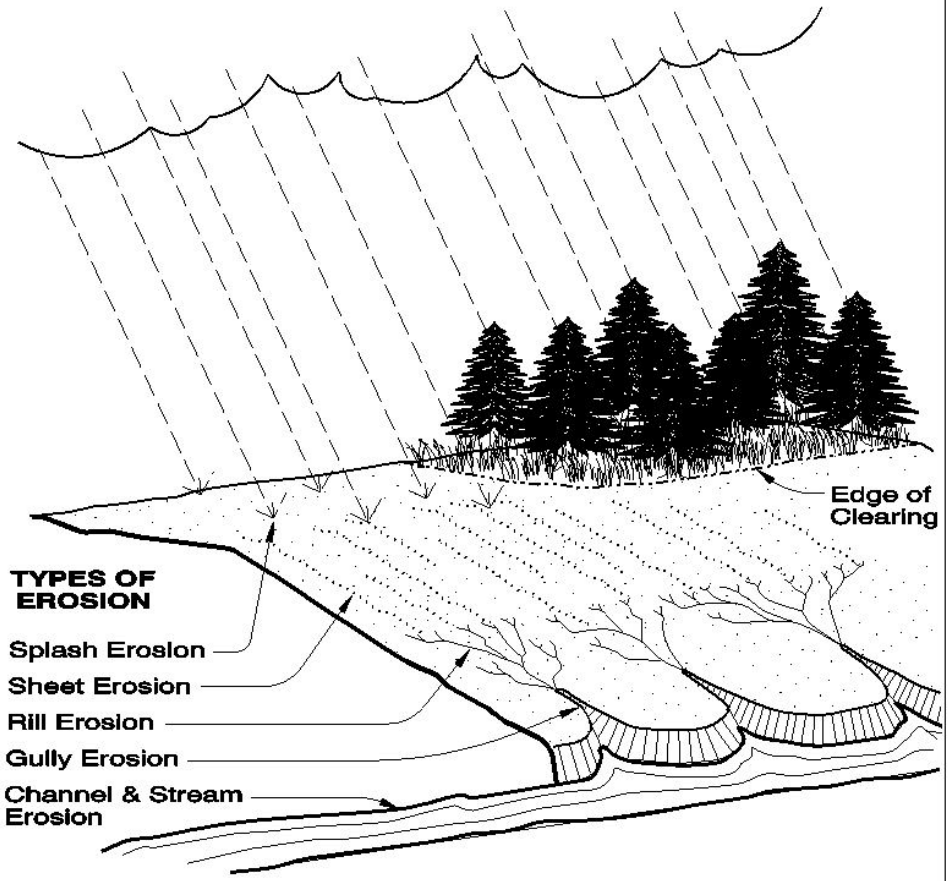
Oregon Department of Transportation

EROSION CONTROL FIELD MANUAL



Geo/Environmental Section
June 2006

PREFACE

This manual is a field guide on erosion and sediment control for projects that use Oregon Department of Transportation standards. The purpose of the guide is to present tools for erosion prevention and sediment containment in a simple, portable format.

The reference for this field guide is the ODOT Erosion Control Manual, which should be consulted for more information. This manual is based on requirements of National Pollutant Discharge Elimination System (NPDES) laws and permits. Refer to the applicable project NPDES Permit for actual requirements.

This manual does not address in-water work such as isolation of work areas for sediment containment. Refer to the latest edition of the ODOT Hydraulics Manual or consult the Region Hydraulics Engineer or the Technical Services Geo/Environmental Senior Hydraulics Engineer.

Project questions and concerns can be addressed by project professional of record. General questions can be addressed to the Region erosion control point-of-contact or the Erosion Control Program Coordinator in the Technical Services Geo/Environmental Section in Salem.

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ACRONYMS

AASHTO	American Association of State Highway and Transportation Officials
AOS	Apparent Opening Size
BMP	Best Management Practice
CWA	Clean Water Act
DEQ	Department of Environmental Quality
DSL	Division of State Lands
EA	Environmental Assessment
ESCP	Erosion and Sediment Control Plan
FHWA	Federal Highway Administration
NMFS	National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System
OAR	Oregon Administrative Rules
ODFW	Department of Fish and Wildlife
ODOT	Oregon Department of Transportation
ORS	Oregon Revised Statutes
PCP	Pollution Control Plan
RUSLE	Revised Universal Soil Loss Equation
TRM	Turf Reinforcement Mats
TSS	Total Suspended Solids
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
USLE	Universal Soil Loss Equation

1 EROSION PREVENTION AND SEDIMENT CONTROL

1.1 Designer, Inspector & Contractor Responsibilities

This corresponds to the ODOT Erosion Control Manual Chapter 1.

The three principal parties involved in implementing an Erosion and Sediment Control Plan (ESCP) are the designer, inspector and contractor. Each of these is responsible for obtaining a copy of the applicable National Pollution Discharge Elimination System (NPDES) 1200 Permit and knowing what it requires. The designer, inspector and contractor also have specific responsibilities, which are summarized below.

1.1.1 Designer Responsibilities

- Research construction project site conditions.
- Ensure that topography and drainage are clearly delineated on the ESCP.
- Understand the scope of the construction project including detour facilities, duration of construction, and time of year construction will commence.
- Develop supplemental Special Provisions as required to specify practices necessary to control erosion and contain sediment on site.
- Provide an ESCP with sufficient bid items to address erosion and sediment throughout project construction.
- Regularly update knowledge of the latest technology in commercial erosion control materials and methods.
- Ensure that the specified erosion control products are readily available or are on the Oregon Department of Transportation (ODOT) Qualified Products List.

1.1.2 Inspector Responsibilities

- Have knowledge and understanding of the project ESCP and Pollution Control Plan (PCP).
- Ensure that the contractor submits revisions to the ESCP and presents the revised ESCP at the Pre-construction meeting.
- Ensure that the contractor updates the ESCP as construction progresses.
- Ensure that the contractor maintains the erosion control facilities as needed.
- Ensure that the contractor completes monitoring reports weekly or after more than 0.5 inches (in) of rain in a 24-hour period during active projects and once every 2 weeks during inactive projects of more than 7 days. (ODOT Form 734-2361 Erosion Monitoring Form or other authorized form).
- Authorize contractor to make changes to ESCP and PCP and ensure payment if changes are beyond original bid estimate and necessary to control erosion.
- Understand Sections 00280 (Erosion and Sediment Control) and 01030 (Seeding) of the Standard Specifications and the 00280 and 01030 Special Provisions for the project.
- Understand how to properly implement best management practices (BMPs) to control erosion and contain sediment.
- Ensure that the contractor and project complies with the NPDES 1200 Permit.
- Be familiar with the ODOT Standard Erosion Details.

1.1.3 Contractor Responsibilities

- Become knowledgeable about the latest technology to control erosion and contain sediment.
- Bid on job with knowledge of site conditions, keeping contingencies in mind.
- Understand the ESCP and Sections 00280 (Erosion and Sediment Control) and 01030 (Seeding) of the Standard Specifications and Special Provisions for the project.
- Revise the ESCP to meet conditions of construction (i.e., phasing, timing, weather) and present the revisions at the Pre-construction meeting.
- Develop a an ESCP that includes a site plan and narrative, describing methods of erosion and sediment control to be used to minimize erosion and sediment from project operations related to disposal sites, borrow pit operations, haul roads, equipment storage sites, fueling operations and staging areas.
- Construct BMP's as described in the project ESCP and specifications.
- Minimize clearing of vegetation and look for opportunities to minimize erosion, offering ideas to ODOT inspectors for approval.
- Monitor erosion control devices and record on ODOT Form 734-2361 Erosion Monitoring Form or other authorized form.
- Maintain erosion control facilities and modify when required to stay in compliance with NPDES 1200 Permit.
- Update the ESCP as work progresses and modify plan as conditions change.
- Ensure that permanent seeding is done within the time frames set in Section 01030 (Seeding) of the specifications

2 EROSION PROCESSES

2.1 Principles of Erosion and Sedimentation

This section corresponds with Chapter 2 of the Erosion Control Manual.

Effective erosion control requires that the soil surface be protected from the erosive forces of wind, rain, and runoff. Preventing or minimizing soil erosion is the first and most important line of defense. Sediment control, or trapping suspended soil particles before they are transported off site, is necessary because some erosion is unavoidable. The following simple principles are effective and should be integrated into a system of control measures and management techniques to control erosion and prevent off-site sedimentation.

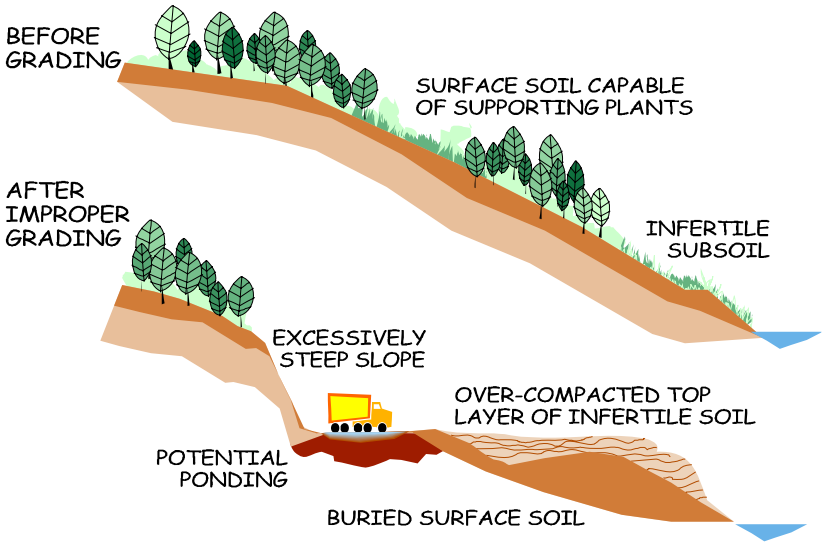


Figure 2-1 Fit construction to the natural contours of the land

- Fit site construction to the terrain. Review and consider all existing conditions in the initial site selection for the project and throughout construction.
- Time grading and construction to minimize soil exposure. Scheduling can be a very effective means of reducing the hazards

of erosion. Stage construction activities to minimize the exposed area and the duration of exposure.

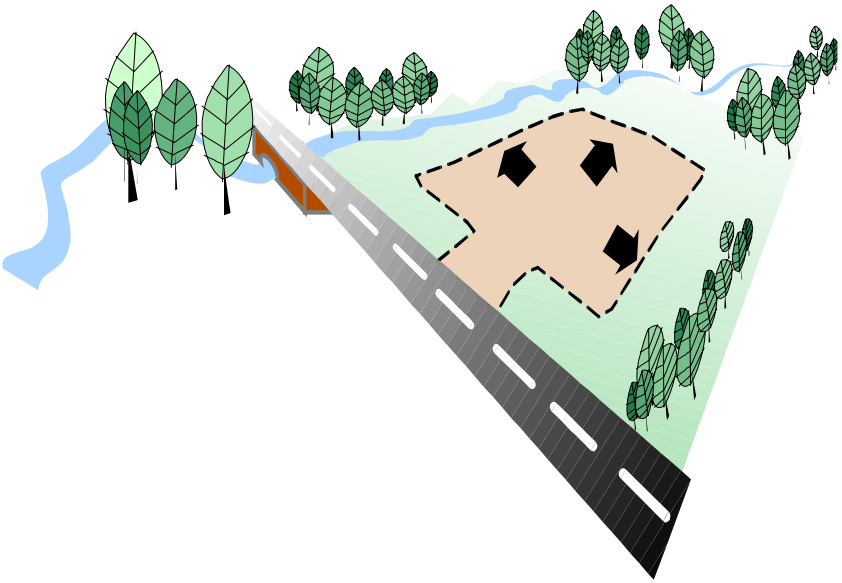


Figure 2-2 Minimize soil exposure

- Retain existing vegetation whenever feasible. Vegetation is the most effective form of erosion control; very little erosion occurs on a soil covered with undisturbed natural vegetation.
- Vegetate and mulch denuded areas. Seed and mulch denuded (i.e., cleared, grubbed, or excavated) soils as soon as possible after grading is completed.
- Divert runoff away from denuded areas. When vegetative cover is removed from land, the soil becomes highly susceptible to erosion. In any such area, runoff should be diverted to avoid excessive erosion and sediment transport.
- Minimize length and steepness of slopes. Slope length and steepness are among the most critical factors in determining erosion potential. Increasing slope length and steepness increases the velocity of runoff, which greatly increases erosive forces.
- Keep runoff velocities low. The energy of flowing water increases as the square of the velocity, that is, as the velocity doubles, the erosive force quadruples and the water can theoretically move sediment amounts 64 times larger by volume.

- Prepare drainage ways and outlets to handle concentrated or increased runoff. Construction changes the characteristics of runoff. The creation of impervious surfaces such as paving, removal of plant cover, and compaction of soil by construction traffic allows less water to infiltrate the soil and therefore increases the volume of runoff.

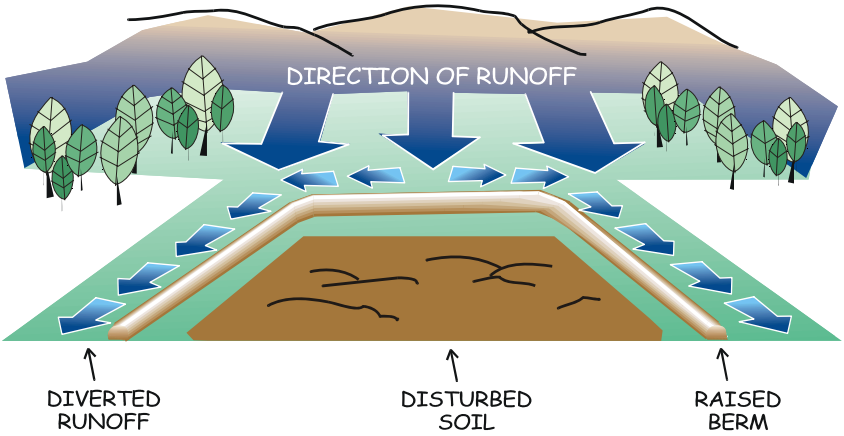


Figure 2-3 Route off-site drainage away from disturbed areas

- Trap sediment on site. Some erosion during construction is unavoidable. The function of a sediment barrier is to prevent sediment from leaving the site after the soil has been eroded from its place of origin.
- Inspect and maintain erosion and sediment control measures. Inspection and maintenance of control measures are vital to the success of an ESCP.

3 EROSION & SEDIMENT CONTROL MEASURES & BMPS

This section corresponds to Chapter 3 of the Erosion Control Manual.

This chapter discusses erosion and sediment control best management practices, or BMPs. As implied by their name, BMPs are stabilization and structural erosion control measures that are the best of commonly accepted practices.

The following "flow" charts organize BMPs by their general function. Note that a BMP may have several functions not shown because the charts are intended to be very general.

BMPS are broken into three categories:

