block and gravel curb inlet protection | Yes | Earthen | Sturdy, but limited filtration. |

### 3.2.11.3 Design and Installation Specifications

#### *Excavated Drop Inlet Protection*

An excavated impoundment around the storm drain. Sediment settles out of the stormwater prior to entering the storm drain.

- Depth 1 to 2 feet, as measured from the crest of the inlet structure.
- Side slopes of excavation no steeper than 2H:1V.

- Minimum volume of excavation 35 cubic yards.
- Shape basin to fit site with longest dimension oriented toward the longest inflow area.
- Install provisions for draining to prevent standing water problems.
- Clear the area of all debris.
- Grade the approach to the inlet uniformly.
- Drill weep holes into the side of the inlet.
- Protect weep holes with screen wire and washed aggregate.
- Seal weep holes when removing structure and stabilizing area.
- It may be necessary to build a temporary dike to the down slope side of the structure to prevent bypass flow.

### *Block and Gravel Filter*

A barrier formed around the storm drain inlet with standard concrete blocks and gravel. See Figure 2 - 20.

- Height 1 to 2 feet above inlet.
- Recess the first row 2 inches into the ground for stability.
- Support subsequent courses by placing a piece of 2x4 lumber through the block opening.
- Do not use mortar.
- Lay some blocks in the bottom row on their side for dewatering the pool.
- Place hardware cloth or comparable wire mesh with ½-inch openings over all block openings.
- Place gravel just below the top of blocks on slopes of 2H:1V or flatter.
- An alternative design is a gravel donut.
- Inlet slope of 3H:1V.
- Outlet slope of 2H:1V.
- 1-foot wide level stone area between the structure and the inlet.
- Inlet slope stones 3 inches in diameter or larger.
- Outlet slope use gravel ½- to ¾-inch at a minimum thickness of 1-foot.

### *Gravel and Wire Mesh Filter*

A gravel barrier placed over the top of the inlet (see Figure 2 - 21). This structure does not provide an overflow.

- Hardware cloth or comparable wire mesh with ½-inch openings.
- Coarse aggregate.
- Place wire mesh over the drop inlet so that the wire extends a minimum of 1-foot beyond each side of the inlet structure.
- If more than one strip of mesh is necessary, overlap the strips.
- Place coarse aggregate over the wire mesh.

- The depth of the gravel should be at least 12 inches over the entire inlet opening and extend at least 18 inches on all sides.

### *Catchbasin Filters*

Inserts (Figure 2 - 22) shall be designed by the manufacturer for use at construction sites. The limited sediment storage capacity increases the frequency of inspection and maintenance required, which may be daily for heavy sediment loads. The maintenance requirements can be reduced by combining a catchbasin filter with another type of inlet protection. This type of inlet protection provides flow bypass without overflow and therefore may be a better method for inlets located along active rights-of-way.

- Should have a minimum of 5 cubic feet of storage.
- Dewatering provisions.
- High-flow bypass that will not clog under normal use at a construction site.
- The catchbasin filter is inserted in the catchbasin just below the grating.
- Only bag filter type catch basin filters are allowed in the City right-of-way.

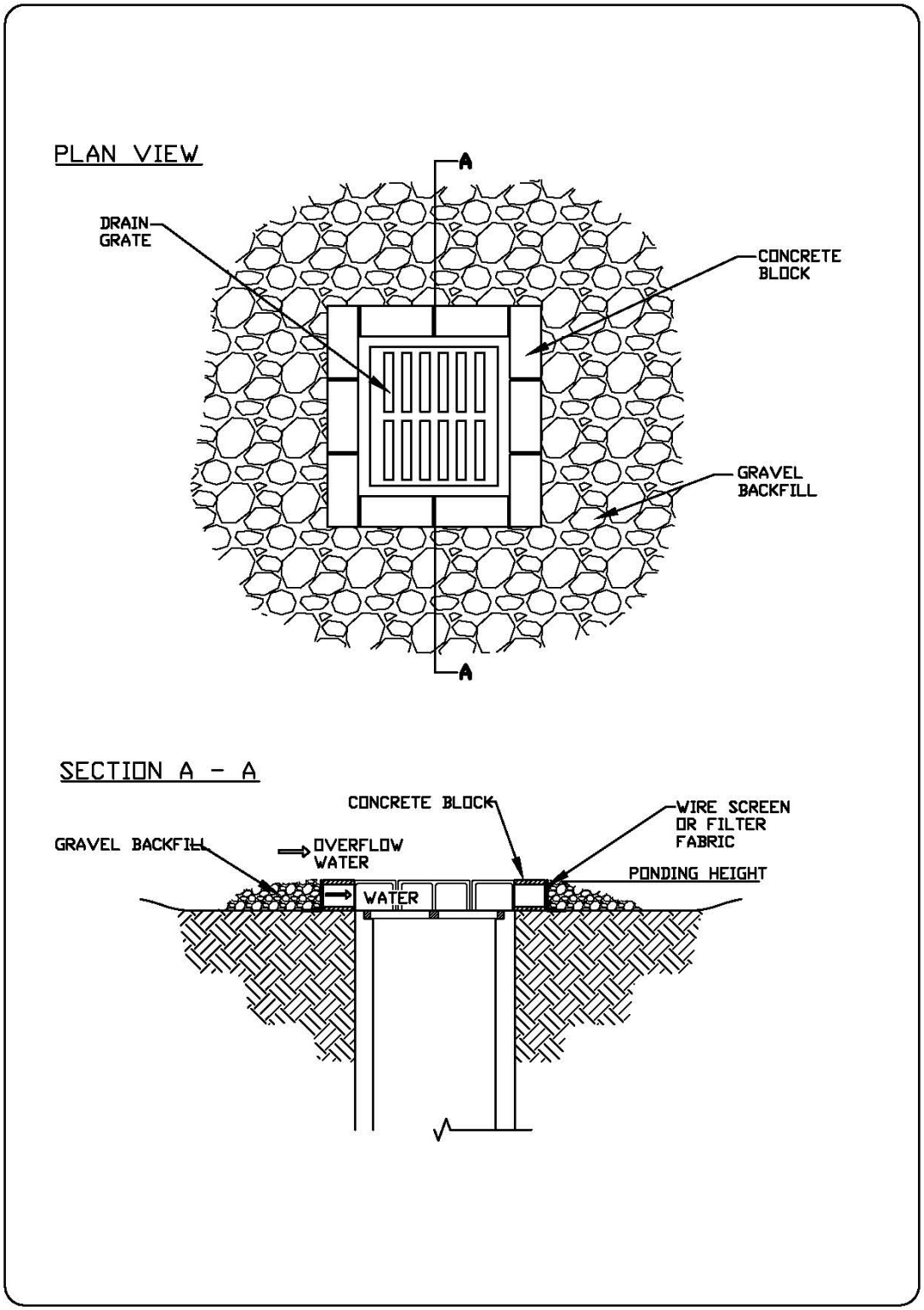



***Figure 2 - 20. Drop Inlet with Block and Gravel Filter***

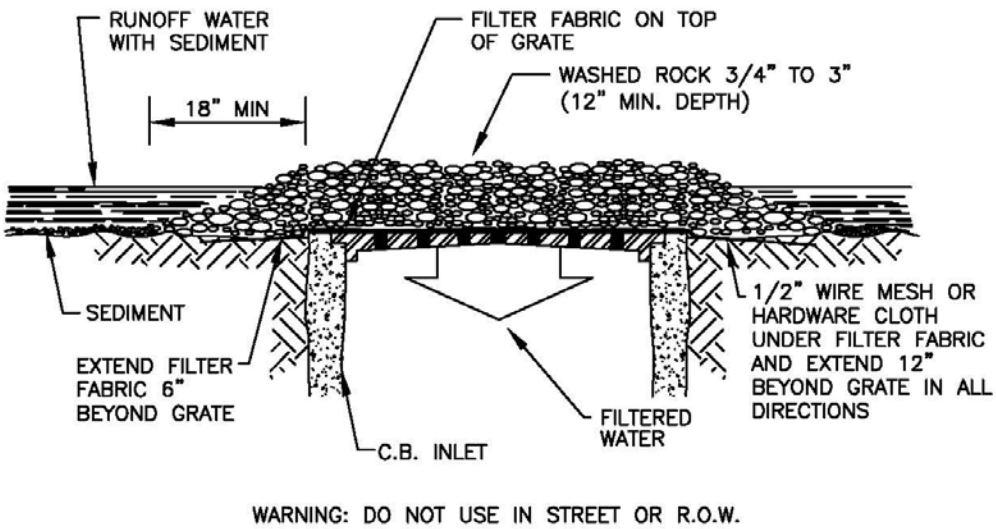
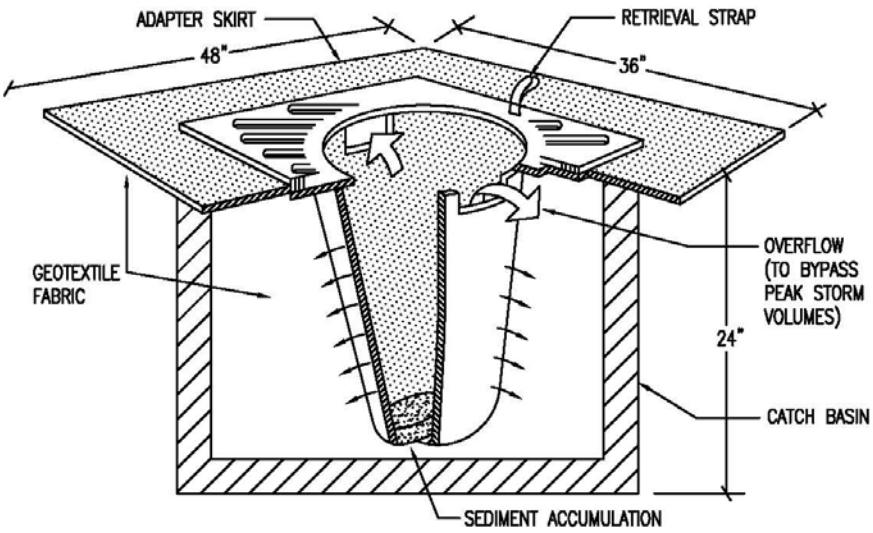



***Figure 2 - 21. Gravel and Wire Mesh Filter***




*INLET PROTECTION NOTES:*

1. FILTERS SHALL BE INSPECTED AFTER EACH STORM EVENT AND CLEANED OR REPLACED WHEN 1/3 FULL.

**BAG FILTER**

NOT TO SCALE

***Figure 2 - 22. Catchbasin Filter***

### *Curb Inlet Protection with Wooden Weir*

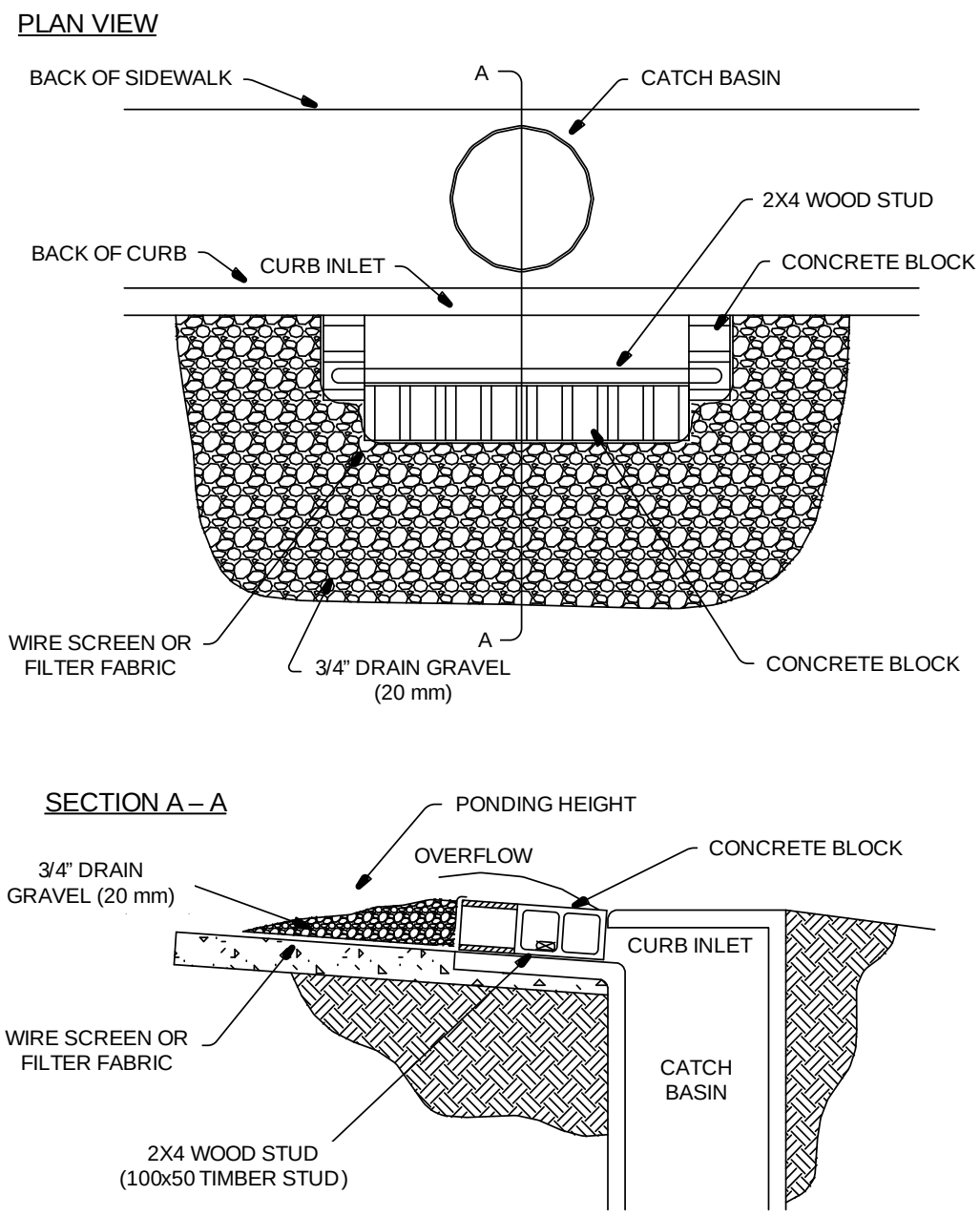
Barrier formed around a curb inlet with a wooden frame and gravel.