- **Erosion Prevention**
- **Runoff Control**
- **Sediment Control**

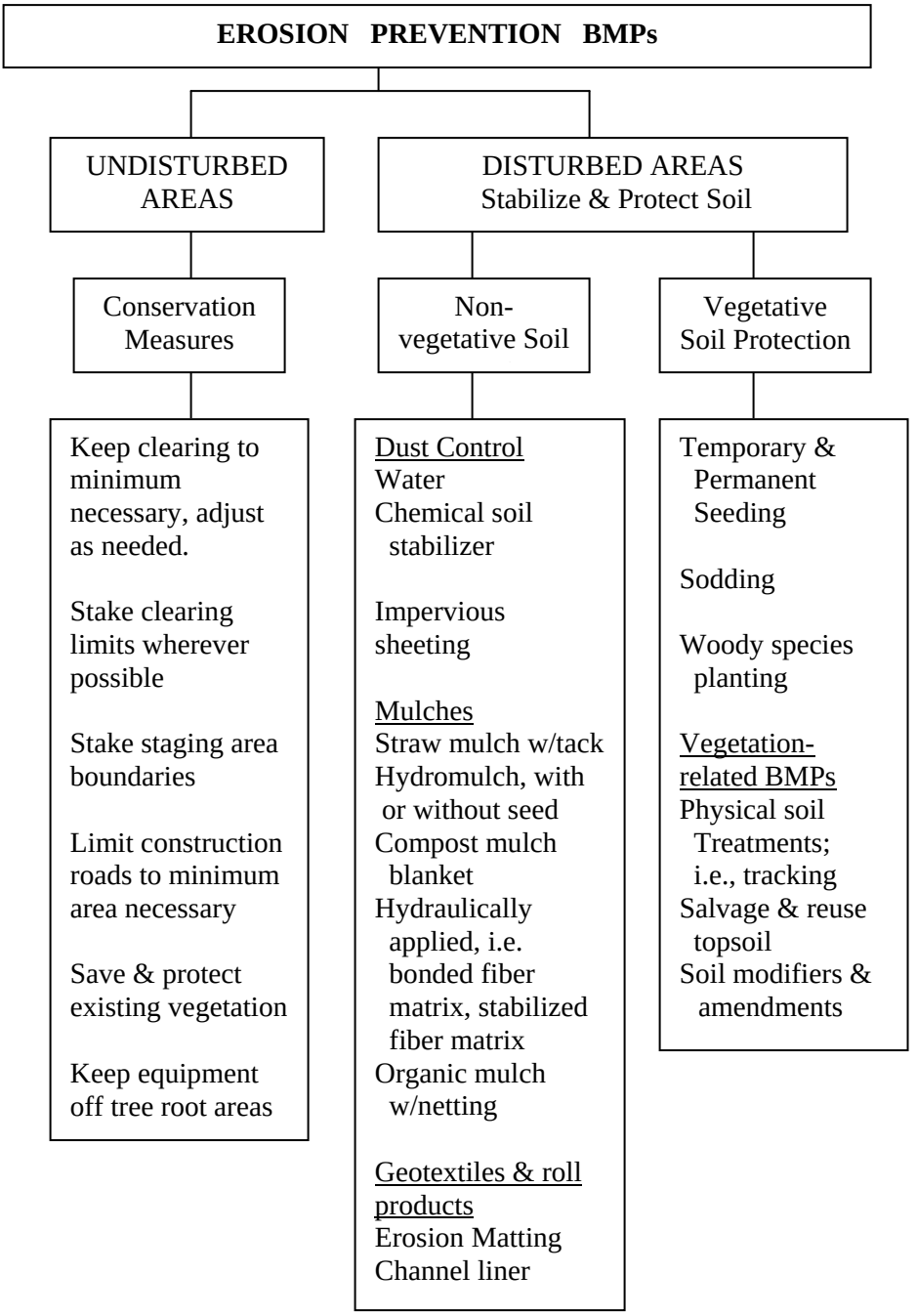


Figure 3-1 Erosion Prevention

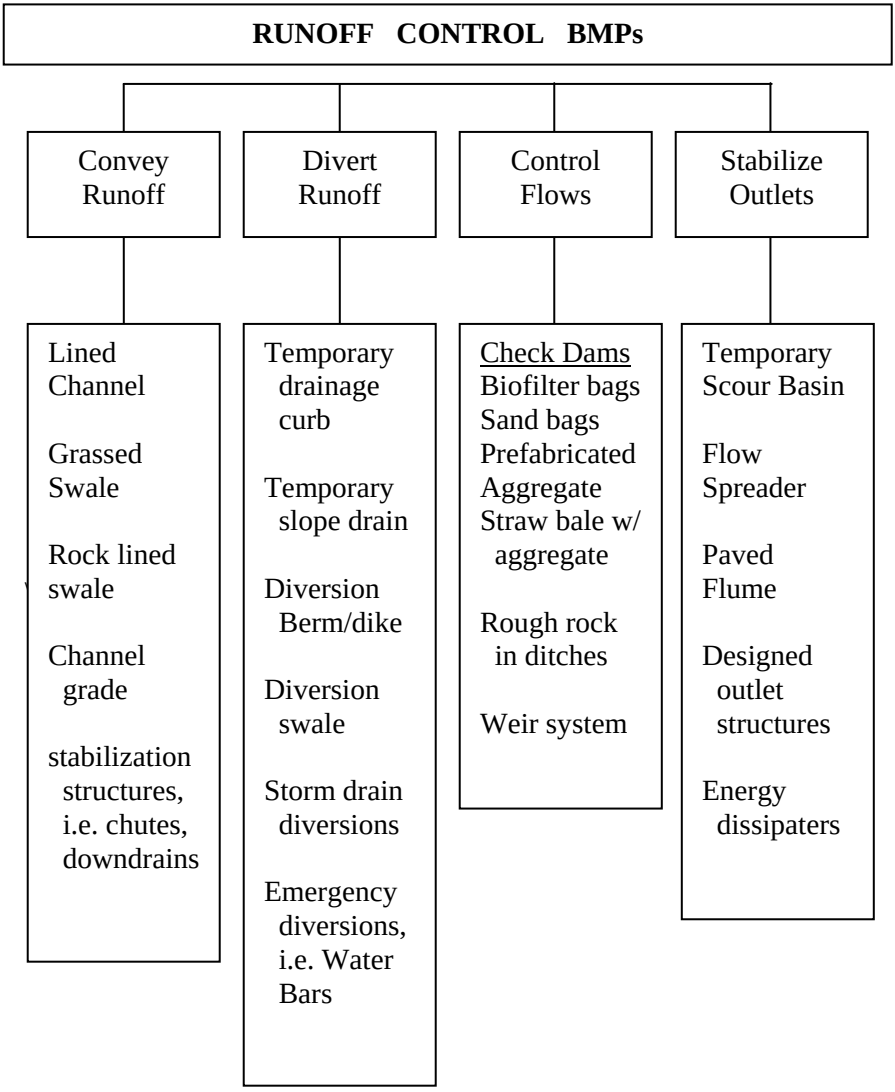
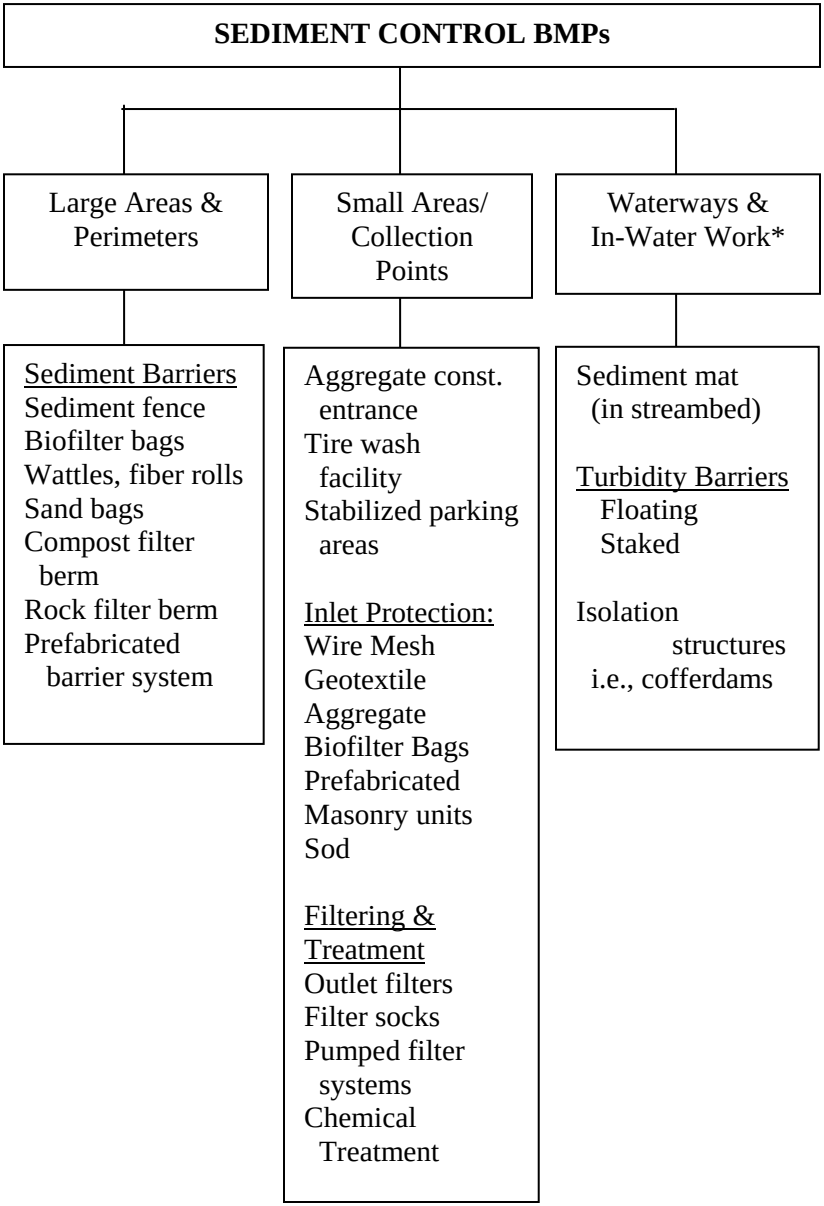


Figure 3-2 Runoff Control



* In-stream temporary water management BMPs not shown.

Figure 3-3 Sediment Control

3.1 Erosion Prevention

Erosion prevention is the most effective and inexpensive method for reducing pollution associated with construction activities. Limiting the amount of exposed soil and directing surface water runoff away from exposed soil are two excellent ways to minimize erosion during construction.

3.1.1 Best Management Practices

The following are some of the most effective erosion prevention BMPs:

- Preserve Natural Vegetation
- Buffer Zone
- Temporary and Permanent Seeding
- Hydraulic Seeding
- Mulch
- Sod
- Matting
- Plastic Sheeting
- Dust Control

3.1.1.1 Preserve Natural Vegetation

This method is always important, but particularly in sensitive areas such as wetlands, stream corridors, lakes, and near steep slopes. The designer, inspector, and contractor should address and discuss preserving natural vegetation during the Pre-construction Meeting.

Applications

Flood plains, wetlands, stream banks, steep slopes and other areas where erosion controls would be difficult to install and maintain, or anywhere clearing ground of natural vegetation does not prove to be necessary.

Advantages	Disadvantages
• Helps reduce soil erosion and runoff while beautifying an area. • Saves landscaping costs, provides areas for wildlife, and provides visual screening. • Helps maintain water temperature. Temperature moderation is especially important when detention ponds drain to salmonid-bearing streams. • Retains existing shade and cover habitat.	• Retaining unhealthy trees could create a safety hazard. • May constrict area available for construction activities.

Maintenance

- Inspect and repair flagging or fencing.
- Re-cover or seal exposed plant roots, or both, as necessary.

3.1.1.2 Buffer Zone

A buffer zone is an undisturbed area or strip of natural vegetation or a newly established suitable planting adjacent to a disturbed area for the purpose of reducing erosion and runoff.

Applications

- Between disturbed areas and streams or other water bodies.
- Along natural swales and wetlands.
- Anyplace an extra measure of erosion reduction and runoff control is desired.

Advantages	Disadvantages
• Filters Sediment. • Promotes infiltration. • Provides habitat. • Reduces velocity and quantity of runoff, dissipates energy. • Provides visual screening. • Can be used to stabilize stream banks. • Low maintenance.	• Requires keeping all construction equipment, debris, and soil out of the natural areas. • Extensive buffers can cover large areas of land that are not available for project development.

Maintenance

- Inspect flagging and fencing frequently and repair as needed.

3.1.1.3 Temporary and Permanent Seeding

A well-established vegetative cover is one of the most effective methods of reducing erosion. Vegetation should be established on most construction sites as the slopes are finished, rather than waiting until all the grading is complete. See Section 00280 of the construction specifications for soil exposure limitations and establishment requirements.

Applications

- On disturbed areas that require seeding, either because the area has reached final grade (permanent seeding), or because the area will remain unworked for over 14 days (temporary seeding). Refer to Section 00280 for soil exposure limitations and seeding dates. (Chapter 6 of this manual has example dates).
- In vegetation-lined channels, seed and then protect with matting.
- In retention/detention ponds.

Advantages	Disadvantages
• Prevents erosion and also traps sediment. • Promotes infiltration. • Improves appearance of the site. • Reduces runoff. • Provides excellent stabilization. • Relatively inexpensive.	• Needs sufficient time for seed to establish. • Requires mulch or other cover until vegetation is established. • May require fertilizer and lime to establish on poor soils. • May require irrigation. • Must be removed prior to applying fill material.

Selection Criteria

Project grass and legume seed mixes for erosion control purposes are found in the project Special Provisions. Statewide mix examples are available from ODOT, but should be modified based on specifics of projects sites and project goals.

Seed Tag or Label

Erosion control seed must be meet requirements of the Standard Specifications and project Special Provisions. A label must be present on each container of furnished seed with the following information, developed from seed lab testing as required by Oregon Seed Law:

- The kind and variety of the seed.
- The kind and variety of each seed of 5% or more in a mixture (by weight).
- If more than one seed is named, the word "mixture" or words "mixed seed".
- The country or state where grown, or if unknown, statement of origin not known.
- The lot number or other lot identification.
- The total percentage, by weight, of other crop seed.
- The total percentage, by weight, of weed seed.
- The total percentage, by weight, of inert matter.
- A statement of "no noxious weed found" or similar.
- For each named seed:
- Percentage of germination.
- Percentage of hard (nonviable) seed.
- Month and year of test date(s).
- Name and address of seed labeler or seed seller.
- Statement of any seed inoculant or chemical treatments used.
- Net quantity of each container by weight.

If shown in the specifications, seeds furnished for erosion control may be required to be Oregon Certified Seed, as shown in the Standard Specifications. This is typically done to ensure the highest varietal purity of seed with an absolute minimum of weed of non-specified seeds. Oregon State University (OSU) Extension Service keeps a listing of seed varieties that are currently certified in the OSU Extension Certified Seed Handbook.

Examples of seed labels, including a Certified Seed Tag, are shown in the Rules of Thumb Appendix.

Calculating Seed Application Rates by PLS

Seed is measured by Pure Live Seed (PLS) weight, which is the portion of a seed lot that is live seed of the desired kind. The purpose of measuring seed on the PLS basis is so seeding rate calculations don't get confused by non-viable seed and inert materials. The basic calculation is percent of seed germination times percent of seed purity = PLS.

Example:

To calculate the amount of seed to be planted from the seed germination and purity rates shown on a furnished seed label:

The project seed mix requires planting 22 pounds (lbs) PLS of Intermediate Wheatgrass. The label on the furnished seed shows the following information:

Intermediate Wheatgrass germination = 80%

Intermediate Wheatgrass purity = 90%

To calculate the amount of seed to be planted, convert these percentages to decimals and multiply: 0.80 X 0.90 = 0.72, or 72% PLS

22 lbs (PLS) to be planted = 0.72 (PLS factor)	Approximately 30.6 lbs of bagged seed needs to be used in order for 22 lbs of PLS to be planted.

Timing of Seed Application

- Apply permanent seeding when no further disturbances are planned or where areas are to be left undisturbed for 1 year or more.
- Apply seed immediately after seedbed preparation while the soil is loose and moist.
- Apply seed before applying mulch.
- To determine optimum dates for seeding, consult a local county extension agent or agronomist.
- The best time to apply seed is early spring or late fall depending on site conditions. Irrigation may be required for areas seeded during dry summer months.
- Seed applied during the winter may take several months to develop a dense ground cover due to cold temperatures. The application and maintenance of mulch is critical for winter seeding. Additional erosion control measures may need to be applied to provide temporary stabilization.
- Apply permanent seeding before seasonal rain or freezing weather is anticipated.
- Apply temporary seeding to stabilize disturbed soils that are not at finished grade and which will be exposed for 2 weeks or longer before being disturbed again.

Site Preparation

- Prepare site according to specification Sections 01030 and 01040.
- For optimum seeding conditions, salvage and stockpile topsoil until final grades are established, then spread topsoil over new grades.
- Consult a Geotechnical Engineer prior to placing topsoil on slopes 1:2 (vertical:horizontal) or steeper.
- Bring the seed bed area to final grade, remove all rocks and debris, and smooth surface undulations larger than 2 inches.
- Divert concentrated flows away from the seeded area.
- Conduct soil tests to determine pH and nutrient content.
- Add and incorporate amendments into soil as needed to adjust pH to 6.0 to 7.5.
- Roughen the soil by harrowing, tracking, grooving or furrowing horizontally across the face of the slope so ridges are oriented along the slope contour..
- The seedbed should be firm but not compact. The top 3 to 6 inches of soil should be loose, moist, and free of large clods and stones over 2" in diameter.
- If the seedbed has been idle long enough for the soil to become compact, work it with a disk, harrow, spring tooth drag, spike tooth drag, or other equipment designed to condition the soil for seeding.

Seeding

- Apply seed according to specification Section 01030.
- Seed-to-soil contact is the key to good germination.
- Apply seed at the rates specified using calibrated seed spreaders, cyclone seeders, mechanical drills, or hydroseeder so the seed is applied uniformly.
- Broadcast seed should be incorporated into the soil by raking or chain dragging, then lightly compact the soil to provide good seed-to-soil contact.
- Apply mulch and tackifier or matting, as specified, over the seeded areas.
- To prevent seed from being washed away, confirm installation of all required surface water control measures.
- Specifications typically call for doubling the seeding rate when mulch and seed is applied in a single application.

Fertilizer

- Apply fertilizer as specified in specification Section 01030.
- Slow-release fertilizer is more efficient and has fewer environmental impacts. Areas being seeded for final landscaping may require soil tests to determine the exact type and quantity of fertilizer needed to prevent the over-application of fertilizer. Use non-phosphorus fertilizer near water bodies and wetlands.
- The use of stockpiled topsoil or compost reduces the need for fertilizer and improves the overall soil quality.

Hydroseed

- Refer to Section 3.1.1.5 of this Chapter.
- Hydroseeding typically requires a mulch or green dye tracer as a visual application aid.
- On slopes steeper than 1:1.5 (!:2 in Clackamas County), hydroseeding specifications typically call for an increased rate of tackifier to be applied.
- During the dry season, hydroseeding with wood fiber mulch is adequate.
- During the wet season, apply this BMP only during the approved seeding dates.

Maintenance

- Inspect newly seeded areas frequently to ensure that grass is growing.
- Spot seeding can be done on small areas to fill bare spots where grass did not grow properly.
- Re-seed and protect with mulch any areas affected by erosion. If the erosion is caused by concentrated runoff, fix the runoff problem and then re-seed and mulch the area.
- If spot seeding is ineffective, use an alternate method such as sodding or matting.

3.1.1.4 Mulch

Mulching is the application of a protective layer of straw or other suitable material to the soil surface. Mulching provides immediate temporary protection from erosion and also enhances plant establishment by conserving moisture, holding fertilizer, seed, and topsoil in place, and moderating soil temperatures. Straw mulch and/or hydromulch are also used in conjunction with seeding as an aid to establish temporary or permanent vegetation.

Applications

- Seed cover.
- Dust control.
- Soil cover on areas that can't be seeded or are otherwise unfavorable for plant growth.
- As temporary stabilization on bare soils exposed by construction activities. Refer to specification Section 00280 for specific requirements.
- On slopes greater than 1:1.5[1], or where the mulch is susceptible to movement by wind or water, the mulch material should be hydraulically applied with a tackifier or the straw mulch should be anchored mechanically.

[1] Clackamas County uses on slopes greater than 1:3

Advantages	Disadvantages
• Provides rapid protection. • Conserves moisture. • Allows vegetation growth through the mulch. • Protects seeding from heat, moisture loss, and transport due to runoff.	• Thick mulches can delay germination. • Can be blown or washed away if not adequately tackified. • Must be removed prior to applying fill material. • May create road hazard if animals begin grazing on straw mulch applied to roadsides.

Organic Mulches

- Straw mulch provides immediate protection lasting about three months. Straw can be spread mechanically or by hand and typically requires anchoring for wind protection. Common anchoring methods include spraying with a tackifier; crimping, disking, or rolling; or covering with netting. The combination of hydroseed slurry and straw mulch is well suited to steep slopes, critical areas, and severe climate conditions.
- Straw used for mulch should not be moldy, caked, decayed or of otherwise low quality. Verification from the supplier should be submitted that the straw is free of noxious weeds. Acceptable documentation submitted should show either (1) that the straw is from an "Oregon Certified Seed" field or (2) the seed lab results of the seed harvested from the straw meet minimum Oregon Certified Seed quality for weed seed content (refer to Appendix D). The Oregon Certified Seed Handbook lists farms with certified fields that sell to the public and is available from County Extension Offices or OSU.
- Wood cellulose, grass straw cellulose, and paper fiber products are commonly applied hydraulically.
- Wood chips are suitable for areas that will not be closely mowed and areas around ornamental plantings. Chips decompose slowly and require nitrogen application to prevent nutrient deficiency in plantings. Both wood and bark chips tend to wash down slopes greater than 6%.
- Corn stalks, which decompose slowly and are resistant to wind, should be shredded into 4 to 6 inch lengths.
- Manure mulches should be well aged and are not suitable for use near water bodies, or when low weed seed content is required.
- Certified yard compost, available in some areas of the state, is suitable for flat areas.

Synthetic Mulches

- Synthetic spray-on mulches and soil binders can seal the soil surface, but may cause adverse effects on water quality. They generally are not recommended for use as mulch.

Maintenance

- Maintain mulch at the specified thickness.

- Re-mulch and protect with a net or blanket any areas that experience erosion. If the erosion problem is drainage related, fix the drainage problem and re-mulch the eroded area.
- Hydraulically-treated areas should be inspected after installation and periodically monitored thereafter.
- Hydraulic mulches and tackifiers must provide the necessary erosion protection until permanent erosion-resistant cover is established. If sheet or rill erosion is evident, then prompt re-application of treatments will be necessary.
- If hydraulic mulch or tackifiers were applied without seed for erosion and dust control, the product must protect for the length of time the soil will remain bare. Inspect these applications regularly to assure continued protection.
- Areas that fail to establish adequate cover to prevent erosion should be re-mulched as soon as such areas are identified.
- If mulched areas are damaged by concentrated runoff, implement additional BMPs promptly as necessary to remedy the problem.

3.1.1.5 Hydraulic Application

Hydraulic application is not actually a BMP, but a specific method for applying erosion control materials to bare soil and establishing erosion-resistant vegetation on disturbed areas.