- Wire mesh with ½-inch openings.
- Extra strength filter cloth.
- Construct a frame.
- Attach the wire and filter fabric to the frame.
- Pile coarse washed aggregate against the wire and fabric.
- Place weight on frame anchors.

### *Block and Gravel Curb Inlet Protection*

Barrier formed around an inlet with concrete blocks and gravel. See Figure 2 - 23.

- Wire mesh with ½-inch openings.
- Place two concrete blocks on their sides abutting the curb at either side of the inlet opening. These are spacer blocks.
- Place a 2x4 stud through the outer holes of each spacer block to align the front blocks.
- Place blocks on their sides across the front of the inlet and abutting the spacer blocks.
- Place wire mesh over the outside vertical face.
- Pile coarse aggregate against the wire to the top of the barrier.




**NOTE:**
1. USE BLOCK AND GRAVEL TYPE SEDIMENT BARRIER WHEN CURB INLET IS LOCATED IN GENTLY SLOPING STREET SEGMENT, WHERE WATER CAN POND AND ALLOW SEDIMENT TO SEPARATE FROM RUNOFF.
2. BARRIER SHALL ALLOW FOR OVERFLOW FROM SEVERE STORM EVENT.
3. INSPECT BARRIERS AND REMOVE SEDIMENT AFTER EACH STORM EVENT. SEDIMENT AND GRAVEL MUST BE REMOVED FROM THE TRAVELED WAY IMMEDIATELY.

***Figure 2 - 23. Block and Gravel Curb Inlet Protection***

***Curb and Gutter Sediment Barrier***

Sandbag or rock berm (riprap and aggregate) 3 feet high and 3 feet wide in a horseshoe shape. See Figure 2 - 24.

- Construct a horseshoe shaped berm, faced with coarse aggregate if using riprap, 3 feet high and 3 feet wide, at least 2 feet from the inlet.
- Construct a horseshoe shaped sedimentation trap on the outside of the berm sized to sediment trap standards for protecting a culvert inlet.
- Sandbag must be gravel filled.

### 3.2.11.4 Maintenance Standards

Inspect catch basin filters frequently, especially after storm events. If the insert becomes clogged, clean or replace it.

- For systems using stone filters: If the stone filter becomes clogged with sediment, the stones must be pulled away from the inlet and cleaned or replaced. Since cleaning of gravel at a construction site may be difficult, an alternative approach would be to use the clogged stone as fill and put fresh stone around the inlet.
- Do not wash sediment into storm drains while cleaning. Spread all excavated material evenly over the surrounding land area or stockpile and stabilize as appropriate.
- Do not allow accumulated sediment to enter the storm drain system.

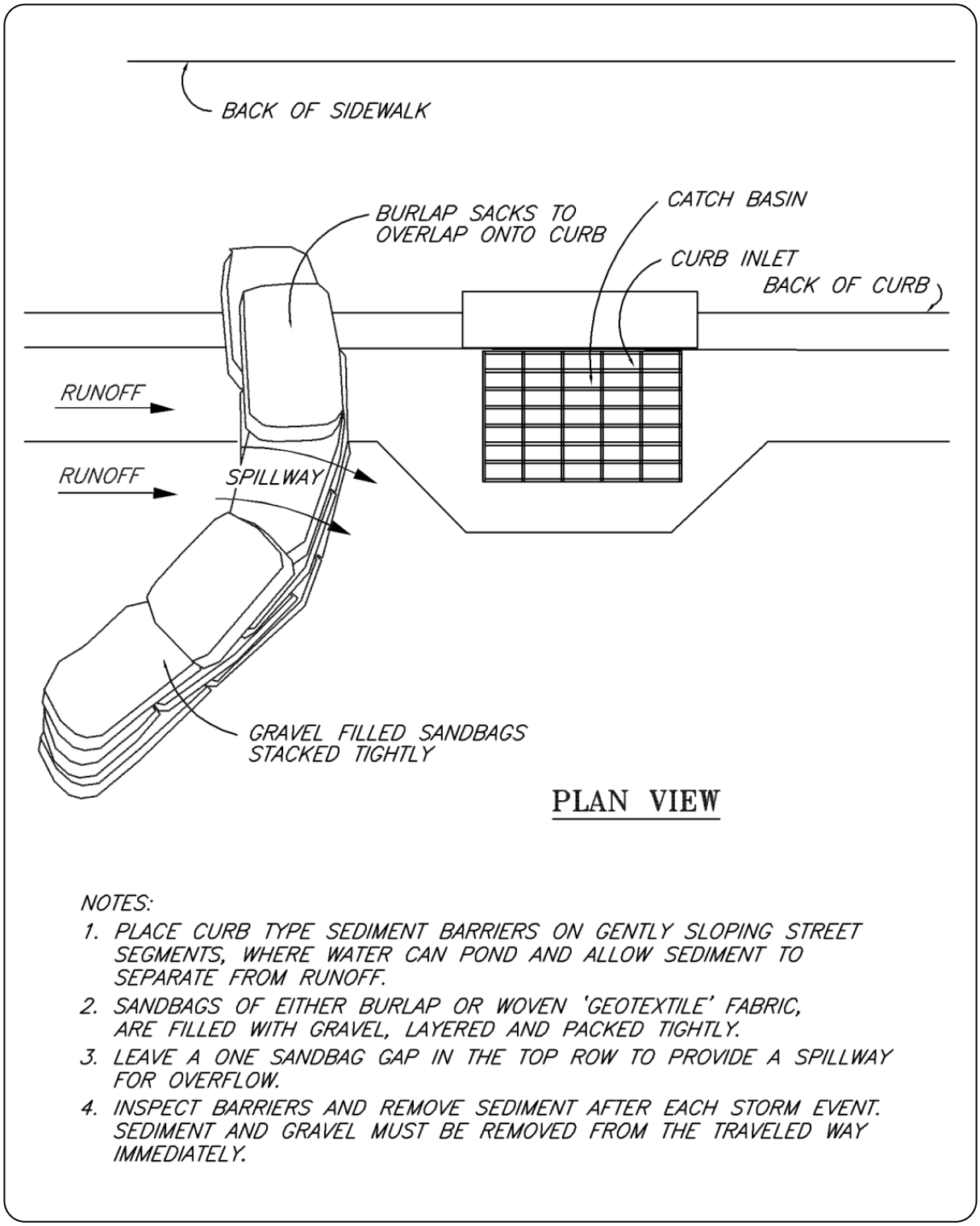



***Figure 2 - 24. Curb and Gutter Sediment Barrier***

## 3.2.14 BMP C233: Silt Fence

### 3.2.14.1 Purpose

Use of a silt fence reduces the transport of coarse sediment from a construction site by providing a temporary physical barrier to sediment and reducing the runoff velocities of overland flow. See Figure 2 - 26 for details on silt fence construction.

### 3.2.14.2 Conditions of Use

Silt fence may be used downslope of all disturbed areas.

- Silt fence is not intended to treat concentrated flows, nor is it intended to treat substantial amounts of overland flow. Convey any concentrated flows through the drainage system to a sediment pond. The only circumstance in which overland flow can be treated solely by a silt fence is when the area draining to the fence is one acre or less and flow rates are less than 0.5 cfs.
- Do not construct silt fences in streams or use them in V-shaped ditches. They are not an adequate method of silt control for anything deeper than sheet or overland flow.

### 3.2.14.3 Design and Installation Specifications

Drainage area of 1 acre or less or in combination with appropriate sediment removal BMPs on larger sites.

Maximum slope steepness (perpendicular to fence line) 1H:1V.

- Maximum sheet or overland flow path length to the fence of 100 feet.
- No flows greater than 0.5 cubic feet per second.
- The geotextile used shall meet the following standards. All geotextile properties listed below are minimum average roll values (i.e., the test result for any sampled roll in a lot shall meet or exceed the values shown in Table 2 - 10).

***Table 2 - 10: Geotextile Standards***

| Standard | Description |
|---|---|
| Polymeric Mesh AOS (ASTM D4751) | 0.60 mm maximum for slit film wovens (#30 sieve). 0.30 mm maximum for all other geotextile types (#50 sieve). 0.15 mm minimum for all fabric types (#100 sieve). |
| Water Permittivity (ASTM D4491) | 0.02 $sec^{-1}$ minimum |
| Grab Tensile Strength (ASTM D4632) | 180 lbs. minimum for extra strength fabric.<br>100 lbs. minimum for standard strength fabric. |
| Grab Tensile Strength (ASTM D4632) | 30% maximum |
| Ultraviolet Resistance (ASTM D4355) | 70% minimum |

- Support standard strength fabrics with wire mesh, chicken wire, 2-inch x 2-inch wire, safety fence, or jute mesh to increase the strength of the fabric. Silt fence materials are available that have synthetic mesh backing attached.

- Filter fabric material shall contain ultraviolet ray inhibitors and stabilizers to provide a minimum of six months of expected usable construction life at a temperature range of 0° to 120° Fahrenheit.
- 100 percent biodegradable silt fence is available that is strong and long lasting.
- The following are standard design and installation methods. Refer to Figure 2 - 26 for standard silt fence details.
    - Install and maintain temporary silt fences at the locations shown in the plans. Install the silt fences in the areas of clearing, grading, or drainage prior to starting those activities. Do not consider a silt fence temporary if the silt fence must function beyond the life of the contract. The silt fence shall prevent soil carried by runoff water from going beneath, through, or over the top of the silt fence, but shall allow the water to pass through the fence.
    - The minimum height of the top of silt fence shall be 2 feet and the maximum height shall be 2½ feet above the original ground surface.
    - Sew the geotextile together at the point of manufacture, or at an approved location as determined by the Engineer, to form geotextile lengths as required. Locate all sewn seams at a support post. Alternatively, two sections of silt fence can be overlapped, provided the Contractor can demonstrate, to the satisfaction of the Engineer, that the overlap is long enough and adjacent fence sections are close enough together to prevent silt laden water from escaping through the fence at the overlap.
    - Attach the geotextile on the up-slope side of the posts and support system with staples, wire, or in accordance with the manufacturer's recommendations. Attach the geotextile to the posts in a manner that reduces the potential for geotextile tearing at the staples, wire, or other connection device. Silt fence back-up support for the geotextile in the form of a wire or plastic mesh is dependent on the properties of the geotextile selected for use. If wire or plastic back-up mesh is used, fasten the mesh securely to the up-slope of the posts with the geotextile being up-slope of the mesh back-up support.
    - Bury the geotextile at the bottom of the fence in a trench to a minimum depth of 4 inches below the ground surface. Backfill the trench and tamp the soil in place over the buried portion of the geotextile, such that no flow can pass beneath the fence and scouring can not occur. When wire or polymeric back-up support mesh is used, the wire or polymeric mesh shall extend into the trench a minimum of 3 inches.
    - Drive fence posts in to a minimum depth of 18 inches. A minimum depth of 12 inches is allowed if topsoil or other soft subgrade soil is not present and a minimum depth of 18 inches cannot be reached. Increase fence post depths by 6 inches if the fence is located on slopes of 3H:1V or steeper and the slope is perpendicular to the fence. If required post depths cannot be obtained, adequately secure the posts by bracing or guying to prevent overturning of the fence due to sediment loading.
    - Locate the silt fences on contour as much as possible, except at the ends of the fence, where the fence shall be turned uphill such that the silt fence captures the runoff water and prevents water from flowing around the end of the fence.
    - If the fence must cross contours, with the exception of the ends of the fence, place gravel check dams perpendicular to the back of the fence to minimize concentrated flow and erosion along the back of the fence. The gravel check dams shall be

approximately 1-foot deep at the back of the fence and be perpendicular to the fence at the same elevation until the top of the check dam intercepts the ground surface behind the fence. The gravel check dams shall consist of crushed surfacing base course, gravel backfill for walls, or shoulder ballast. Locate the gravel check dams every 10 feet along the fence where the fence must cross contours. The slope of the fence line where contours must be crossed shall not be steeper than 3H:1V.