Applications

- For applying seed, fertilizer, mulch, tackifier, soil amendments, bonded fiber matrix, and chemical stabilization.
- Steep slopes where mulch would otherwise be difficult to anchor.
- On sites where the application of a hydraulically applied bonded fiber matrix (mat) system is desirable.
- On sites where other soil stabilization, seeding, and mulching practices would result in unacceptable levels of ground disturbance.
- Where site conditions, such as irregular soil surfaces, existing vegetation, and shallow soils preclude the installation of erosion blankets and mats.
- On sites where straw mulch has been applied and the straw needs to be anchored (tacked) with tackifiers or hydraulic mulches.
- On sites where dust control is needed.
- Please refer to the Rules of Thumb on the Hydroseeding Mixture Worksheet.

Advantages		Disadvantages
• Provides rapid installation. • Generally requires less seedbed preparation, surface soil may be left irregular with large clods, stones, or rock outcropping exposed. • Uniformly distributes seed and mulch material. • Increases favorable conditions for quick germination and growth. • Can be used effectively on steep slopes and other areas where access is limited.		• Can be more expensive than broadcast or drilling seed applications. • Overly thick mulch applications can delay germination. • Can be blown or washed away if not adequately tackified. • Required application rates can vary significantly depending on site preparation.

3.1.1.6 Sod

Establishes permanent turf for immediate erosion protection and stabilizes drainage ways.

Applications

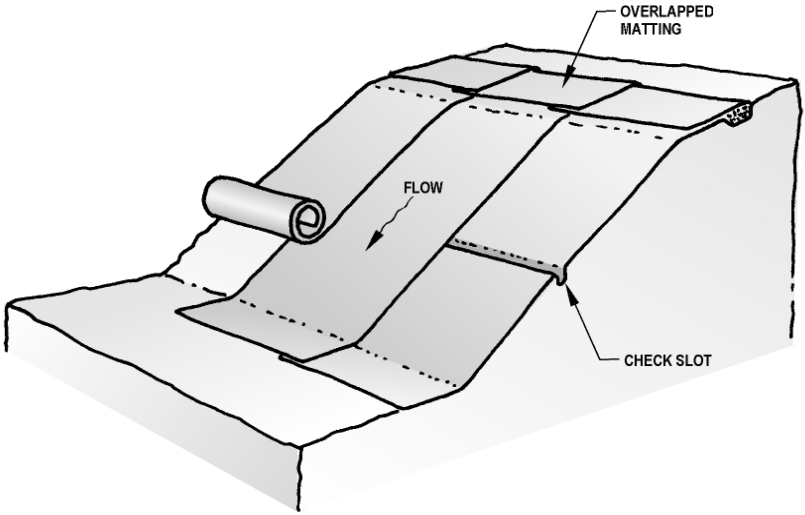
- Disturbed areas requiring short-term or long-term cover.
- Disturbed areas requiring immediate vegetative cover.
- Waterways carrying intermittent flow (except biofiltration swales) and requiring immediate stabilization or aesthetic mitigation.
- Around inlets located off roadways.

Advantages		Disadvantages
• Provides immediate, effective protection, and is aesthetically pleasing. • Provides high-density vegetation much more quickly than seeding. • Placement can occur any time soil moisture is adequate and the ground is not frozen.		• Expensive. • Availability is seasonal. • Irrigation may be required if installed in summer. • Difficult to mow if installed on slopes steeper than 1:3. • Installation in grassed waterways may roll up if not anchored or drained properly. • Time is still necessary for complete root establishment.

Maintenance

- Inspect sodded area frequently for soil moisture content and root establishment.
- Re-tack, re-sod, or re-seed as necessary.
- If it is impossible to establish a healthy ground cover due to frequent saturation, instability, or some other cause, remove the sod, seed the area with an appropriate mix, and protect with matting.

3.1.1.7 Matting



Applications

- On disturbed areas that require cover for more than 30 days.
- For permanent stabilization of slopes 1:2 or steeper and with more than 10 feet of vertical relief.
- For permanent reinforcement of turf to protect drainage ways during high flows.
- For permanent stabilization of channels, possibly providing a cost-effective, environmentally preferable alternative to riprap.
- For drainage ditches and swales. The appropriate netting or blanket applied to drainage ditches and swales can protect bare soil from channelized erosion while vegetation is established.
- On steep slopes and in channels to prevent erosion while holding seed and mulch in place.

Advantages		Disadvantages
• Immediate cushioning against splash erosion from raindrop impact. • Does not generate high-velocity runoff and, therefore, offers temporary slope protection superior to plastic sheeting. • Captures a great deal of sediment due to its open, porous structure. • Usually easy to install.		• Correct installation is critical to the product effectiveness. Good ground contact during installation prevents runoff concentrating under the blanket and causing significant erosion (tenting). • Soil surface must be graded smooth with no surface irregularities. • Limited protection capabilities when used as flexible channel liner.

Maintenance

- Inspect periodically, especially following severe storms.
- Repair any damaged areas of the net or blanket and staple any areas not in close contact with the ground surface into the ground.
- If erosion occurs, repair and protect the eroded area. Consider if BMP needs to be added or changed to prevent continuing problem.

3.1.1.8 Plastic Sheeting

Provides immediate, short-term protection to slopes and disturbed areas where mulch is not practicable. Poor application, installation, and maintenance can cause problems, so use alternatives to plastic sheeting whenever possible.

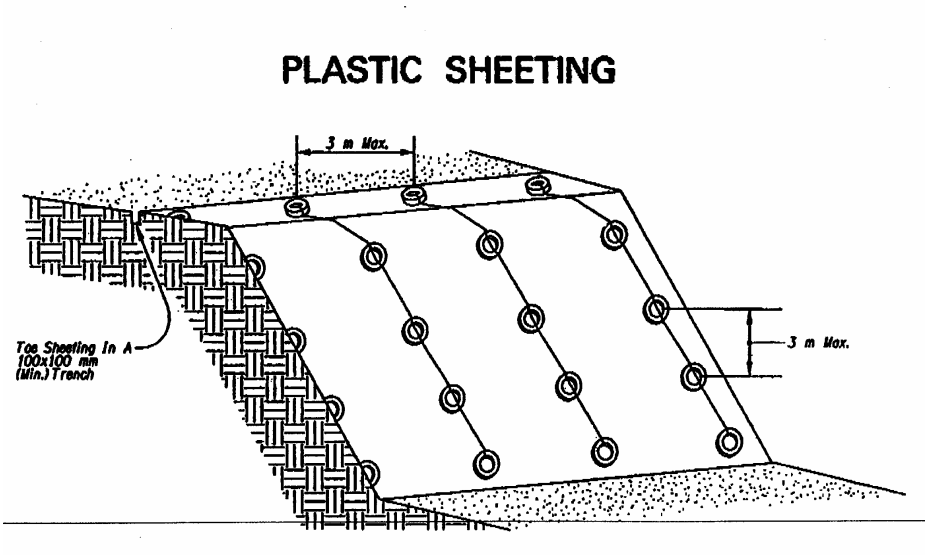
Applications

- On disturbed areas that require cover for less than 30 days.
- On cut and fill slopes and stockpiles.
- Use only on small areas when vegetation cannot be established to protect soil during rainy season; for larger areas consider matting (see Section 3.1.1.7)
- Can be used alone or in conjunction with sediment fences, diversion dikes, or soil stockpiles.

Advantages	Disadvantages
• Provides immediate, short-term erosion protection to slopes and disturbed areas. • Fairly quick and easy to install.	• Plastic sheeting may concentrate sunrays and burn the vegetation beneath it. • Plastic sheeting can generate high velocity runoff. • Plastic breaks down quickly when exposed to ultraviolet radiation. • Plastic, when it is not completely removed, can clog drainage system inlets and outlets. • If not properly anchored, wind may transport plastic onto roadways and create traffic hazards.

Maintenance

- Replace torn sheets and repair open seams.
- Completely remove and replace plastic when it begins to deteriorate.
- Completely remove all plastic once it is no longer needed.
- Check anchoring system and repair or add anchors.



3.1.1.9 Dust Control

Measures used to prevent or minimize wind transport of soil which prevents traffic hazards and helps keep sediment from being deposited in water resources.

Applications

On construction routes and other disturbed areas subject to surface dust movement and where off-site damage may occur if dust is not controlled.

Advantages	Disadvantages
• Keeps soil in place. • Reduces movement of soil to offsite areas. • Maintains visibility.	• Over-watering may cause erosion. • Most methods require immediate reapplication if disturbed.

Maintenance

- Maintain dust control measures through dry weather periods until all disturbed areas have been stabilized.
- Re-stabilize areas disturbed by project operations or other activities (wind, water, vandalism, etc.) within 2 days of disturbance.

3.2 Runoff Control Practices

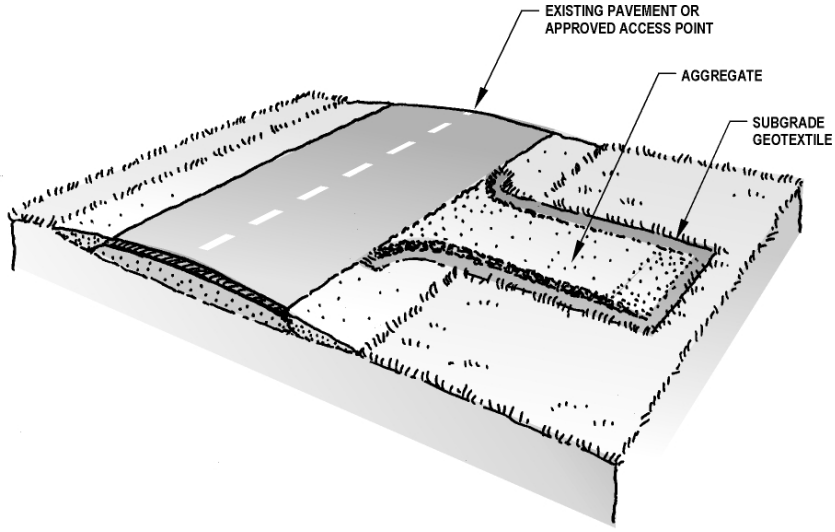
Runoff controls divert runoff from exposed areas and reduce runoff velocities. Runoff control BMPs that divert runoff from exposed areas include pipe slope drains and diversion swales.

3.2.1 Best Management Practices

Runoff control BMPs include:

- Construction Entrance Enhancement
- Tire Wash Facility
- Construction Road/Parking Area Stabilization
- Slope Drain
- Outlet Protection
- Surface Roughening
- Check Dam
- Interceptor Dike and Interceptor Swale
- Grass-lined Swale

3.2.1.1 Aggregate Construction Entrance



A stabilized aggregate pad, placed at construction site ingress/egress points to reduce the amount of sediment transported onto paved roads by vehicles.

Applications

- Wherever traffic will be leaving a construction site at a rate of at least 25 trips per day and traveling on paved roads or other paved areas located within 100 feet of the site.
- NPDES 1200-CA Permits (Schedule A. Subsection 8c) require that each site have graveled, paved, or constructed entrances, exits, and parking areas to reduce the tracking of sediments onto public or private roads.

Advantages		Disadvantages
• Reduces traffic hazards caused by debris on public roadways. • Reduces sediment on roadways that can wash into the storm sewer system.		• Only effective if erosion and sediment controls are implemented throughout the construction site. • Only works if installed at every location where significant construction traffic leaves the site. • Fills with sediment quickly and requires frequent maintenance or replacement of rock.

Maintenance

- Immediately sweep up and remove or stabilize onsite any sediment that is tracked onto pavement.
- If the sediment poses a threat to public safety and street sweeping proves ineffective, consider washing the street and collecting the water in a sediment pond or sump before it leaves the site.
- Add aggregate as needed to maintain the specified dimensions.
- Immediately remove any aggregate that gets carried from the pad to the roadway.
- Maintain any fencing installed as construction traffic control.
- If the aggregate construction entrance continues to be ineffective, consider upgrading protection by installing a tire wash facility.

3.2.1.2 Tire Wash Facility

Two types of tire wash facilities are available depending on the severity of sediment tracking and the size of the project. A Type 1 facility is a stabilized gravel pad similar to a stabilized construction entrance that is graded or otherwise constructed to collect wash water and convey it to a sediment trap, basin, or other suitable treatment facility. A Type 2 facility consists of a shallow concrete lined basin partially filled with water, through which exiting vehicles drive.

Applications

- Wherever traffic will be leaving a construction site and traveling on paved roads or other paved areas located within 100 feet of the site.
- Where sediment removal on a stabilized construction entrance alone is inadequate to prevent tracking.

Advantages	Disadvantages
• Reduces traffic hazards caused by debris on public roadways. • Reduces sediment on roadways that can wash into the storm sewer system. • Easy to construct and relatively inexpensive. • Useful for high traffic volumes or large projects of long duration.	• Only works if installed at every location where construction traffic leaves the site. • Fills with sediment quickly and requires frequent maintenance. • Requires a source of wash water. • Requires a turnout or doublewide exit to avoid entering vehicles driving through the wash area. • Requires labor to wash the tires of all vehicles exiting the site. • Costly to construct. • Will generate large volumes of sediment-laden water requiring treatment elsewhere on site.

Maintenance

- Wash pad when sediment clogs aggregate.
- Add or re-grade aggregate as needed.
- Immediately remove any aggregate that gets carried from the pad to the roadway.
- Assure that wash water drainage, collection, and treatment system is functioning.
- Remove/discharge wash water as needed.
- Remove accumulated sediment from bottom of basin.

3.2.1.3 Construction Road/Parking Area Stabilization

Stabilized parking areas and on-site vehicle transportation routes reduce erosion caused by construction traffic or runoff.

Applications

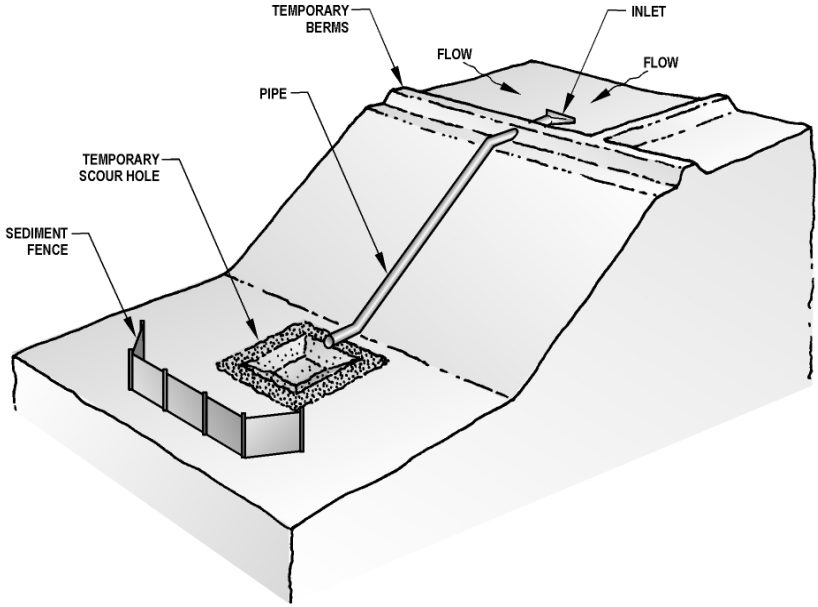
- Permanent or temporary roads or parking areas used by construction traffic.
- NPDES 1200-CA Permits require that all unpaved roads located on site be graveled. Other effective erosion and sediment control measures either on the road or down gradient may be used in place of gravel.

Advantages	Disadvantages
• Reduces onsite erosion, dust, and off-site tracking of soils. • Can speed and enhance efficiency of on-site work.	• Temporary stabilized construction roads can be expensive to install and maintain.

Maintenance

- Add crushed rock, gravel base, as required to maintain a stable driving surface and stabilize any eroded areas.

3.2.1.4 Temporary Slope Drain



A pipe extending from the top of a cut or fill to the bottom. The slope drain carries concentrated runoff down steep slopes, then discharges into a stabilized watercourse, sediment trapping device, or other stabilized area. This avoids causing gullies, erosion, or saturation of slide-prone soils on slopes.

Applications

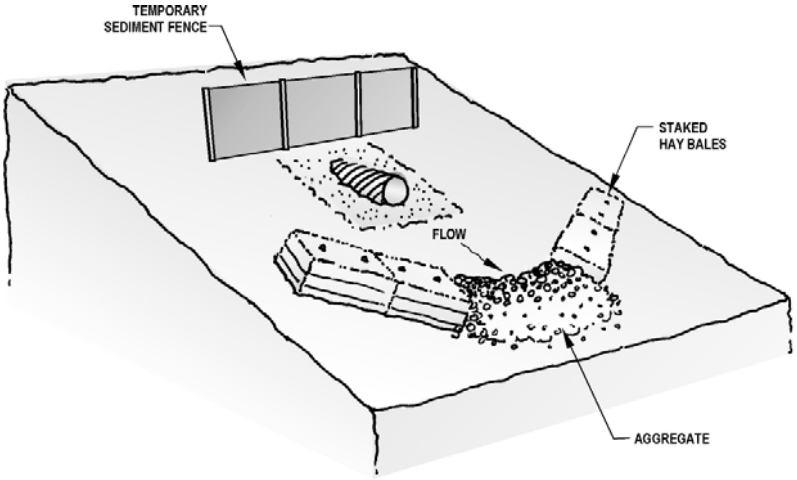
- On any slope where a large amount of flow must be collected and conveyed to avoid erosion.
- Areas where clean water should be kept separate from sediment-laden water.
- If a permanent measure is needed, it should be designed as part of the roadway drainage facilities.

Advantages		Disadvantages
• Effective method of conveying water down steep slopes. • Reduces or eliminates erosion. • Easy installation and little maintenance.		• Drain can be under-designed or incorrectly located. • Area cleared for drain installation requires stabilization to prevent erosion occurring under the pipe. • Piping systems constructed of pipe segments could develop leaks causing erosion and failure of the system. • Failures on erodable slopes can cause downstream sedimentation or even mudflows. • Adjustment of pipe length is necessary as cut and fill slopes are extended.

Maintenance

- Adjust lengths of pipe when cut and fill slopes are extended.
- Regularly inspect the inlet and outlet points, especially following heavy rains. If there are signs of undercutting or water is going around the point of entry, reinforce the head wall with compacted earth or sand bags.
- Regularly inspect connection points for signs of erosion. Tighten fittings and repair erosion as needed.
- Immediately repair and install appropriate protection if erosion occurs at the outlet.

3.2.1.5 Outlet Protection



Outlet protection reduces the speed of concentrated flow, thereby preventing scour at conveyance outlets. By dissipating energy, outlet protection lowers the potential for downstream erosion. Outlet protection includes riprap-lined basins, concrete aprons, and settling basins. Outlet protection prevents scour at storm water outlets, and minimizes the potential for downstream erosion.

Applications

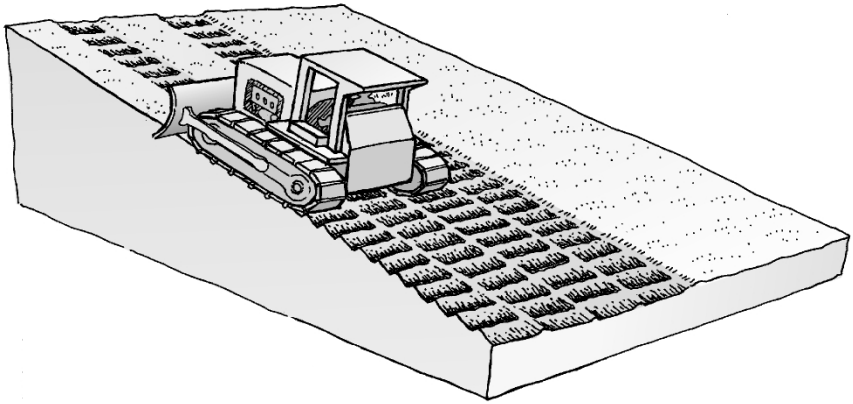
- At the outlets of ponds, pipe slope drains, ditches, or other conveyances, and where runoff is conveyed to a natural or man-made drainage feature such as a stream, wetland, lake, or ditch.
- Culverts and other permanent features will normally have designed outfall protection shown on the plans unless the outfall is at a temporary location.

Advantages		Disadvantages
• Many techniques are effective, relatively inexpensive, and easy to install. • Removes sediment and reduces velocity.		• Can be unsightly. • May be difficult to remove sediment without removing and replacing the structure itself. • Rock outlets with high velocity flows may require frequent maintenance.

Maintenance

- If there is scour at the outlet, protect the eroded area by increasing the size of the energy dissipater facility.
- Remove accumulated sediment frequently.

3.2.1.6 Surface Roughening



Leaving the slopes in a roughened condition after clearing or creating a rough soil surface with horizontal depressions or grooves will trap seed and reduce runoff velocity. Roughening can be accomplished by 'track walking' slopes with tracked equipment, by using a serrated wing blade attached to the side of a bulldozer, or by other agricultural equipment such as spike-toothed harrows.

Applications

- All slopes to be seeded.
- All slopes steeper than 1:3 having a vertical rise of 5 feet or greater.
- On areas that would otherwise be unfavorable for plant growth.
- As a temporary stabilization on bare soils exposed by construction activities.

Advantages	Disadvantages
• Grooves trap seed. • Increases establishment of vegetation. • Reduces runoff velocity, increases infiltration. • Provides some instant protection from sheet erosion. • Traps soil eroded from the slopes above.	• Tracking with heavy equipment compacts the soil. • May increase time to finish slopes. • Should not be relied upon as sole means of erosion control.

Cut Slope Roughening

- Stair-step grade or groove the cut slopes that are steeper than 1:3.
- Use stair-step grading on all erodible material soft enough to be ripped with a bulldozer. Slopes consisting of soft rock with the same subsoil are particularly suited to stair-step grading.
- Make the vertical cut distance less than the horizontal distance, and slightly slope the horizontal position of the "step" in toward the vertical wall.
- Do not make individual vertical cuts more than 2 feet high in soft materials or more than 3 feet in rocky materials.
- Groove the slope using machinery to create a series of ridges and depressions that run across the slope, on the contour.

Fill Slope Roughening

- Place fill slopes with a gradient steeper than 1:3 in lifts not to exceed 8 inches[1], and make sure each lift is properly compacted.
- Ensure that the face of the slope consists of loose, uncompacted fill 4 to 6 inches deep.
- Use horizontal grooving along the contour or tracking to roughen the face of the slopes, if necessary.
- Apply seed, fertilizer and straw mulch, and then track or punch the mulch with a bulldozer.
- Do not blade or scrape the final slope face.

Cuts, Fills, and Graded Areas

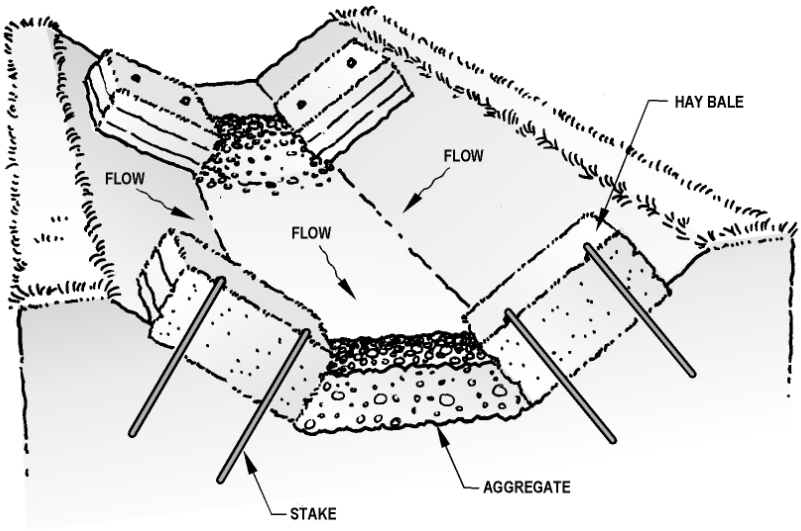
- Make mowed slopes no steeper than 1:3.
- Roughen these areas to shallow grooves by normal tilling, disking, harrowing, or use a cultipacker seeder. Make the final pass of any such cultivation on the contour.
- Make grooves formed by such implements close together, 12 inches maximum spacing, and not less than 1 inch deep.
- Excessive roughness is undesirable where mowing is planned.

Maintenance

- Periodically inspect the seeded slopes for rills and washes. Fill these areas slightly above the original grade, then re-seed and mulch as soon as possible.

[1] Clackamas County uses 6 inches

3.2.1.7 Check Dam



Small dams constructed across a swale or ditch to reduce velocities of concentrated flows, thereby reducing erosion in the swale or ditch. Check dams not only prevent gully erosion from occurring before vegetation is established, but also allow a significant amount of suspended sediment to settle out.

- Check Dams can be constructed from a variety of materials:
  - Type 1 – Aggregate: Aggregate material only.
  - Type 2 – Straw Bales: Entrenched straw bales staked to the ground with an aggregate weir.
  - Type 3 – Bio-filter Bags: Bio-filter bags staked to the ground with or without an aggregate weir.
  - Type 4 – Sand Bags: Sand bags with or without an aggregate weir.
  - Type 5 – Pre-fabricated Check Dam System: A manufactured system specifically designed to slow water so that suspended particles settle out. Field-fabricated systems are not allowed.
- Refer to detail RD1005 - Check Dam located at the end of this section.

Applications

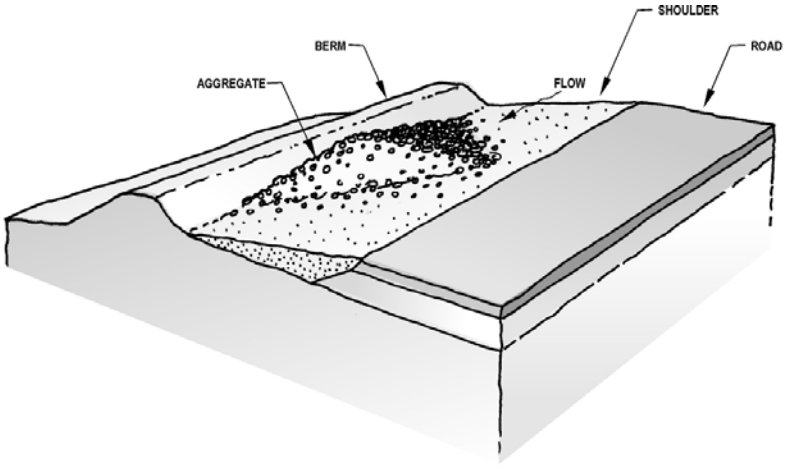
- In temporary or permanent channels not yet vegetated when installing channel lining is not feasible.
- In small open channels that drain 10 acres or less.
- Do not place check dams in streams or rivers.

Advantages	Disadvantages
• Prevent erosion and promote settling of sediment in runoff. • When carefully located and constructed, check dams may function as permanent installations. • Inexpensive and easy to install. • Aggregate can be spread into ditch and used as a channel lining when the check dam is no longer necessary. • Some pre-fabricated check dams are reusable.	• Measures may be unsightly. • Removal may be costly for some types of check dams. • Suitable only for a limited drainage area. • May reduce hydraulic capacity of the channel. • May create turbulence downstream, causing erosion of the channel banks. • Ponded water may kill grass in grass-lined channels. • May be an obstruction to construction equipment.

Maintenance

- Periodically inspect check dams for performance and sediment accumulation.
- Remove sediment once it reaches one-third the depth of the rock weir.
- Replace aggregate weir when filtering capacity is reduced by one-half.

3.2.1.8 Diversion Dike/Diversion Swale



A ridge of compacted soil or a lined swale with vegetative lining located at the top, base or somewhere along a sloping disturbed area. The dike or swale intercepts and conveys smaller flows along low-gradient drainage ways to larger conveyances such as ditches or pipe slope drains or to a stabilized outlet. Dikes and swales may be used alone or in combination with each other.

Applications

- Install above a disturbed slope to intercept runoff and reduce runoff volume on the disturbed area.
- Install below a disturbed area to divert runoff to a sediment-trapping device.
- Install across a disturbed slope to reduce runoff velocity.

Advantages		Disadvantages
• Provides a practical, inexpensive method to divert runoff. • Can handle flows from large drainage areas. • Use on-site material and equipment to construct.		• If improperly constructed, can contribute to erosion caused by concentrating the flow. • High flow velocity can damage vegetation.

Maintenance

- Immediately repair damage resulting from runoff or construction activity.
- If the dike or swale regularly overflows, increase the capacity or frequency of the dikes or swales, or both.
- Inspect and repair as necessary after every major storm.
- Minimize construction traffic over temporary dikes and swales.
- Clean out clogged pipes (as part of the swale system) under roads.

3.2.1.9 Grass-lined Swale

A channel with vegetative lining constructed to convey and dispose of concentrated surface runoff without damage from erosion, deposition, or flooding.

Applications

- Areas where concentrated runoff will cause damage from erosion or flooding.
- In channels where a vegetative lining can provide sufficient stability for the channel cross section and grade.
- On projects where slopes are generally less than 5%.
- Where space is available for relatively large cross section.

Advantages		Disadvantages
• Does not generate high velocity runoff and offers temporary slope protection that is superior to plastic sheeting. • Captures a great deal of sediment due to the filtering effect of the vegetation. • Usually easy to install.		• May require temporary irrigation to establish vegetation. • Cannot be used until vegetation is established.

Maintenance

- During initial establishment, grass-lined channels should be repaired and grass re-established if necessary.
- After grass has become established, the channel should be inspected periodically to determine if the channel is withstanding flow velocities without damage.
- Inspect the channel for debris, scour, or erosion and immediately make repairs. It is particularly important to inspect the channel outlet and all road crossings for bank stability and evidence of piping or scouring. Make repairs immediately.
- Remove all significant sediment accumulations to maintain the designed capacity.

- Keep the grass in a healthy, vigorous condition at all times, since it is the primary erosion protection for the channel.
- Permanent grassed waterways should be seasonally maintained by mowing or irrigating, depending on the type of vegetation selected.
- Newly seeded areas need to be inspected frequently to ensure the grass is growing.
- If the seeded area is damaged due to runoff, additional storm water measures such as check dams or matting may be needed.
- Spot seeding can be done on small areas to fill in bare spots where grass did not grow properly.

3.3 Sediment Control Practices

Once soil erosion occurs, sediment trapping or removal techniques can reduce the amount of sediment and associated pollutants that leave the site, thus protecting nearby streams, wetlands, and lakes. Sediment controls are usually placed throughout construction sites, and around the perimeter of a disturbed area, and where concentrated water leaves the site. Sediment control BMPs should be in place before land clearing and grading begins. It is important to note that sediment controls, if poorly maintained, can become sources of sediment and other pollutants during larger storms.

3.3.1 Best Management Practices

Sediment control BMPs include:

- Sediment Barrier
  - Biofilter Bags
  - Filter Berm
  - Straw Rolls (Wattles)
  - Pre-fabricated Barrier System
  - Sand Bags
  - Brush Barrier
  - Straw Bales
- Sediment Fence
- Inlet Protection
- Sediment Trap
- Sediment Basin

3.3.1.1 Sediment Barrier

Sediment barriers can be constructed from a variety of materials. Barrier types according to ODOT specifications and drawings include:

- Type 1 – Straw Bales: Entrenched straw bales staked to the ground.
- Type 2 – Biofilter Bags: Entrenched biofilter bags staked to the ground.
- Type 3 – Straw Rolls (Wattles): Entrenched straw rolls staked to the ground.
- Type 4 – Sand bags: Bags filled with sand or gravel.
- Type 5 – Brush Barrier: Entrenched and mounded woody materials or strippings.
- Type 6 – Filter Berm: Entrenched and mounded aggregate.
- Type 7 – Pre-fabricated Barrier System: A manufactured system specifically designed for temporary erosion control applications. Field fabricated systems are not allowed.

Table 3-3 Barrier spacing for general application

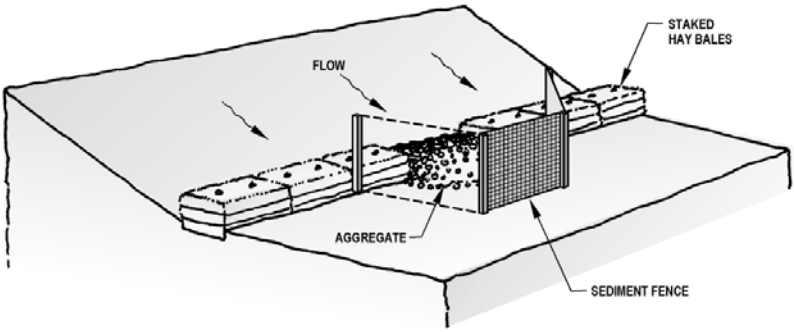
BARRIER SPACING FOR GENERAL APPLICATION

INSTALL PARALLEL ALONG CONTOURS AS FOLLOWS		
% SLOPE	SLOPE (V:H)	MAXIMUM SPACING ON SLOPE
<10 %	<1:10	300 ft
10 > % ≥ 15	1:10> X ≥ 1:7.5	150 ft
15 > % ≥ 20	1:7.5 > X ≥ 1:5	100 ft
20 > % ≥ 30	1:5 > X ≥ 1:3	50 ft
>30 %	>1:3	25 ft

Applications

- Below areas subject to sheet and rill erosion.
- 1:2 slopes or flatter. Slopes with maximum contributing drainage area of 1/4 acre per 100 feet of barrier length.
- Swales or ditches with maximum 2 acres contributing drainage.

3.3.1.1.1 Straw Bale – Sediment Barrier Type 1



A temporary sediment barrier consisting of a row of entrenched and anchored straw bales with check dams at low points. Straw bale sediment barriers trap small amounts of sediment by decreasing sheetflow and low-to-moderate channel flow velocities. Water is channeled through the aggregate weir, and a sediment fence is used to trap sediment that has moved through the weir.

Advantages		Disadvantages
• Relatively inexpensive method of sediment control.		• Effective approximately 3 months. • Misuse or incorrect installation can contribute to sediment loading. • Difficult to tell if bales are properly installed. • Improper applications, such as installations in drainage ways and swales where high-water volumes and velocities can occur, destroys effectiveness. • Improper placement and/or installation can allow undercutting and end-flow. • Inadequate maintenance can greatly reduce effectiveness of sediment removal. • Heavy and hard to move when wet.

Maintenance

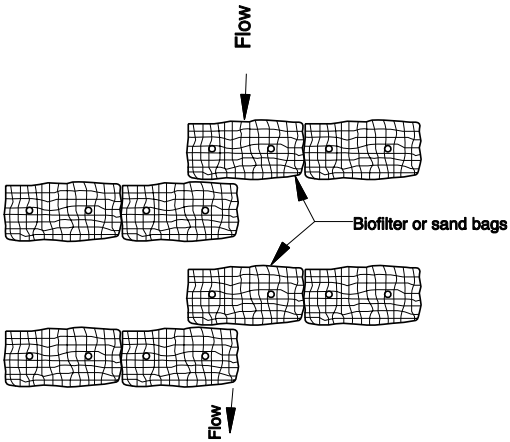
- The barriers should be inspected periodically during the winter and after each significant storm. Repairs or replacement should be made promptly.
- Sediment should be removed when it has reached one-third the height of the barrier.
- Replace deteriorated bales.

3.3.1.1.2 Biofilter Bags – Sediment Barrier Type 2

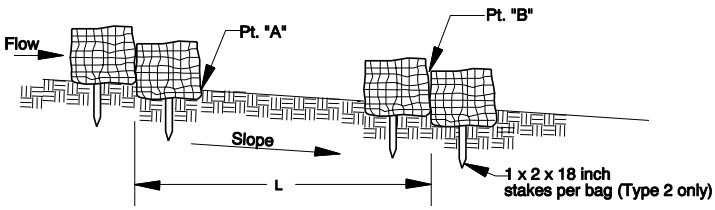
Biofilter bags are manufactured from 100% wood or other recycled products placed in plastic mesh bags. They are typically 30 inches long by 18 inches wide and weigh approximately 45 lb.

Applications

- To capture and retain sediment on slopes.
- To capture sediment around drain inlets (see Section 3.3.1.1.3).
- To capture sediment and reduce water velocity on paved streets.
- To capture sediment and reduce water velocity in unlined and lined channels, swales or ditches.
- Can be staked in developing rills or gullies to capture sediment and reduce water velocity, swales or ditches.
- Can be staked in developing rills or gullies to capture sediment and reduce water velocity.



PLAN



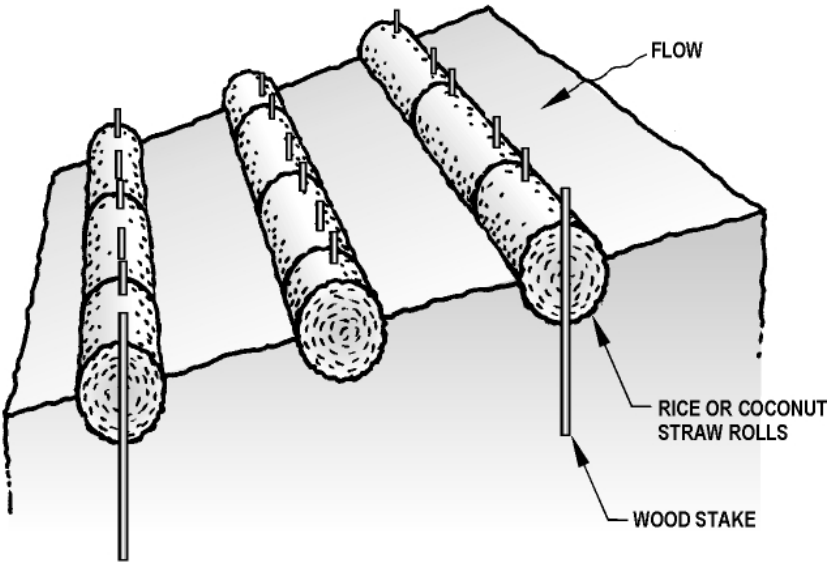
CROSS SECTION

Advantages	Disadvantages
• Relatively low cost. • In some cases, can be used in place of sediment fences on slopes. • Wood products can be recycled or used on site when no longer needed. • Installation is simple, can be done by hand. • Bags are easy to move, replace and reuse on paved surfaces. • Are good short-term solution in situations where concentrated flows are causing erosion (can be stuffed or staked in developing rills).	• Generally effective for only a few months. • Can be easily damaged by construction equipment or by traffic in paved areas. • Can become clogged with sediment and cease to filter runoff. • If not properly staked, will fail on slope applications. • If improperly installed can allow undercutting or end-flow. • Not effective where water velocities or volumes are high. • Light weight results in higher buoyancy if not properly installed. • Low sediment retention capacity may require frequent maintenance.