- Use wood, steel or equivalent posts. Wood posts shall have minimum dimensions of 2 inches by 2 inches by 3 feet minimum length, and shall be free of defects such as knots, splits, or gouges. Steel posts shall consist of either size No. 6 rebar or larger; ASTM A120 steel pipe with a minimum diameter of 1-inch; U, T, L, or C shape steel posts with a minimum weight of 1.35 pounds per foot; or other steel posts having equivalent strength and bending resistance to the post sizes listed. The spacing of the support posts shall be a maximum of 6 feet.
- Fence back-up support, if used, shall consist of steel wire with a maximum mesh spacing of 2 inches, or a prefabricated polymeric mesh. The strength of the wire or polymeric mesh shall be equivalent to or greater than 180 pounds grab tensile strength. The polymeric mesh must be as resistant to ultraviolet radiation as the geotextile it supports.

- Specification details for silt fence installation using the slicing method follow. Refer to Figure 2 - 27 for slicing method details.
  - The base of both end posts must be at least 2 to 4 inches above the top of the silt fence fabric on the middle posts for ditch checks to drain properly. Use a hand level or string level, if necessary, to mark base points before installation.
  - Install posts 3 to 4 feet apart in critical retention areas and a maximum of 6 feet apart in standard applications. If wire backing is used, post spacing may be increased to 8-foot maximum.
  - Install posts 24 inches deep on the downstream side of the silt fence, and as close as possible to the fabric, enabling posts to support the fabric from upstream water pressure.
  - Install posts with the nipples facing away from the silt fence fabric.
  - Attach the fabric to each post with three ties, all spaced within the top 8 inches of the fabric. Attach each tie diagonally 45 degrees through the fabric, with each puncture at least 1 inch vertically apart. In addition, each tie should be positioned to hang on a post nipple when tightening to prevent sagging.
  - Wrap approximately 6 inches of fabric around the end posts and secure with 3 ties.
  - No more than 24 inches of a 36-inch fabric is allowed above ground level.
  - The installation should be checked and corrected for any deviation before compaction. Use a flat-bladed shovel to tuck fabric deeper into the ground, if necessary.
  - Compaction is vitally important for effective results. Compact the soil immediately next to the silt fence fabric with the front wheel of a tractor, skid steer, or roller exerting at least 60 pounds per square inch. Compact the upstream side first and then each side twice for a total of four trips.

### 3.2.14.4 Maintenance Standards

- Repair any damage immediately.
- If concentrated flows are evident uphill of the fence, intercept and convey them to a sediment pond.
- It is important to check the uphill side of the fence for signs of the fence clogging, acting as a barrier to flow, and then causing channelization of flows parallel to the fence. If this occurs, replace the fence or remove the trapped sediment.
- Remove sediment deposits when the deposit reaches approximately one-third the height of the silt fence, or install a second silt fence.
- If the filter fabric (geotextile) has deteriorated due to ultraviolet breakdown, replace it.