Maintenance

- Inspect biofilter bag installations after storms. Check that stakes are secure and ends of bags are tightly abutted. Check that undercutting or end-flow is not occurring.
- Check that flow is not becoming channeled behind bags (i.e., parallel to row of bags).
- Inspect plastic mesh bags for tears.
- Remove sediment accumulated behind bags when sediment reaches one-third of the barrier height.
- Replace damaged bags as needed.

3.3.1.1.3 Straw Rolls (Wattles)–Sediment Barrier Type 3



Straw rolls are manufactured from straw that is wrapped in tubular plastic netting. They are approximately 8 inches in diameter by 26 to 29.5 feet[1] long. Straw rolls are placed in shallow trenches and staked along the contour of newly constructed or disturbed slopes.

Applications

- To capture and retain sediment on slopes.
- To temporarily stabilize slopes by reducing soil creep and sheet and rill erosion until permanent vegetation is established.
- Installed on unvegetated slope areas above concrete v-ditches.
- To control erosion from entering paved areas by installing behind sidewalk or curb.

[1] Clackamas County 7 to 25 feet long
West Washington is 25 to 30 feet long

Advantages	Disadvantages
• They can often replace sediment fences or straw bales on steep slopes. • Rolls are a short-term solution to help establish native vegetation. • Rolls store moisture for vegetation planted immediately upslope. • May be left in place to biodegrade or photodegrade. • Straw becomes incorporated into the soil with time, adding organic material to the soil and retaining moisture for vegetation. • Reduces runoff velocity. • Requires minimal ground disturbance to install. • Lightweight and easy to install.	• Rolls only function for one or two seasons. • If not installed properly with sufficient trench, rolls may fail during the first rain event. • Straw rolls may require maintenance to ensure that the stakes are holding and the rolls are still in contact with the soil. This is especially true on steep slopes in sandy soil. • Low sediment retaining capacity may require frequent maintenance.

Maintenance

- Inspect the straw rolls and the slopes after significant storms. Make sure the rolls are in contact with the soil.
- Repair any rills or gullies promptly.
- Re-seed or re-plant vegetation if necessary until the slope is stabilized.

3.3.1.1.4 Sand Bags – Sediment Barrier Type 4

Sandbags are manufactured from durable, weather resistant tightly woven material sufficient to prohibit leakage of the filler material. The bags should measure 24 inches by 12 inches by 6 inches and be filled with firmly packed sand weighing at least 75 lb.

Applications

- To capture and retain sediment on slopes.
- To capture sediment around drain inlets.
- To capture sediment and reduce water velocity on paved streets.
- To capture sediment and reduce water velocity in unlined and lined channels swales or ditches.
- Can be placed in developing rills or gullies to capture sediment and reduce water velocity.

Advantages	Disadvantages
• Relatively low cost. • Installation is simple, can be done by hand. • Bags are easy to move, replace and reuse on paved surfaces. • Are good short-term solution in situations where concentrated flows are causing erosion (can be stuffed or staked in developing rills). • Can be used to divert and slow velocity of small flows. • Can be used in concrete-lined ditches capture sediment and reduce water velocity	• Do not filter water effectively. • Generally effective for only a few months. • Can be easily damaged by construction equipment or by traffic in paved areas. • Can contribute sediment to runoff if bags rupture. • Cannot be staked and are not appropriate on steep slope applications. • Not effective in steep swales, channels, or ditches. • If improperly installed can allow undercutting or end-flow. • Not effective where water velocities or volumes are high, can get washed away.

Design Criteria

- On slope applications should be installed on contour.
- See table at beginning of Section 3.3.1.1 for spacing on slopes.
- Ends of bags must be tightly abutted and overlapped to direct flow away from bag joints.

Maintenance

- Inspect sandbag installations after storms. Check that ends of bags are tightly abutted. Check that undercutting or end-flow is not occurring.
- Check that flow is not becoming channeled behind bags (i.e., parallel to row of bags).
- Remove sediment accumulated behind bags when sediment reaches one-third of the barrier height.
- Replace damaged bags as needed.

Common Failures

Failures most commonly result from sandbags not being tightly abutted together, which allows flow between or under the bags to cause rilling. Another common failure occurs when the bags are not installed on contour and water flow becomes channeled behind the bags. Sandbags can also be dislodged when placed in high velocity flows.

3.3.1.1.5 Brush Barrier – Sediment Barrier Type 5

A brush barrier is a temporary sediment barrier constructed at the perimeter of a disturbed area using materials available from clearing and grubbing of the site. The barrier intercepts and retains sediments that are washed from disturbed areas.

Applications

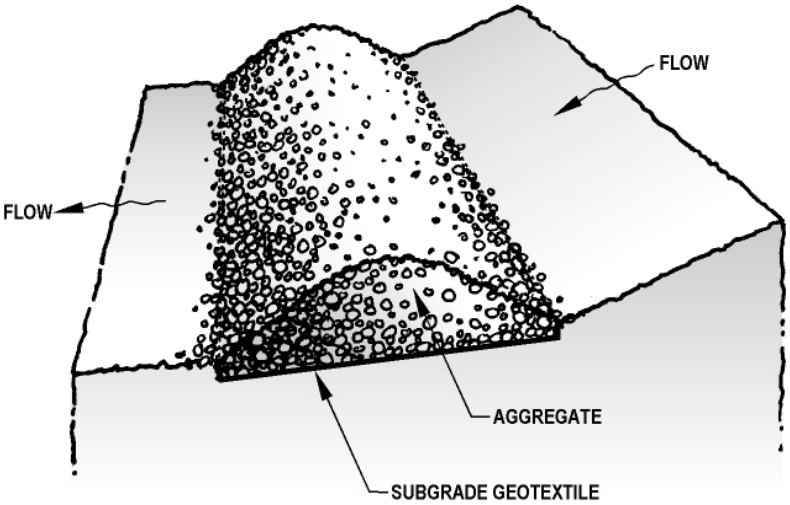
- On gently sloped areas.
- Disturbed areas draining less than .25 acres, where runoff is primarily sheet flow.
- Where residual materials are available on-site for barrier construction.

Advantages		Disadvantages
• Minimizes erosion control costs by utilizing materials on-site. • Reduces velocity and quantity of runoff.	•	• Only effective if erosion and sediment are controlled elsewhere on site. • Suitable for only a limited drainage area. • Has a limited life span.

Maintenance

- Generally requires little maintenance.
- Heavy buildup of sediment on the upslope side of the barrier should be removed when sediment reaches one-third of the barrier height.
- The barrier fabric should be inspected occasionally for tears and repaired as necessary.
- When the barrier is no longer needed, the fabric can be removed to allow natural establishment of vegetation within the barrier.

3.3.1.1.6 Filter Berm – Sediment Barrier Type 6



Retains sediment in gravel or crushed rock berm.

Applications

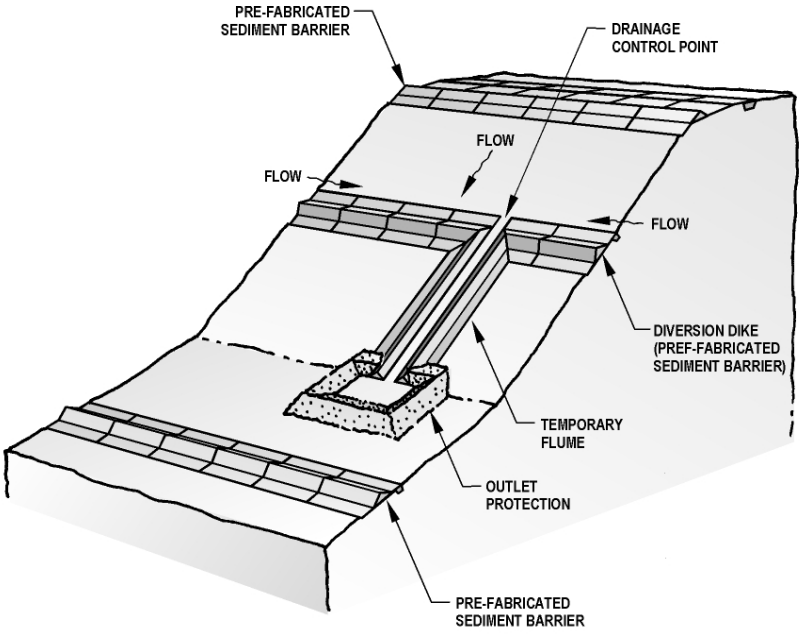
- In traffic areas on construction sites.
- On gently sloped areas.
- Along roadway edges to dissipate sheet flow.

Advantages	Disadvantages
• Very efficient method for sediment removal. • Reduces runoff velocity.	• More expensive than some other measures because it requires clean gravel or crushed rock rather than materials found on site. • Clogging from mud and soil may make maintenance difficult. • Has a limited life span.

Maintenance

- Remove and replace gravel when filtering capacity is reduced by half to maintain performance.
- Removed sediment accumulation from behind the berm when it reaches one-third of the barrier height.

3.3.1.1.7 Pre-Fabricated Barrier System – Sediment Barrier Type 7



Pre-fabricated barrier systems typically consist of a triangular shaped dike, usually made of foam or another flexible, lightweight material. The dike is wrapped in geotextile, which extends from the bottom of the dike to provide aprons on the upslope and downslope sides of the dike. The dike is anchored by trenching and stapling the aprons. Barrier materials, section lengths, and weights vary among manufacturers.

Applications

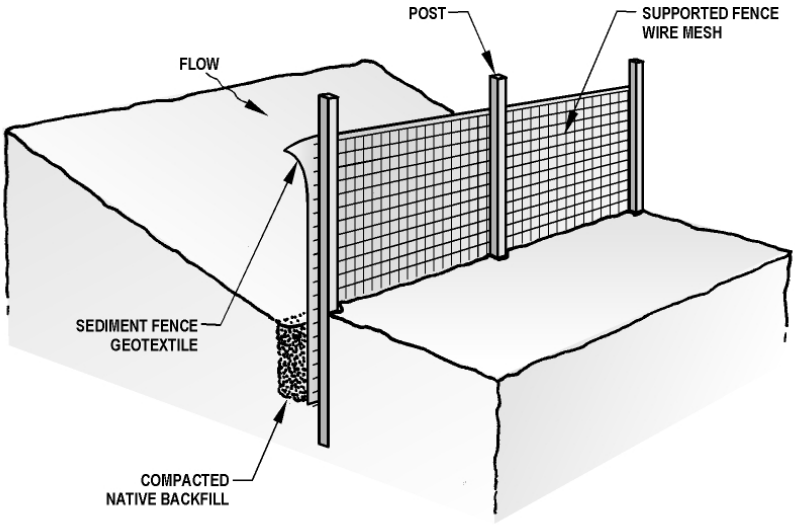
- To capture and retain sediment on slopes.
- To capture and direct water to a suitable conveyance or exit point, such as at the tops of slopes or at intermediate locations on cut-fill slopes.
- Diversion dike.
- Check dam.

Advantages	Disadvantages
• Lightweight. • Installation is relatively simple. • Can be used to divert and slow velocities or small flows. • Conforms to curves and rough terrain. • Reusable.	• Effective for unknown period of time (depends on material properties). • Can be easily damaged by construction equipment. • Not effective in steep swales, channels, or ditches. • If improperly installed, can allow undercutting or end-flow. • Not effective where water velocities or volumes are high. • Installation must be done exactly as specified by manufacturer. • May be difficult to install on steep slopes, trenching required. • Can be easily damaged during sediment removal operations.

Maintenance

- Inspect pre-fabricated barriers after storms. Check that undercutting or end-flow is not occurring.
- Check that barrier is not otherwise damaged.
- Check that aprons are securely anchored.
- Check that flow is not becoming channeled behind barrier (i.e., parallel to barrier)
- Remove sediment accumulation behind barrier when sediment reaches one-third the barrier height.
- Replace damaged sections as needed.

3.3.1.2 Sediment Fence



Temporary sediment trap consisting of an entrenched geotextile stretched across and attached to supporting posts. Sediment fences are adequate to treat flow depths consistent with overland or sheet flow. Supported sediment fences consist of geotextile backed with wire or polymeric mesh of equivalent strength supported by metal posts. Unsupported sediment fences do not have mesh backing and may be supported by wood stakes. Refer to specification Section 00280 for more specific information.

Applications

- Sediment fences can be used alone when the area draining to the fence is less than 3/4 acres per 300 feet of sediment fence and the average slope (perpendicular to the fence) is 1:3 or flatter. Otherwise, use sediment fences in conjunction with other measures.
- Slopes flatter than 50%.
- Install downslope of disturbed areas and prior to upslope clearing and grading.
- Do not use sediment fences in v-ditches or streams.
- Around inlets in non-traffic areas.

Advantages	Disadvantages
• Reduces runoff velocity. • Requires minimal ground disturbance to install. • Relatively inexpensive.	• Applicable to small drainage areas and overland flow; not applicable to concentrated flows. • Incorrect geotextile or installation decreases sediment fence performance. • Requires frequent maintenance and inspection.

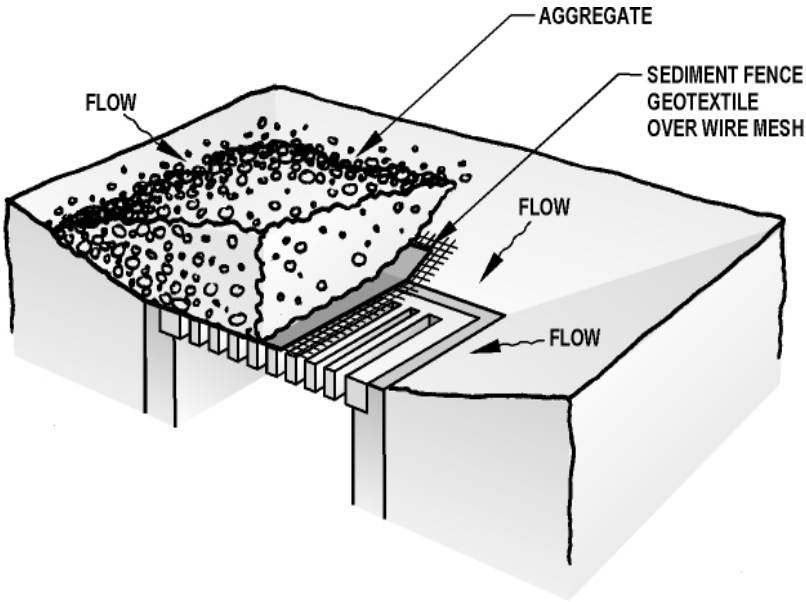
Maintenance

- Inspect fences weekly and after each storm event. Immediately repair any damage.
- Remove accumulated sediment once it has reached one- third the height of the sediment fence or 1 foot maximum.
- Inspect for channel formation parallel to the fence, which indicates the geotextile is acting as a flow barrier.
- Replace deteriorated or clogged geotextile.
- Check for undercutting or piping under fence.

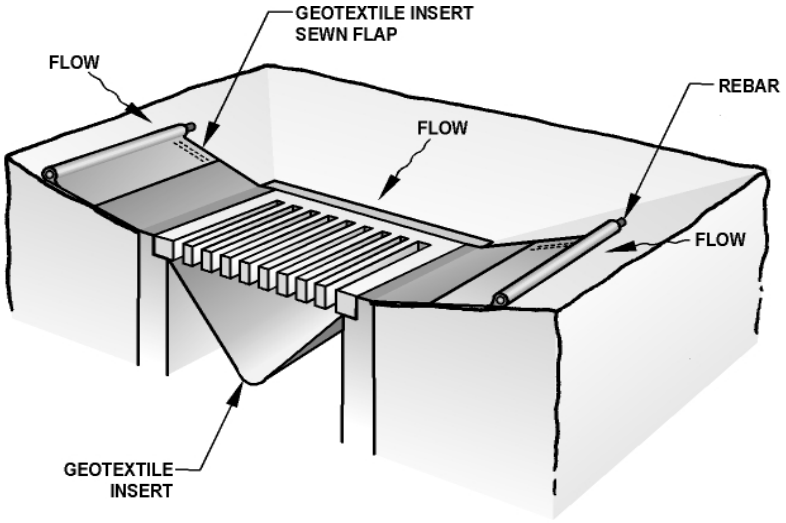
3.3.1.3 Inlet Protection

Prevents coarse sediment from entering storm drainage systems by filtering runoff and retaining sediment before it reaches a drainage inlet or storm sewer system. There are many options and variations of inlet protection available.

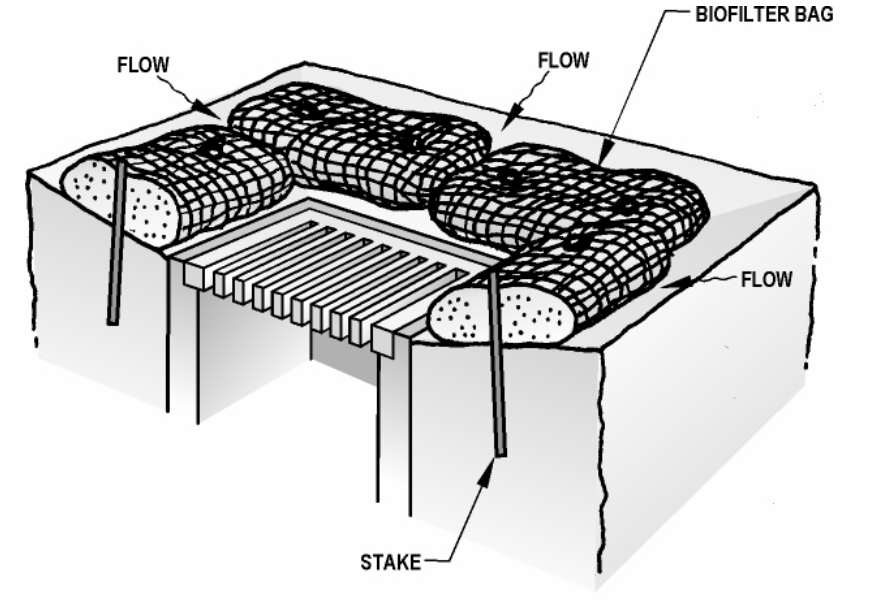
- Inlet protection types include:
  - Type 1 - Sediment Fence
  - Type 2 - Geotextile with Aggregate Filter
  - Type 3 - Catch Basin Insert
  - Type 4 - Biofilter Bags
  - Type 5 - Masonry Aggregate
  - Type 6 - Sod



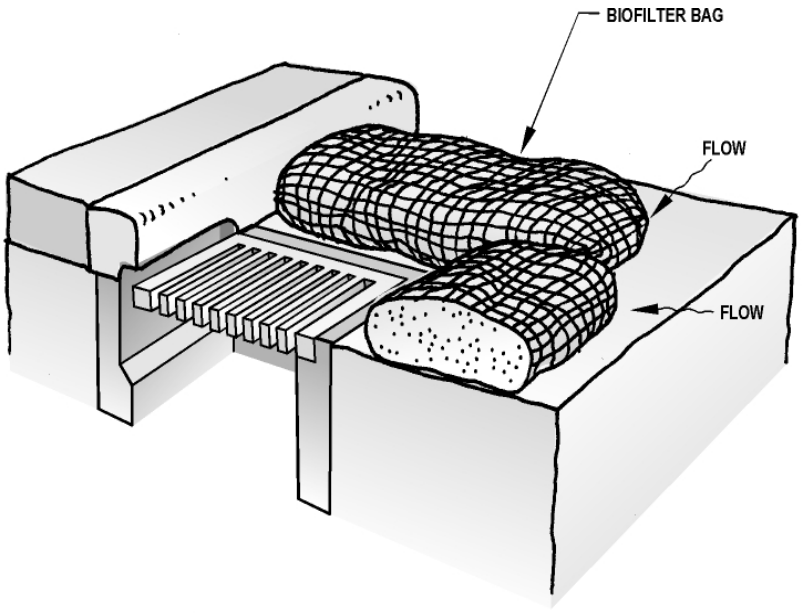
Inlet Protection - Geotextile/Wire Mesh/Aggregate (Type 2)



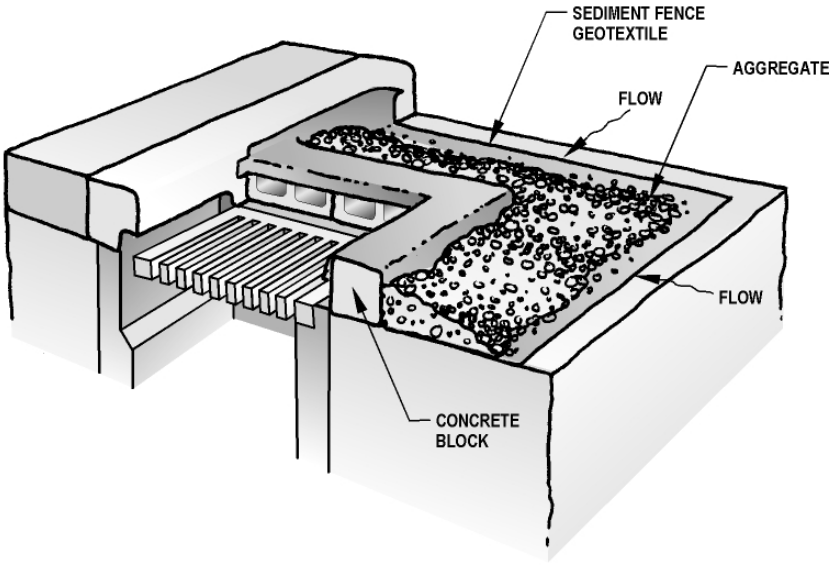
Inlet Protection - Prefabricated Filter Insert (Type 3)



Inlet Protection – Biofilter Bags around Area Drain (Type 4)



Inlet Protection – Biofilter Bags around Catch Basin (Type 4)



Inlet Protection – Masonry/Aggregate (Type 5)

Applications

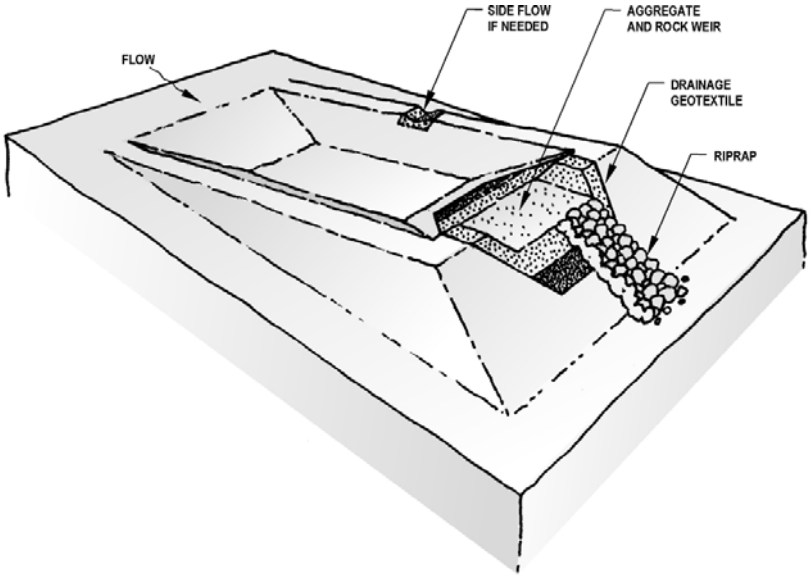
- At inlets that are ready for use before completion of final stabilization and that receive runoff from drainage areas less than 1 acre (0.4 hectare) in size.
- At storm drain inlets downslope and within 500 feet of a disturbed area or construction entrance.
- As a secondary measure downstream from erosion prevention and sediment trapping measures.

Advantages	Disadvantages
• Prevents sediment from entering the storm drain system. • Reduces amount of sediment leaving the site.	• May result in ponding of water above the catch basin. • Sediment removal may be difficult under high-flow conditions. • May result in a traffic hazard. • Short-circuiting of flow may occur if not properly installed. • Useful only for low flows having low sediment loading. • Improper installation, maintenance, or removal may introduce sediment into the storm drain system.

Maintenance

- Inspect and clean inlet protection during and after each significant storm and remove sediment from behind structure after every storm.
- If the aggregate becomes clogged with sediment, it must be carefully removed from the inlet and either cleaned or replaced.
- Assess the impacts of allowing water to pond at the inlet and provide an overflow weir or some other type of relief as needed.
- Consider the effect of placing obstructions at inlets on grade may have on their efficiency. Refer to the ODOT Hydraulics Manual or contact the ODOT Geo-Hydro Unit when placing protection at several inlets on grade along a roadway section.
- When possible, include a sediment sump 12 to 24 inches deep with 1:4 side slopes.
- Do not use water to remove sediment.
- Remove sediment accumulated on or around the protection as needed to maintain intended functions.
- Repair or replace materials as needed to ensure proper functioning.

3.3.1.4 Sediment Trap



A sediment trap consists of a small, temporary ponding area, with a rock weir or perforated riser pipe at the outlet, formed by excavation or by constructing a weir. The sediment trap serves drainage areas 5 acres and smaller and has a design life of approximately six months.

Applications

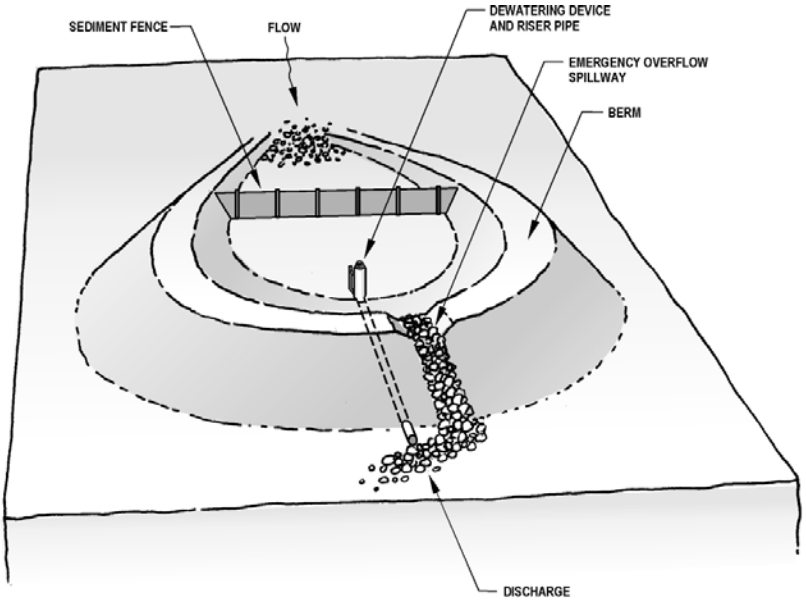
- Drainage areas that are 5 acres and smaller.
- Sites in proximity to salmonid streams, wetlands, or phosphorus-sensitive water bodies.
- Sites where major clearing and grading is likely to occur during the wet season.
- Sites with downstream erosion or sedimentation problems.
- Downslope of disturbed areas.

Advantages	Disadvantages
• Protect downstream riparian areas from sediment deposits. • Prevent reduced downstream capacity due to sediment deposition in a stream channel. • Prevents clogging of downstream facilities. • Removes particles up to medium silt size (.0008 inches). • Surface water conveyances can be connected to the facility as site development proceeds. The designer may want to route surface water collected from disturbed areas of the site through a sediment trap prior to release from the site.	• May become an attractive nuisance. Care must be taken to adhere to all safety practices. • Maintenance and sediment removal is essential for adequate performance. • Serves limited areas. • Does not reduce turbidity resulting from fine silts and clays in runoff. Traps are more effective when used in conjunction with other measures such as seeding and mulching.

Maintenance

- Constant maintenance is essential for proper functioning.
- Remove sediment from the trap when it reaches one-third the storage capacity.
- Repair any damage to the trap, embankments, or slopes.

3.3.1.5 Sediment Basin



A temporary sediment basin has one or more inflow points and baffles to spread the flow, wet storage and dry storage, a securely anchored riser pipe, a dewatering device and an emergency overflow spillway. The sediment basin serves drainage areas less than 10 acres and has a design life of approximately one year.

Basins are large facilities that treat runoff from large drainage areas. Because of this, basins have limited application to highway construction projects. The applications, advantages and disadvantages of basins are included here for the designer's edification.

Applications

- Drainage areas from 5 to 10 acres.
- Sites in proximity to salmonid streams, wetlands, or phosphorus-sensitive water bodies.
- Sites where major clearing and grading is likely to occur during the wet season.
- Sites with downstream erosion or sedimentation problems.
- Downslope of disturbed areas. Install prior to any upslope clearing and grading.

Advantages	Disadvantages
• Protect downstream riparian properties from sediment deposits. • Prevent reduced downstream capacity due to sediment deposition in a stream channel. • Prevents clogging of downstream facilities. • Remove particles up to medium silt size (.0008 inches). • Surface water conveyances can be connected to the facility as site development proceeds.	• May become an attractive nuisance. Care must be taken to adhere to all safety practices. • Failure of a basin that is not properly located could result in loss of life, damage to homes or buildings, or interruption of services such as transportation or power. • Maintenance and sediment removal is essential for adequate performance. • Does not reduce turbidity resulting from fine silts and clays in runoff. Basins are more effective when used in conjunction with other measures such as seeding and mulching.

Maintenance

- Inspect weekly and after each storm.
- All damage caused by soil erosion or construction equipment should be repaired before the end of each working day.
- Remove sediment when the sediment storage zone is half full. This sediment should be placed in such a manner that it will not erode from the site. The sediment should not be deposited downstream from the embankment or in or adjacent to a stream or floodplain.
- When temporary structures have served their intended purpose and the contributing drainage area has been properly stabilized, the embankments and resulting sediment deposit should be leveled or otherwise disposed of in accordance with the approved ESCP.

4 EROSION CONTROL PLAN

This section corresponds to Chapter 5 of the Erosion Control Manual.

- The erosion and sediment control plan (ESCP) provides a blueprint for the location, installation, and maintenance of measures to control erosion and prevent sediment from leaving the site during construction. The original project ESCP typically contains all the measures anticipated to be needed for the project, but it must be continually monitored throughout the project and adjusted if it fails to achieve all the goals required by the NPDES Permit.

4.1 Assessing the Project Site

The goals of the ESCP are 1) prevent soil erosion, 2) control the amount and velocity of runoff, and 3) capture all sediment on site during each phase of the construction project.

When assessing erosion control needs for the project, the designer should note any of the following conditions:

Regulatory Requirements

1. Particular requirements of the permitting agency, municipality or county.
2. Special requirements by the Oregon Department of Fish and Wildlife (ODFW), Oregon Department of Environmental Quality (DEQ), or other agencies.
3. Recommendations and considerations, including endangered species, mentioned in the environmental assessment (EA), environmental impact statement (EIS), environmental technical report (ETR), or any other project-related documents.

Existing Conditions

1. Type and condition of existing vegetation.
2. Soil types shown on soil reports or seen during site assessment.
3. Runoff flowing onto the construction site.
4. Swales or streams that traverse the site.
5. Runoff that concentrates in drainage swales or ditches.
6. Streams that could rise during high water flow.
7. Storm drain system with inlets that might receive sediment-laden water.
8. Outlets at culverts and other storm water conveyances.
9. Permanent landscaping or vegetative mitigation.

Construction Conditions

1. Construction traffic crossing a drainage swale or stream.
2. Runoff flowing onto the construction site.
3. Runoff that will flow onto disturbed areas having slopes 1:4 or steeper.
4. Cut or fill slopes 1:3 or steeper and higher than 6 feet.
5. Runoff leaving disturbed areas as sheet flow or concentrated flow.
6. Exposed soils within 100 feet of a waterway or wetland.
7. Disturbed areas of more than 5 acres that drain to a common location.
8. Disturbed areas of less than 5 acres that drain to a common location.
9. Storm drain inlets with any potential to receive sediment-laden water.
10. Outlets at culverts and other storm water conveyances.
11. Permanent landscaping.

Five Basic Rules

Paying attention to the following five basic rules at the planning stage will help develop a successful program:

1. **Timing** – Schedule work to minimize overall disturbance impacts.
2. **Stage work** – Identify and construct critical areas first, look at new drainage patterns created through phases of construction.
3. **Minimize disturbances** – Create buffers and reduce mass grading.
4. **Pre-construction planning** – Identify and layout erosion control measures based on planned construction sequences.
5. **Documentation** – Record any unusual existing conditions and modifications made to the ESCP throughout construction.

The ESCP should be developed according to the following general principles of erosion and sedimentation (as discussed in Chapter 2).

1. Fit grading to the surrounding terrain.
2. Time grading operations to minimize soil disturbance.
3. Emphasize erosion control measures to stabilize disturbed areas.
4. Retain existing vegetation wherever possible.
5. Direct runoff away from disturbed areas.
6. Minimize the length and steepness of slopes.
7. Use energy dissipation devices to reduce runoff velocities.
8. Install permanent storm drainage facilities as soon as possible.
9. Manage clean water to prevent it from coming into contact with exposed soil.

4.1.1 Project Scheduling

Coordinating 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 ground cover leaves a site vulnerable to accelerated erosion. Construction procedures that limit land clearing, provide timely installation of erosion and sediment controls, and restore protective cover quickly can significantly reduce the erosion potential of a site.

Construction projects should be sequenced to reduce the amount and duration of soil exposure to erosion by wind, rain, runoff, and vehicle tracking. A good construction schedule lists all major land-disturbing activities together with the necessary erosion and sediment control measures planned for the project. This type of schedule guides the contractor through work sequencing so that serious erosion and sediment problems can be avoided.

For each phase of the scheduled work, the ESCP should indicate how the proposed erosion and sediment control measures will stabilize exposed soil, limit runoff from exposed areas, filter sediment, and divert or store flows. The following activities should be included in the schedule, if applicable:

- Clearing and grubbing for perimeter controls.
- Installation of perimeter controls.
- Construction phasing.
- Clearing and grubbing, grading and trenching for activities other than perimeter control.
- Grading (including off-site activities) related to the project.
- Final grading, landscaping, and stabilization.
- Work at bridges and other watercourse structures.
- Utility installation and removal.
- Work required in any wetland.
- Monitoring of rainfall.
- Inspection of controls.
- Installation and maintenance of permanent controls.
- Installation, maintenance, and removal of temporary controls.
- Disposal of waste materials generated on-site.

Note that the construction activities listed above do not usually occur in a linear sequence, and schedules will vary due to weather and other unpredictable factors.

Schedules for temporary and permanent erosion control work, work required in wetlands, clearing and grubbing, grading, trenching, bridges, and other structures at water-courses, construction, and paving should be submitted for review by the Agency. Plans for erosion control on haul roads and borrow pits, and plans for disposal of waste materials should also be submitted. The contractor may submit the ESCP separate from the project plans if it is appropriate for the stage of construction.

4.1.2 Site Characteristics

The removal of existing surface ground cover leaves a site vulnerable to accelerated erosion. Identifying site characteristics will reduce land clearing, provide necessary controls, and restore protective cover efficiently and effectively.

Projects should be designed to integrate existing land contours. Significant regrading of a site will require more costly erosion and sediment control measures and may require installation of on-site drainage and sediment control facilities. The existing site terrain and vegetation should be inventoried and evaluated. Decisions must be made on the steepness of cut and fill slopes, how they will be protected from runoff, how they will be stabilized, and how they will be maintained. Whenever possible, slopes should be inclined 1:2 or flatter to reduce erosion potential and increase slope stability. Steeper slopes are unstable and may increase maintenance issues.

4.1.3 Grading Plan

The grading plan should be used to establish drainage areas, drainage patterns, and runoff velocities. The plan should identify disturbed areas, cuts, fills, and finished project elevations. All practices necessary for controlling erosion on the graded site and minimizing sedimentation downstream should be included. These practices may be temporary or permanent, depending on the need after construction is completed.

5 CONSTRUCTION IMPLEMENTATION

This section corresponds to Chapter 6 of the Erosion Control Manual.

Continual inspection of erosion and sediment control measures is necessary to assure their effectiveness. Unless measures are properly installed and maintained, there is a strong chance of failure during the construction period.

5.1 Erosion and Sediment Control Manager

The contractor will designate and supply an Erosion and Sediment Control Manager (ESCM), experienced in all aspects of construction and qualified to design and implement erosion control plans and measures. At a minimum, the ESCM should attend an agency-sponsored class, or the equivalent, covering all relevant aspects of erosion control. The ESCM is responsible for assuring the implementation of the ESCP and should have the authority to immediately mobilize necessary personnel to correct or modify erosion and sediment controls if required.

Duties of the ESCM include:

- Managing and properly implementing the ESCP.
- During periods of active construction, maintaining the ESCP at the project site so that it's available for review.
- Accompanying agency staff in a field review of the ESCP prior to the beginning of work.
- Monitoring rainfall on the project site.
- Inspecting erosion and sediment controls on active construction sites weekly.
- Inspecting erosion and sediment controls on inactive sites at least bi-weekly.
- Inspecting erosion and sediment controls on both inactive and active sites at least daily during rainy periods where a minimum 1/2 inch of rain has fallen in a 24-hour period.

- Mobilizing crews to make immediate repairs to, or install erosion and sediment controls during working and non-working hours.
- Documenting any cleanup of significant amounts of sediment.
- Completing erosion control monitoring forms (sample in Appendix E) after each inspection, erosion control facility modification, or maintenance action. Submit forms to agency weekly for active sites and bi-weekly for inactive sites.
- Maintaining up-to-date ESCP.
- Preparing a contingency plan in preparation for emergencies and the rainy season.
- Accompanying agency staff on inspections and, if requested, on inspections made by other regulatory agencies.

5.1.1 Ineffective Controls

The ESCM should document measures taken to clean up significant amounts of sediment. Should a control measure not function effectively, one or more of the following actions should be performed:

- Immediately repair the control.
- Replace the control.
- Provide additional controls.