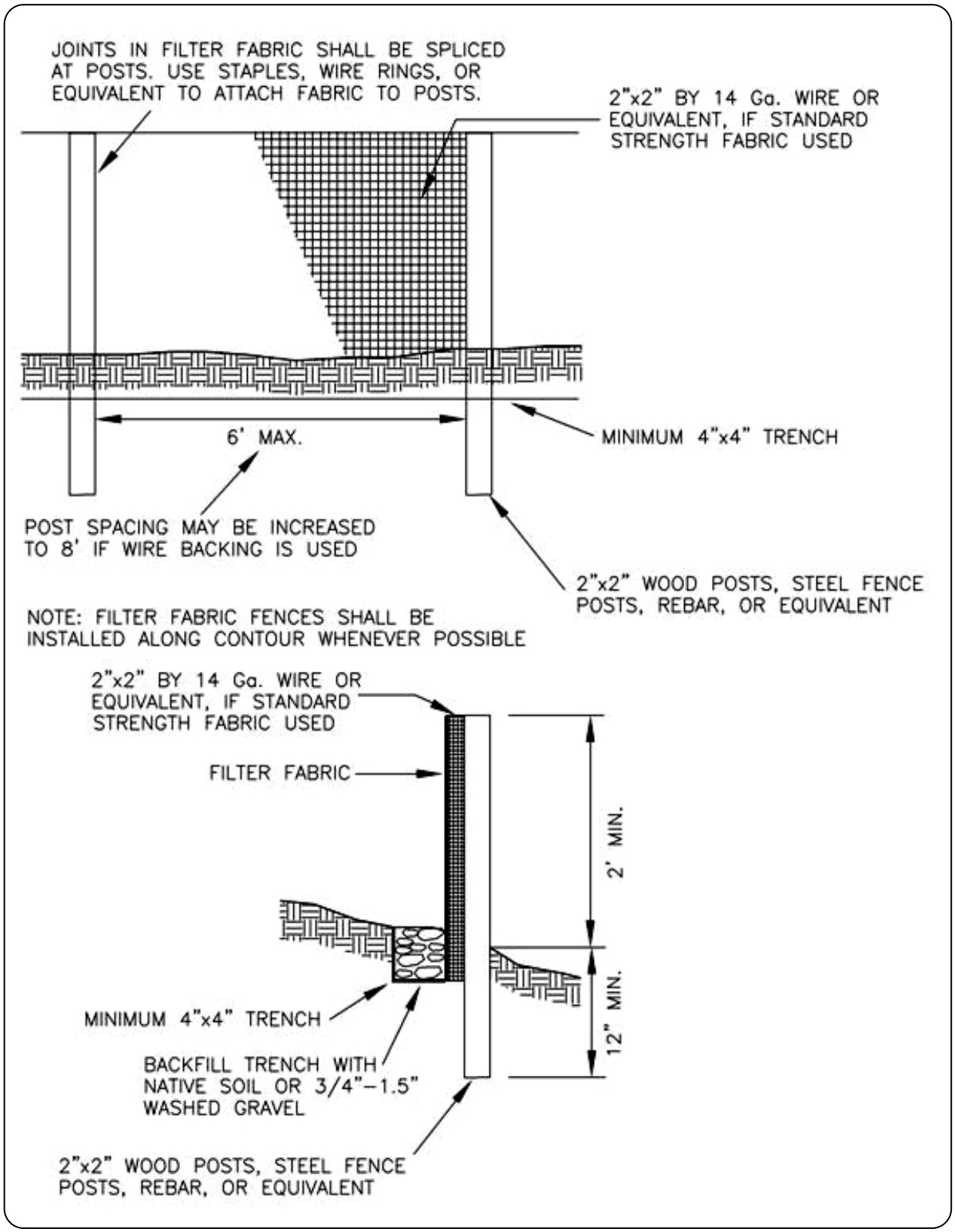



***Figure 2 - 26. Silt Fence***

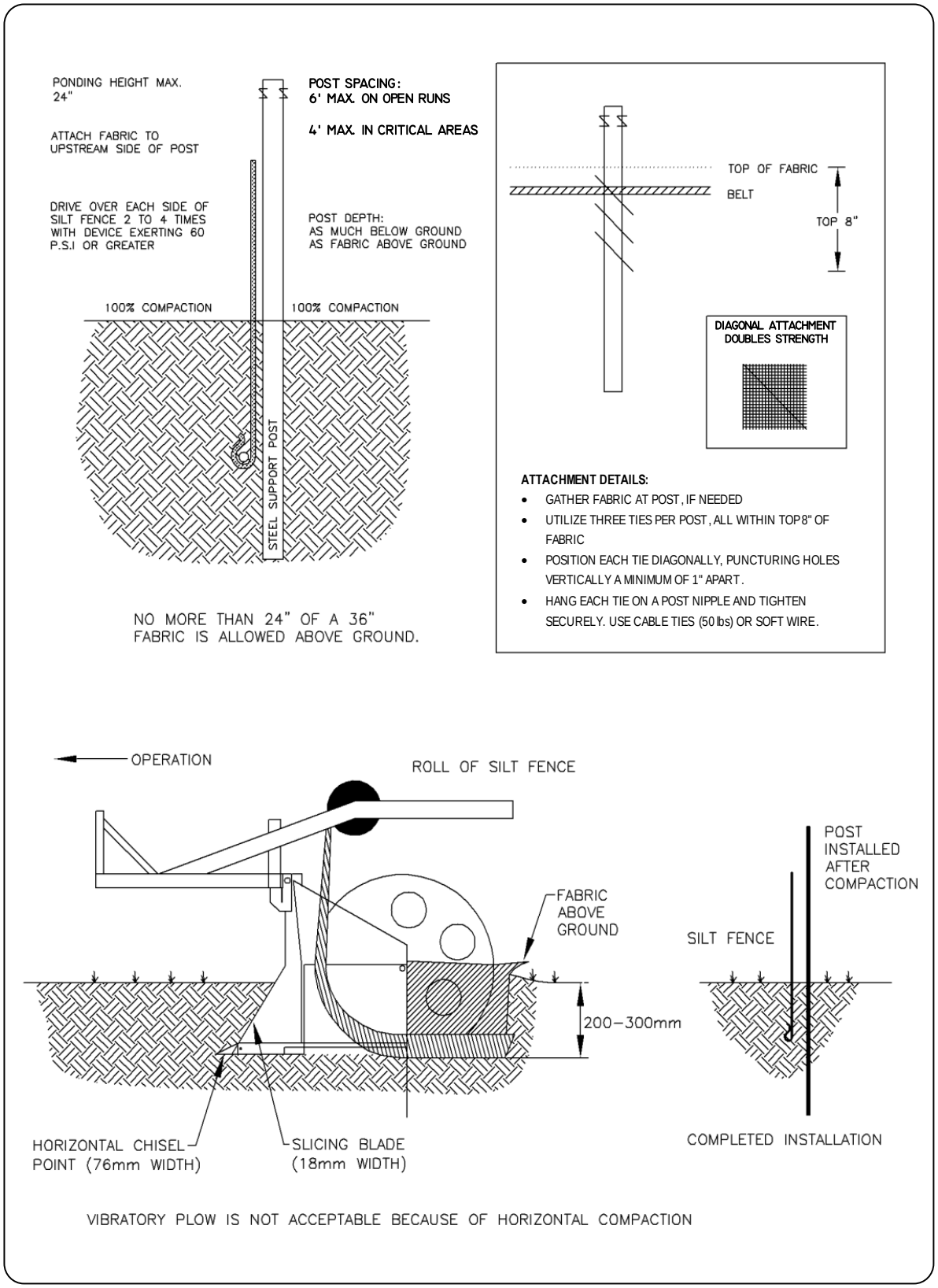



***Figure 2 - 27. Silt Fence Installation by Slicing***

## 3.2.16 BMP C235: Straw Wattles

### 3.2.16.1 Purpose

Straw wattles are temporary erosion and sediment control barriers consisting of straw that is wrapped in biodegradable tubular plastic or similar encasing material. They reduce the velocity and can spread the flow of rill and sheet runoff, and can capture and retain sediment. Straw wattles are typically 8 to 10 inches in diameter and 25 to 30 feet in length. The wattles are placed in shallow trenches and staked along the contour of disturbed or newly constructed slopes. See Figure 2 - 28 for typical construction details.

### 3.2.16.2 Conditions of Use

- Disturbed areas that require immediate erosion protection.
- Exposed soils during the period of short construction delays.
- On slopes requiring stabilization until permanent vegetation can be established.
- Straw wattles are effective for one to two seasons.
- If conditions are appropriate, wattles can be staked to the ground using live cuttings for added revegetation.

### 3.2.16.3 Design Criteria

- It is critical that wattles are installed perpendicular to the flow direction and parallel to the slope contour.
- Dig narrow trenches across the slope on contour to a depth of 3 to 5 inches on clay soils and soils with gradual slopes. On loose soils, steep slopes, and areas with high rainfall, dig the trenches to a depth of 5 to 7 inches, or 1/2 to 2/3 of the thickness of the wattle.
- Start building trenches and installing wattles from the base of the slope and work up. Excavated material should be spread evenly along the uphill slope and compacted using hand tamping or other methods.
- Construct trenches at contour intervals of 3 to 30 feet apart depending on the steepness of the slope, soil type, and rainfall. The steeper the slope, the closer together the trenches shall be.
- Install the wattles snugly into the trenches and abut tightly end to end. Do not overlap the ends. Rilling can occur beneath wattles if not properly entrenched, and water can pass between wattles if not tightly abutted.
- Install stakes at each end of the wattle, and at 4-foot centers along entire length of wattle.
- If required, install pilot holes for the stakes using a straight bar to drive holes through the wattle and into the soil.
- At a minimum, wooden stakes should be approximately 3/4 x 3/4 x 24 inches. Live cuttings or 3/8-inch rebar can also be used for stakes.
- Stakes should be driven through the middle of the wattle, leaving 2 to 3 inches of the stake protruding above the wattle.