5.1.2 Rainfall Monitoring

The ESCM should furnish and install a rain gauge at the project site. Rainfall should be monitored and the agency should be notified if 0.5 inch (minimum) of rainfall occurs within 24 hours. The entire project should be inspected to evaluate the condition of the control measures as soon as practicable, but no later than 24 hours after the storm event, including weekends and holidays.

5.2 Pre-Construction Meeting &ESCP

The contractor and inspector should carefully review the ESCP prior to the Pre-construction Meeting to understand what is required. Implementing the ESCP and assuring its performance may involve significant expense. The following pre-construction activities are typically required:

- Prior to the Pre-construction Meeting, review and comment on the contractor-modified ESCP or contractor-proposed ESCP modifications.
- During the Pre-construction Meeting, review the comments and finalize the ESCP implementation schedule with the contractor.
- Prohibit clearing and grading operations prior to ESCP approval and implementation.
- Tentatively locate construction accesses.
- Delineate clearing limits, drainage courses, easements, setbacks, wetlands, and other sensitive areas and their buffers.
- The Pre-construction Meeting provides an opportunity for the contractor to discuss the plan with the agency inspector and learn which elements of the ESCP require the most attention. Adjustments to improve performance or make installation easier and maintenance more reliable may also be discussed.
- The Pre-construction Meeting is also an opportunity to discuss the inspection schedule and procedures. Key points to consider in the pre-construction meeting are:
- Qualifications of individual designated as the ESCM.
- Methods to be used to document and update the ESCP.
- Areas that need a high degree of protection from sedimentation, particularly environmentally sensitive areas such as wetlands, stream crossings, channels, and water disposal outlets.
- Location and implementation of erosion and sediment controls.
- Installation sequence of erosion and sediment control measures with respect to the construction schedule.
- Stabilization plans for disturbed soils, including temporary and permanent seeding.
- Construction schedule and any anticipated shutdown periods.
- Maintenance plans and the contractor’s procedure for monitoring performance of erosion and sediment controls.

- Location of all material sources and disposal areas.
- Emergency or contingency plans.
- Any special requirements identified in project permits.
- Monitoring record submittal requirements, provide a copy of the monitoring form (ODOT Form 734-2361 Erosion Monitoring Form or approved equivalent) to the contractor.
- The project Biological Assessment report covers special needs and concerns for threatened and endangered species on the project. The contractor should be aware of its contents.

5.2.1 Contractor-Modified ESCP

Most project plan sets will include an ESCP prepared by designers. This plan is only a guide and is unlikely to have adequately addressed all erosion concerns for the project. The ESCP included in the plan set should not be followed blindly. It is the contractor's responsibility to propose modifications to the ESCP. The modifications can be marked on the ESCP included in the plan set and submitted to ODOT for approval. The Project Manager reviews and comments on the contractor-modified ESCP.

In order to assess the adequacy of the ESCP, the reviewer should ask the questions listed below. The ESCP should include a brief narrative describing any unique site characteristics or special considerations. Sufficient detail should be provided to implement the plan properly to control erosion and sediment during each phase of site development.

1. Is the information site-specific? Any information provided by the contractor for the ESCP must be site and project specific rather than generic.
2. Does the ESCP fulfill the following minimum requirements, when applicable?
    - Show protection and buffers for sensitive areas, streams, lakes, and wetlands?
    - Protect adjacent and downstream properties and waterways from erosion by controlling velocity and volume of runoff as it leaves the site?
    - Prevent upslope runoff from flowing over disturbed areas?
    - Provide measures that trap sediment on site?

- Route dewatering devices through a sediment-trapping device before leaving the site?
- Protect inlets and the storm drain system from sediment?
- Provide perimeter protection downslope and along the full length of disturbed areas?
- Provide erosion prevention for steep slopes?
- Provide protection at cut and fill slope transitions?

Updating the ESCP

Effective erosion control is closely tied to a contractor's staging, operation methods, and construction timing. When the agency develops the ESCP, the contractor's staging and operation methods are unknown. The agency therefore expects the contractor to propose changes to the ESCP and update the plan as needed throughout the life of the project.

Changes to the ESCP are the responsibility of the contractor-appointed ESCM. Changes to the ESCP should be submitted to the agency for approval. The modified ESCP will be documented using procedures approved by the agency. Generally, changes to the ESCP can be made by hand on the plan itself, which will be used as a master up-to-date ESCP. An example of an up-to-date ESCP is provided in Appendix C. Notes on the up-to-date ESCP should indicate the location, date, and status of each BMP (I=installed, M=maintained, R=removed).

Construction Schedule Review

Refer to specification Sections 00170.30(c), 00180.41, and 00280 for specific requirements. The implementation schedule should include the following:

- Timing of activities to limit seasonal and weather impacts.
- Timing of wet season work and temporary work shut down.
- Timing of activities to meet "in-water" work restrictions.
- Installation of erosion prevention and sediment controls shown on the plans before ground-disturbing activities begin.
- Installation of permanent facilities, such as sediment traps and basins, which will be used during construction as temporary measures.

- Retention of temporary perimeter controls until all upstream areas are stabilized.
- Timing of seeding operations.

Monitoring Form

All inspections are to be recorded on the ODOT Erosion Monitoring Form, which is included in Appendix E. Also included in Appendix E is a sample form showing proper descriptions of the performance of various BMPs on a hypothetical project. The effectiveness of each BMP at every location on site should be documented on the form, as well as general observations on site conditions. Information provided on the form is useful for tracking repairs and demonstrating permit compliance. It is noteworthy, that in the event of permit violations or subsequent enforcement actions, the information recorded on the form, along with photographs and videos, may be used to evaluate the responsibility of involved parties.

5.3 Materials

The following sections present information on some of the erosion and sediment control products and materials approved for use on ODOT projects. Information necessary to verify proper quality assurance/quality control (QA/QC) consistent with the specifications is also provided.

5.3.1 ODOT Qualified Products List

The ODOT Qualified Products List (QPL) is for products that have been reviewed and found to be suitable for use in a specific category. Erosion control products are found in Section 00280.10 of the QPL. Job control testing may still be necessary.

- Approved List: Commercially available products having a low consequence of failure; products may be used for appropriate applications only.
- Rejected List: Products that should not be used for that specific category.
- Conditional List (unpublished): Conditionally approved products that require specific approval for each application.

Specific questions regarding products on the Conditional List can be answered by calling (503) 986-3059.

The QPL is also accessible on the Internet at:

http://www.oregon.gov/ODOT/HWY/CONSTRUCTION/QPL/QPIndex.shtml

Weed Free Straw/Straw Bales

Grass seed crops in Oregon become certified through the OSU Extension Service. This program was created to assure that commercially produced seed will be the correct species and variety, and have genetic purity. The certification program includes an inspection of the field by the OSU Extension Service to confirm the field has a buffer distance to prevent cross pollination from other plant varieties, is noxious weed free, and

meets other criteria related to seed purity. ODOT relies upon the OSU Extension Service seed certification program when specifying straw and sometimes grass seed for erosion control in an effort to control the spread of noxious and other invasive weeds.

Straw is not certified in Oregon at this time, therefore, straw bales will not have a tag indicating certification. The field from which the straw originates, however, should be certified by the OSU Extension Service. Because straw is often left on the project site after the work is completed, ODOT must assure that the straw bale does not harbor weed species that can be invasive to agricultural fields and wildlife habitat. Documentation must be obtained from the supplier that demonstrates the source of the straw was a certified field or a field which was tested for weed seed content and met the same requirements for a certified field.

Straw can originate from cereal grain as well, however, the grain crop must be from a certified field. The OSU Extension Service keeps track of fields around the state that are certified. The OSU Extension Service has a presence in every county in Oregon and can be called if anyone needs assistance in finding a source for weed-free straw and certified grass seed.

5.4 Installation

Proper installation of erosion and sediment controls is absolutely essential. Performance of control measures is directly determined by how they are installed in the field, and often times the measures themselves can cause more damage when improperly installed than if they are not used at all. Installation of all base measures should be inspected and any deficiencies corrected prior to the start of land-disturbing activities. Subsequent inspections of all installations should also be made throughout the life of the project.

The inspector should be familiar with installation details for each BMP used on the project. Details for the installation of all specified BMPs are provided in the ESCP. Installation details for BMPs are also provided in Chapter 3 of this manual, and in specification Section 00280 (Appendix A).

The application of mulch and seed is normally based on the rate described in the specifications. To assure the appropriate rate is applied, mark off an area of known dimensions and apply the specified amount of material over the area. This will provide a visual baseline for inspecting the rate of application over similar project areas.

5.5 Measures During Construction

The approved ESCP should be viewed as an open-ended document, subject to approved adjustments and modifications, as necessary. Contingencies, such as changes in the construction schedule or unexpectedly severe weather, frequently call for changes or adjustments to the ESCP. In addition, the contractor is expected to monitor the performance of all erosion and sediment control practices and make minor adjustments as needed on a day-to-day basis. Major modifications, on the other hand, must be approved by the agency before implementation.

The contractor's responsibility does not end with installation and maintenance of designated measures. The plan must also work effectively. Excessive erosion on site or off-site damage from sediment is not acceptable. If performance of the ESCP is not adequate the plan must be revised, approved, and implemented. Minor revisions may be made in the field, if they are well documented and work effectively.

Major or minor revisions that are ineffective must be discussed with the engineer of record. All graded areas and the supporting erosion and sediment control measures should be checked periodically, especially after heavy storm events. All sediment from diversions and other water-disposal practices should be promptly removed. If washouts occur, they should be repaired immediately. Prompt maintenance of small, eroded areas, before they become significant gullies, is an essential part of an effective ESCP.

Inspections, changes, problems, and solutions should be documented on the master up-to-date ESCP as described in Section 5.2.2. Meetings to review and update the ESCP before winter work or temporary work shutdown should be conducted. Submittals for materials and alternative measures should be reviewed and approved.

5.5.1 Work Restrictions

All agency construction projects are required to restrict certain types of work that may contribute to sediment-laden water leaving the project site or entering waterways. The following are work restrictions that may apply:

1. Flag Clearing Limits
2. Perimeter Controls before Grubbing
3. Wet Season Plan and Schedule
4. Limit Disturbed Areas
5. Install BMPs Early
6. Stop Work

Stabilization Requirements

All soils that are exposed and disturbed by construction-related activities should be stabilized according to the following locations and time frames:

- Statewide (Entire Year): Within 7 days of exposure, stabilize all areas within 100 feet of waterways, wetlands, or other sensitive areas.
- West of the Cascades (Entire Year): Stabilize all other areas within 14 days of exposure.

- East of the Cascades (October 1 through May 1): Stabilize all other areas within 14 days of exposure.
-
- East of the Cascades (May 1 through October 1): Stabilize slope and embankment construction in stages based on site conditions, weather, and as determined by the agency.

5.5.2 Erosion Control Contingency Items

The contractor is required to have materials on hand as a contingency in the event of a failure or when required to shore up BMPs installed as part of the ESCP. An example of when to use these items would be in the event of a heavy rainfall that creates runoff beyond the capabilities of the existing erosion control facilities at the project site. At a minimum, the following materials should be kept on site for use in emergencies:

- 30 feet[1] unsupported sediment fence
- 215 square feet[2] of 6-mil plastic sheeting
- 1200 feet[3] rope (for tethering sand bag anchoring system over plastic sheeting)
- 50 empty bags for sand bags
- 5 straw bales[4] with 10 stakes.
- 10 biobags with 20 stakes

[1] Clackamas County uses 100 feet
[2] Clackamas County uses 260 square feet
[3] Clackamas County uses 1000 feet
[4] Clackamas County uses 10 bales

It is the designer's perogative to specify additional or alternate material types and quantities depending on the scope of the project.

The contingency items may also be used at the discretion of the inspector to strengthen the erosion control measures as needed during construction project. A discussion should take place between the inspector and the ESCM when making the decision when to employ these contingency erosion control items. An example would be when the contractor creates a stockpile of soil on site that was not anticipated during development of the ESCP. The plastic sheeting could be employed to cover the

stockpile, and the rope and sandbags used to secure the plastic from blowing around in the wind. Available ontingency materials that are not installed are paid for in the Lump Sum Bid Item specification Section 00280 - Erosion Control. If the contingency erosion control items are not used during the life of the construction project, the contractor may re-use these items at another site.

5.6 BMP Maintenance

Erosion and sediment controls must be maintained in good working order at all times in order to function as intended. These controls must be retained in place until the agency issues a notification of acceptance of permanent stabilization. All maintenance and repairs should be included in the bid price submitted by the contractor and are therefore at the contractor's expense.

Typical maintenance activities, guidelines, and failure modes for BMPs are discussed in Chapter 3 of this manual, and in specification Section 00280 (Appendix A). The inspector should be familiar with maintenance requirements for each BMP used on the project. It is noteworthy that maintenance activities and frequencies vary among the different BMPs, and will depend largely on weather and other site conditions. In general, the more effective erosion control measures are, the less maintenance will be required for sediment controls.

5.6.1 Sediment Removal

Sediment should be removed and the controls upgraded or repaired as needed, or as soon as practicable, but no later than 2 days after the surrounding exposed ground has dried sufficiently to prevent further damage from equipment needed for repair operations. In the event of continuous rainfall over a 24-hour period, or other circumstances that preclude equipment operation in that area, additional sediment controls should be hand-carried and installed consistent with BMPs approved by the agency. Catch basins should be maintained so that no more than a 6 inches sediment depth accumulates within traps or sumps. Sediment should be removed from controls, such as sediment fences, sediment barriers, check dams, inlet protection, and sediment traps once the sediment buildup has reached one-third of the exposed height of the control or storage depth. Rock filters and filter berm material should be replaced with new aggregate material when sediment reduces the filtering capacity by 50 percent.

5.6.2 Construction Entrances and Paved Areas

Aggregate, or other specified material, should be added or removed as needed to maintain proper function of the entrance areas. All paved areas should be kept clean for the duration of the project.

5.6.3 Sediment Disposal

Removed sediment should be re-graded into slopes or removed and disposed of off site in accordance with all federal, state, and local laws and ordinances. Sediment-laden water should not be flushed into the storm drain system.

5.6.4 Finishing and Clean-up

Within 30 days of the notification of acceptance of permanent stabilization, temporary erosion and sediment control materials should be removed from the area. Areas affected by the removal process should be permanently stabilized. All materials associated with temporary erosion and sediment controls that are not incorporated into the permanent work will become the contractor's property.

Removed sediment should be re-graded into slopes or removed and disposed of off-site. Sediment-laden water can be settled, treated, or reused on site. It should not be discharged directly to any water body, either treated or untreated.

5.7 Inspector's Tools

The following sections provide additional resources for the inspector to verify that adequate erosion and sediment control measures are implemented. These checklists and guidelines are also useful for the ESCM as they outline the agency's expectations for proper erosion and sediment control management.

5.7.1 Inspector Checklist

The inspector checklist should be used by agency representatives when inspecting erosion and sediment controls on a project site. The checklist is intended to summarize the key elements of a successful erosion and sediment control program. Topics on the checklist include:

- Schedule Review
- ESCP
- ESCM
- Sensitive Areas
- Contingency Plans
- Materials On-Hand
- Maintenance
- Monitoring Forms
- Slope Protection and Stabilization
- Plan Revisions and Modifications
- BMP Evaluation
- Technical Resources
- Additional Items

5.7.2 Winterization

The wet season in Western Oregon is approximately October 1 through April 30. Prior to wet season work and before temporary work shutdown for winter, the contractor should meet with the agency to review and

update the ESCP and develop a schedule to assure that appropriate controls are implemented and maintained during wet season and work shutdown periods. Winter preparations should begin in August. Winterization planning should address the items listed above in the inspector checklist.

Rules of Thumb

Several Rules of Thumb worksheets are provided to aid designers and inspectors in determining and verifying the quality and quantity of various erosion control items. These are especially useful when verifying the application rates of various mulch and hydraulically applied products. Rules of Thumb includes the following:

County Extension Offices Phone List,
Seed Label Requirements Diagram
Example Seed Tags
Slope Measurement Table
Slope Inclination Conversion Worksheet
Common Metric Abbreviations Table
English/Metric Conversion Tables
Metric Conversion Factors Table
Pipe Sizes
Rebar Sizes
Straw Mulch Table
Hydraulic Application Equations
Seed or Fertilizer Hydraulic Application Table, A-1
Seed or Fertilizer Hydraulic Application, Table, B-1
Wood Fiber Mulch Hydraulic Application, Table C-1
Wood Fiber Mulch Hydraulic Application, Table C-2
Wood Fiber Mulch Hydraulic Application, Table C-3
Wood Fiber Mulch Hydraulic Application, Table C-4
Wood Fiber Mulch Hydraulic Application, Table D-1
Wood Fiber Mulch Hydraulic Application, Table D-2
Wood Fiber Mulch Hydraulic Application, Table D-3
Wood Fiber Mulch Hydraulic Application, Table D-4
Hydraulic Application Example Problems 1-4 (English Units)
Hydraulic Application Example Problems 1-4 (Metric Units)
Inspector Checklist for Erosion Control
Winterization Checklist

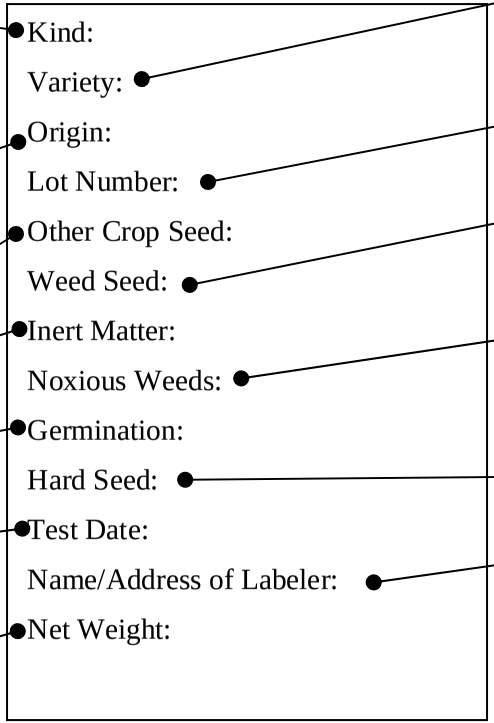
County Extension Offices **

Contact for Weed, Seed certification. or other inquiries

County	Telephone	County	Telephone
Benton	541-757- 6750	Malheur	541-881-1417
Clackamas	503-655-8631	Marion	503-588-5301
Crook	541-447-6228	Morrow	541-676-9642
Douglas	541-672-4461	Polk	503-623-8395
Gilliam	541-384-2271	Sherman	541-565-3230
Harney	541-573-2506	Umatilla	541-276-7111
Jackson	541-776-7371	Union	541-963-1010
Jefferson	541-475-3808	Wallowa	541-426-3143
Klamath	541-883-7131	Wasco	541-296-5494
Lane	541-687-4243	Washington	503-681-7007
Linn	541-967-3871	Yamhill	503-434-7517

***County extension agents are listed in the current Oregon Certified Seed Handbook*

SEED LABEL REQUIREMENTS



Commonly accepted name of the kind of each agricultural seed component constituting five percent or more of the whole and the percentage by weight of each.

The country or state where seed grown. If unknown, the fact that the country or state where grown is unknown shall be stated.

Total percentage, by weight, of other crop seed.

Total percentage, by weight, of inert matter.