### 3.2.16.4 Maintenance Standards

- Wattles may require maintenance to ensure they are in contact with soil and thoroughly entrenched, especially after significant rainfall on steep sandy soils.
- Inspect the slope after significant storms and repair any areas where wattles are not tightly abutted or water has scoured beneath the wattles.

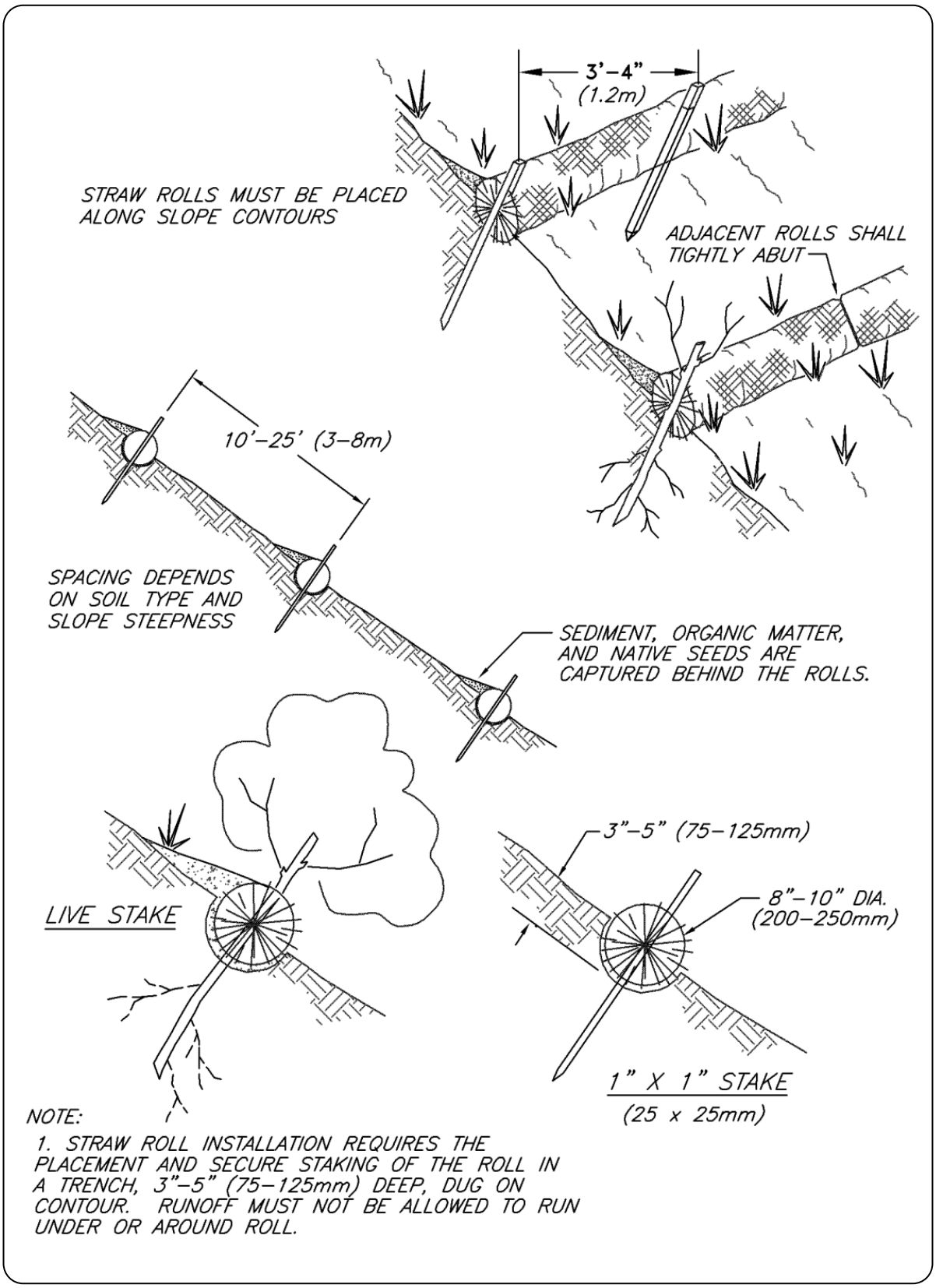



***Figure 2 - 28. Straw Wattles***

# APPENDIX B
## Opinion of Anticipated Material Quantities and Costs

# Appendix B - Opinion of Anticipated Material Quantities and Costs

| Type | Material/ Alternatives | Description | Unit Cost ($) | | Units | Quantity | Cost Range ($) | |
|---|---|---|---|---|---|---|---|---|
| | | | Low | High | | | Low | High |
| *Nets or Blankets* | Jute | Made from Jute Fiber; 100% biodegradable | $0.20 | $0.30 | SF | 63,000 | $12,600.00 | $18,900.00 |
| | Coir | Made from coconut husk; 100% biodegradable | $0.20 | $0.30 | SF | 63,000 | $12,600.00 | $18,900.00 |
| *Debris Containment* | Silt Fencing | As described in BMP C223 Tacoma Stormwater Management Manual Vol. 2 | - | $1.00 | LF | 1,200 | - | $1,200.00 |
| | Ecology Blocks | 2'Wx2'Hx3'L concrete block | $35.00 | $45.00 | each | 14 | $490.00 | $630.00 |
| | | 2'Wx2'Hx6'L concrete block | $35.00 | $45.00 | each | 7 | $245.00 | $315.00 |
| | Traffic Barriers | 120"L x 24"W x 34"H | $250.00 | $846.00 | each | 5 | $1,250.00 | $4,230.00 |
| *Wattles* | Straw | Straw bundled with biodegradable material | - | $1.00 | LF | 3,840 | - | $3,840.00 |

# APPENDIX C
## Report Limitations and Guidelines for Use

## APPENDIX C
## REPORT LIMITATIONS AND GUIDELINES FOR USE[1]

This appendix provides information to help you manage your risks with respect to the use of this report.

### Read These Provisions Closely

It is important to recognize that the geoscience practices (geotechnical engineering, geology and environmental science) rely on professional judgment and opinion to a greater extent than other engineering and natural science disciplines, where more precise and/or readily observable data may exist. To help clients better understand how this difference pertains to our services, GeoEngineers includes the following explanatory "limitations" provisions in its reports. Please confer with GeoEngineers if you need to know more how these "Report Limitations and Guidelines for Use" apply to your project or site.

### Geotechnical Services are Performed for Specific Purposes, Persons and Projects

This report has been prepared for City of Tacoma and for the Project specifically identified in the report. The information contained herein is not applicable to other sites or projects.

GeoEngineers structures its services to meet the specific needs of its clients. No party other than the party to whom this report is addressed may rely on the product of our services unless we agree to such reliance in advance and in writing. Within the limitations of the agreed scope of services for the Project, and its schedule and budget, our services have been executed in accordance with our Agreement with City of Tacoma dated September 22, 2015 and generally accepted geotechnical practices in this area at the time this report was prepared. We do not authorize, and will not be responsible for, the use of this report for any purposes or projects other than those identified in the report.

### A Geotechnical Engineering or Geologic Report is based on a Unique Set of Project-Specific Factors

This report has been prepared for the Schuster Slope Management Area Unit 1 located in Tacoma, Washington. GeoEngineers considered a number of unique, project-specific factors when establishing the scope of services for this project and report. Unless GeoEngineers specifically indicates otherwise, it is important not to rely on this report if it was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

[1] Developed based on material provided by ASFE, Professional Firms Practicing in the Geosciences; www.asfe.org.

For example, changes that can affect the applicability of this report include those that affect:

- the function of the proposed structure;
- elevation, configuration, location, orientation or weight of the proposed structure;
- composition of the design team; or
- project ownership.

If changes occur after the date of this report, GeoEngineers cannot be responsible for any consequences of such changes in relation to this report unless we have been given the opportunity to review our interpretations and recommendations. Based on that review, we can provide written modifications or confirmation, as appropriate.

### Environmental Concerns are Not Covered

Unless environmental services were specifically included in our scope of services, this report does not provide any environmental findings, conclusions, or recommendations, including but not limited to, the likelihood of encountering underground storage tanks or regulated contaminants.

### Subsurface Conditions Can Change

This geotechnical or geologic report is based on conditions that existed at the time the study was performed. The findings and conclusions of this report may be affected by the passage of time, by man-made events such as construction on or adjacent to the site, new information or technology that becomes available subsequent to the report date, or by natural events such as floods, earthquakes, slope instability or groundwater fluctuations. If more than a few months have passed since issuance of our report or work product, or if any of the described events may have occurred, please contact GeoEngineers before applying this report for its intended purpose so that we may evaluate whether changed conditions affect the continued reliability or applicability of our conclusions and recommendations.

### Geotechnical and Geologic Findings are Professional Opinions

Our interpretations of subsurface conditions are based on field observations from widely spaced sampling locations at the site. Site exploration identifies the specific subsurface conditions only at those points where subsurface tests are conducted or samples are taken. GeoEngineers reviewed field and laboratory data and then applied its professional judgment to render an informed opinion about subsurface conditions at other locations. Actual subsurface conditions may differ, sometimes significantly, from the opinions presented in this report. Our report, conclusions and interpretations are not a warranty of the actual subsurface conditions.

### Geotechnical Engineering Report Recommendations are Not Final

We have developed the following recommendations based on data gathered from subsurface investigation(s). These investigations sample just a small percentage of a site to create a snapshot of the subsurface conditions elsewhere on the site. Such sampling on its own cannot provide a complete and accurate view of subsurface conditions for the entire site. Therefore, the recommendations included in this report are preliminary and should not be considered final. GeoEngineers' recommendations can be finalized only by observing actual subsurface conditions revealed during construction. GeoEngineers

cannot assume responsibility or liability for the recommendations in this report if we do not perform construction observation.

We recommend that you allow sufficient monitoring, testing and consultation during construction by GeoEngineers to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes if the conditions revealed during the work differ from those anticipated, and to evaluate whether earthwork activities are completed in accordance with our recommendations. Retaining GeoEngineers for construction observation for this project is the most effective means of managing the risks associated with unanticipated conditions. If another party performs field observation and confirms our expectations, the other party must take full responsibility for both the observations and recommendations. Please note, however, that another party would lack our project-specific knowledge and resources.

### A Geotechnical Engineering or Geologic Report Could Be Subject to Misinterpretation

Misinterpretation of this report by members of the design team or by contractors can result in costly problems. GeoEngineers can help reduce the risks of misinterpretation by conferring with appropriate members of the design team after submitting the report, reviewing pertinent elements of the design team's plans and specifications, participating in pre-bid and preconstruction conferences, and providing construction observation.

### Do Not Redraw the Exploration Logs

Geotechnical engineers and geologists prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. The logs included in a geotechnical engineering or geologic report should never be redrawn for inclusion in architectural or other design drawings. Photographic or electronic reproduction is acceptable, but separating logs from the report can create a risk of misinterpretation.

### Give Contractors a Complete Report and Guidance

To help reduce the risk of problems associated with unanticipated subsurface conditions, GeoEngineers recommends giving contractors the complete geotechnical engineering or geologic report, including these "Report Limitations and Guidelines for Use." When providing the report, you should preface it with a clearly written letter of transmittal that:

- advises contractors that the report was not prepared for purposes of bid development and that its accuracy is limited; and
- encourages contractors to confer with GeoEngineers and/or to conduct additional study to obtain the specific types of information they need or prefer.

### Contractors are Responsible for Site Safety on Their Own Construction Projects

Our geotechnical recommendations are not intended to direct the contractor's procedures, methods, schedule or management of the work site. The contractor is solely responsible for job site safety and for managing construction operations to minimize risks to on-site personnel and adjacent properties.

## Biological Pollutants

GeoEngineers' Scope of Work specifically excludes the investigation, detection, prevention or assessment of the presence of Biological Pollutants. Accordingly, this report does not include any interpretations, recommendations, findings or conclusions regarding the detecting, assessing, preventing or abating of Biological Pollutants, and no conclusions or inferences should be drawn regarding Biological Pollutants as they may relate to this project. The term "Biological Pollutants" includes, but is not limited to, molds, fungi, spores, bacteria and viruses, and/or any of their byproducts.

A Client that desires these specialized services is advised to obtain them from a consultant who offers services in this specialized field.