Percentage of germination.

Month and year the test to determine the data required by this section was completed.

Statement of net quantity of the contents of each container in terms of the net weight of such container.

Each agricultural seed component shall be labeled to variety or labeled with the statement “Variety Not stated”.

The lot number or other lot identification.

Total percentage, by weight, of weed seed.

Name and number per pound of each kind of restricted noxious weed seed. (Note: Labels for ODOT seed must say “No noxious found” or similar).

Percentage of hard seed, if more than one percent.

Name and address of the dealer or person who labeled the seed or who sells offers or exposes such seed for sale within the state.

Label Examples

ABC COMPANY
123 Street
Anytown, Oregon 90001

MIXTURE NAME: DAYVILLE #1 MIX
LOT NO: XX1-111-02
TEST DATE: 4/01/06 **AMS:** 1234
BAG NET WEIGHT: 50 LBS **BAG:** 1 of 1

	VARIETY	% IN MIX	GERM	PURITY	ORIGIN
1)	LUNA PUBESCENT WHEATGRASS	6.20%	91.00%	94.96%	ID
2)	CEREAL RYE	5.26%	86.00%	99.84%	CAN
3)	SECAR B. W.	20.52%	89.00%	98.59%	WA
4)	PAIUTE ORCHARDGRASS	29.09%	96.00%	96.29%	OR
5)	JOSEPH IDAHO FESCUE	11.06%	91.00%	84.67%	ID
6)	SMALL BURNETT	12.89%	86.00%	98.67%	OR
7)	FAIRWAY CRESTED WHEATGRASS	12.84%	90.00%	98.29%	CAN
	WEEDS:	0.02%			
	OTHER CROP SEED:	0.11%			
	INERT MATTER:	4.81%			
	TOTAL:	100%			

NOXIOUS WEED: NONE FOUND (*)

Example 1—Seed mix label

*All seed offered for public sale in Oregon must be tested for noxious weed seed content according to ORS 633. Seed containing listed noxious weeds is prohibited in Oregon.

ABC COMPANY
123 Street
Anytown, Oregon 90001

MIXTURE NAME: Native Emergent Mixture
LOT NO: XX1-121-04
TEST DATE: 8/01/05 **AMS:** 1324
BAG NET WEIGHT: 50 LBS **BAG:** 1 of 1

	VARIETY	% IN MIX	GERM	PURITY	ORIGIN
1)	Scirpus microcarpus (Small-fruited Bulrush)	25.00%	81.00%	92.84%	OR
2)	Carex stipata (Sawbeak Sedge)	20.00%	68.00%	87.59%	WA
3)	Juncus tenuis (Slender Rush)	10.00%	64.00%	92.29%	OR
4)	Eleocharis palustris (Creeping Spike Rush)	10.00%	74.00%	84.67%	WA

WEEDS:	0.02%
OTHER CROP SEED:	0.11%
INERT MATTER:	4.81%
TOTAL:	100%

NOXIOUS WEED: NONE FOUND

Example 2 – Native Seed Label

Standards for Native Seeds:

There is currently no universal definition for what constitutes “native” when it comes to plant seed. Since native seed is used for various goals, the standards of the seed specifier can vary depending on those goals, i.e., a native prairie restoration may have higher seed standards than a wetland mitigation being done to meet permit requirements. The specifier should be involved in reviewing contractor seed submittals and any proposed substitutions.

Instead of common names, botanical names are the standard for native seeds. There may also be more taxonomic precision where a variety is added to the species and subspecies name. These can be on the label, seed lab test results, or other acceptable supplier certification for that seed lot. Seed that is specified to be native but is delivered with only a common name may not be acceptable to the specifier.

Native seed may be specified for erosion control seeding to fulfill specific project environmental goals.

These are just a few of the broad sets of standards that could be used for native seed:

1. Broad regional - Seed with the same botanical name as seed that is known to be native within some defined geographical boundaries where it will be planted, i.e., North America. The label or supplier's certification must show accurate botanical names in order to ascertain whether the correct seed is being supplied.
2. Source identified - Seed whose source is specified, typically within the same identified ecological zone where it will be planted. It may still be grown (agriculturally increased) anywhere. The label or certification must show the parent seed source, country or state where grown, and have accurate botanical names.
3. Source and agricultural growing area identified - Seed whose geographical source is specified as the same ecological zone ("seed transfer zone") where it will be planted and may also have geographical limits to where the seed can be grown. The seed source could be shown on the label or on supplier certification accompanying the seed shipment to the site. The label or certification must show both the source of the parent seed and where the seed was grown, plus have accurate botanical names.
4. Collection site specified - Seed specified to be collected from identified sites in the area near the replanting site and propagated (agriculturally increased) within a set short distance of where it will be planted, often no more than just a few miles. Seed collection typically must go through special procedures for quality assurance with all information typically reviewed by the specifier. In this case, the label may only certify the accurate name of the seed, quantity, and make reference to the certified collection information.
5. Hand collected - Seed specified to be hand-collected from specific sites or within a defined distance from where it will be planted. (Sometimes not even be allowed to be increased because if fear of contamination). This method is usually clearly specified in he special provisions. The contractor's seed collection methods must be approved before work begins and seed may not have to go through the normal testing and formal labeling process if custom collected for a single project.

There are other seed standards which may be used and additional unique requirements may have been added by the specifier. These will typically need documented certification, whether on the label or on other certification.

Oregon State University Seed Laboratory

Corvallis, Oregon 97331
(Member Association of Official Seed Analysts)
Phone: (541) 737-4464
Fax: (541) 737-2126
http://www.oscs.orst.edu

Report of Seed Analysis

NAMES AND ADDRESSES:
[redacted]
LEBANON OR 97355

DATE RECEIVED	DATE COMPLETED	TEST NO
08-02-2004	08-24-2004	78519

SENDERS INFORMATION*

KIND: **Perennial ryegrass**
VARIETY: ***Linn***
GENUS/SPECIES: **Lolium perenne**
LOT NUMBER: [redacted]
SIZE OF LOT: **1,100 Sacks; 55,000 Pounds**
FIELD NUMBER: [redacted]
SAMPLE TYPE: **Official Certification C-22**
OTHER INFORMATION: **None**

Certified Generation

*The information provided here is that of the sender and not of the laboratory.

PURITY ANALYSIS

(5.199 GRAMS ANALYZED)

PURE SEED COMPONENT(S):

Perennial ryegrass **Lolium perenne**	**99.71%**

VIABILITY ANALYSIS

Germination %	Dormant %	Hard Seed %	Total Viable %	No. Seeds (Germ)	Days Tested	TEST FLUOR %		TZ %
94	X	X	94	400	14	4.51		96

OTHER CROP SEED 0.00 % INERT MATTER 0.29 % WEED SEED 0.00 %	COMMENTS: **Meets OSCS viability standard**

OTHER CROP SEED:

None Found

All States (Except Hawaii) NOX. WEED SEEDS **50.03 GMS. ANALYZED:**

None Found

INERT MATTER: **Sterile florets, stems, chaff.**

WEED SEED:

None Found

OTHER DETERMINATIONS: **Meets OSCS purity standard**

EXCLUDING UGS.

Final Certification approval will be determined at OSCS by evaluating sample eligibility and seed quality results.

TEST CODES AND FEES: **p-$59.00 tz-$54.00 fl-$39.00**

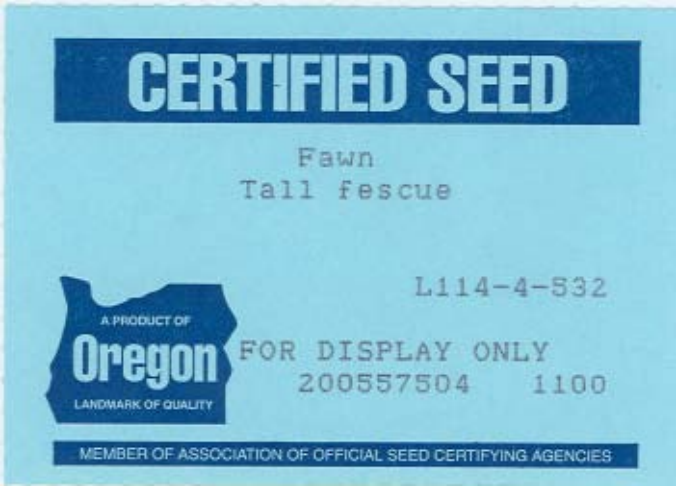
4 A/O

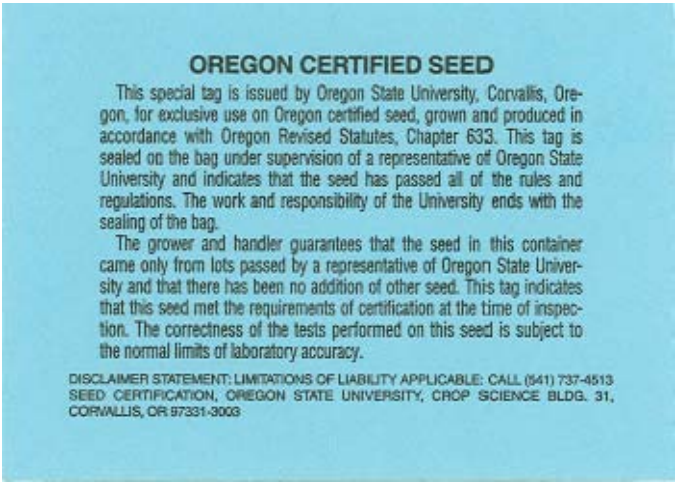
RULES FOLLOWED OTHER THAN AOSA: _____

SIGNATURE _____

The purity and germination test results reported on this form have been carried out in accordance with AOSA rules unless otherwise specified. Test results reflect the condition of the submitted sample and may not reflect the condition of the seed lot from which the sample was taken.

Example 3: Sample of a seed lab test report. Testing is required on every lot of seed offered for sale in Oregon. In the event of questions about a seed container label, copies of the seed lot test results can be requested.





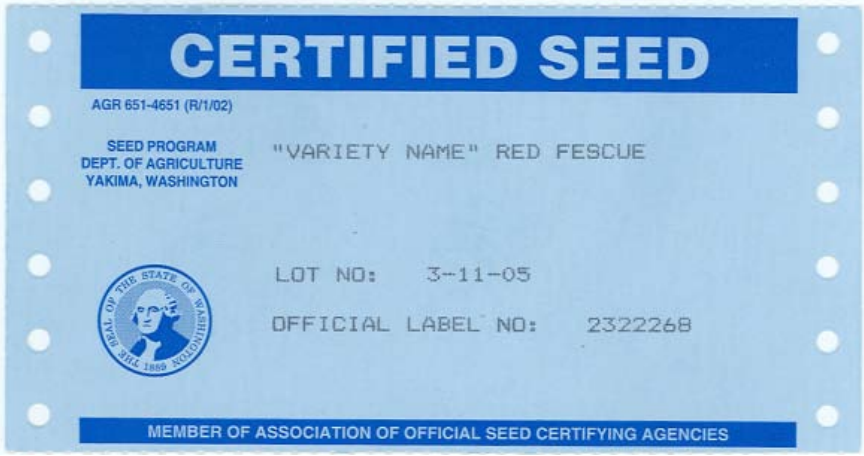
OREGON CERTIFIED SEED

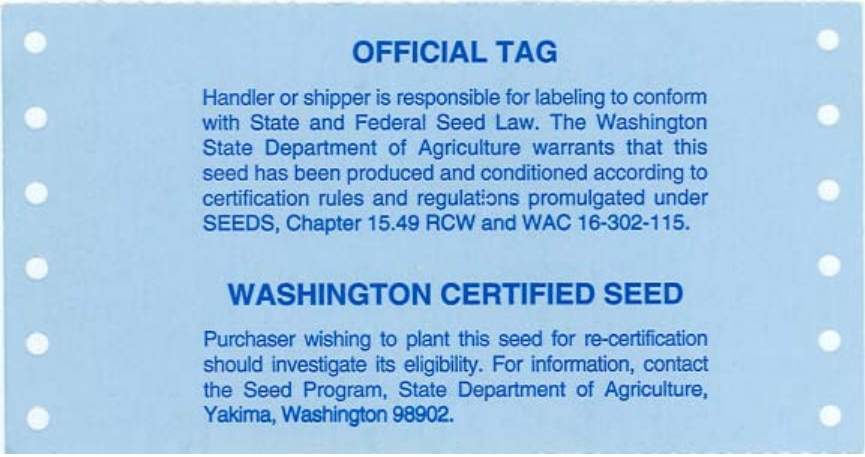
This special tag is issued by Oregon State University, Corvallis, Oregon, for exclusive use on Oregon certified seed, grown and produced in accordance with Oregon Revised Statutes, Chapter 633. This tag is sealed on the bag under supervision of a representative of Oregon State University and indicates that the seed has passed all of the rules and regulations. The work and responsibility of the University ends with the sealing of the bag.

The grower and handler guarantees that the seed in this container came only from lots passed by a representative of Oregon State University and that there has been no addition of other seed. This tag indicates that this seed met the requirements of certification at the time of inspection. The correctness of the tests performed on this seed is subject to the normal limits of laboratory accuracy.

DISCLAIMER STATEMENT: LIMITATIONS OF LIABILITY APPLICABLE: CALL (541) 737-4513 SEED CERTIFICATION, OREGON STATE UNIVERSITY, CROP SCIENCE BLDG. 31, CORVALLIS, OR 97331-3003

Example 4: Oregon Certified Seed Tag—Front and back





Example 5: Washington Certified Seed Tag—Front and back

SLOPE MEASUREMENT

VERTICAL MEASURE		HORIZONTAL MEASURE	MULTIPLYING FACTOR
1	TO	3/4	1.6670
1	TO	1	1.4142
1	TO	1 1/2	1.2019
1	TO	2	1.1180
1	TO	2 1/2	1.0770
1	TO	3	1.0541
1	TO	4	1.0308
1	TO	5	1.0198

To calculate area in acres:

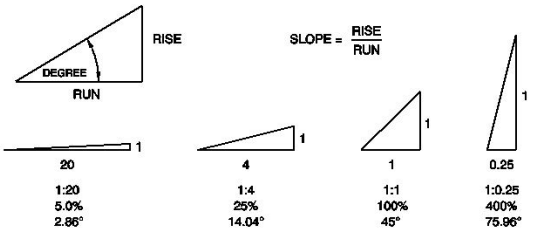
Multiply square feet by the slope factor above and divide by 43,560, or;

Multiply square yards by the slope factor above and divide by 4,840.

SLOPE INCLINATION CONVERSION WORKSHEET

RISE	RUN	RATIO	PERCENT	DEGREE
1	20	1:20	5.0	2.86
1	10	1:10	10.0	5.71
1	9	1:9	11.1	6.34
1	8	1:8	12.5	7.12
1	7	1:7	14.3	8.13
1	6	1:6	16.67	9.46
1	5	1:5	20	11.31
1	4	1:4	25	14.04
1	3	1:3	33.3	18.43
1	2	1:2	50	26.57
1	1.5	1:1.5	66.67	33.69
1	1.25	1:1.25	87	38.66
1	1	1:1	100	45
1	0.75	1:0.75	133.33	53.13
1	0.50	1:0.50	200	63.43
1	0.25	1:0.25	400	75.96

EXAMPLES:



OREGON DEPARTMENT OF TRANSPORTATION

GEO / ENVIRONMENTAL SECTION

SLOPE CONVERSION TABLE

DATE: 6/01/2006

http://www.oregon.gov/ODOT/HWY/GEOENVIRONMENTAL/erosion_control.shtml

SOME COMMON METRIC ABBREVIATIONS

ABBREVIATION		MEASUREMENT
Mgm/ha/year	=	megagram per hectare per year
L	=	liter
ha	=	hectares
kg	=	kilogram = $1x10^3$ grams
m	=	meter
km	=	kilometer = $1x10^3$ meters
mm	=	millimeter
Mgm	=	megagram = $1x10^6$ grams
kN/m^3		kiloNewtons per cubic meter
Pa		Pascal

Measurement in:	From English Units:	To Metric Units:	Multiply By:
LENGTH	inch (in)	millimeter (mm)	25.40
	foot (ft)	meter (m)	0.3048
	yard (yd)	meter (m)	0.9144
	mile (mi)	kilometer (km)	1.609
AREA	in 2	mm 2	645.2
	ft2	m2	0.0929
	yd2	m2	0.8361
	mi2	km2	2.590
	acre	hectare (ha)	0.4047
	acre	in 2	4047

Familier Conversions to Metric Units:

LENGTH	Thickness of a Dime	1 mm
	Diameter of a ballpoint pen	10 mm
	Length of a- paper clip	30 mm
	Length of a dollar bill	150 mm
	Height of a Door	2 m
	Length of a football field	100 m
	Width of a piece of paper	85 mm
WEIGHT	Large paper clip	1 gram (g)
	Nickel	5 g
	Large Apple	50 g
	Size "D" Battery	100 g
	Large Can of Tomatoes	1 kilogram (kg)
TEMPERATURE	Water Freezes	0 degrees Celcius (° C)
	Body Temperature	37° C
	Water Boils	100" C

1. When converting, rounding to nearest significant figure is common practice.
2. *Reference: Metric Basics. 1994. ODOT Technical Services.

METRIC CONVERSION FACTORS

Quanti	**From SI Units**	To **English Units**	Divided B
Length	km	mile	1.609
	m	yard	0.9144
	m	foot	0.3048
	mm	inch	25.4
Area	km2	square mile	2.59
	m2	acre	4047
	hectare	acre	0.404
	m2	square yard	0.836
	m2	square foot	0.092
	mm 2	square inch	645.2
Volume	m3	acre foot	1233
	m3	cubic yard	0.764
	m3	cubic foot	0.028
	L(1000 cm3)	cubic foot	28.32
	m3	1000 board feet	2.36
	L(1000 em3)	gallon	3.785
	cm 3	cubic inch	16.39
Mass	kg	pound mass lb.-mass, 1 bn,	0.4536
Mass Density	kg/m3	lb.-mass/ft	16.02
Force	N	lb.	4.448
	kN	kip	4.448
Force/Unit Length	N/m	lbs/ft	14.59
	kN/m	kips/ft	14.59
Force/Unit Area,	kPa	lbs/in2	6.895
Pressure Stress,	MPa	kips/in 2	6.895
Modulus of Elasticity	Pa	lbs/ft2	47.88
	kPa	ki s/ft2	47.88
Force/Volume Unit	N/m3	lbs/ft3	157.1
Weight	kN/m3	ki s/ft3	157.1
Bending Moment,	kN-m	ft-lb	1.356
Torque Moment of		ft-kip	1.356
Force			
Work	Nm	lb-ft	1.355818
Energy	Joules	ft-lb	1.355818
Volume Rate of Flow	in 3/S	ft3	0.02832
	in 3/S	cfin	0.000472
	L/s	c fm	0.4719
	in 3/S	m d	0.0438
Temperature	°C	°F	(°F-32°)/1.8
Velocity, Seed	m/s	ft/s	0.3048
Acceleration	m/s2	ft/s2	0.3048

Reference. FHWA Geotechnical Metrication Guidelines

PIPE

Pipe is one of the most ubiquitous products in construction. It is made of a wide variety of materials, including galvanized steel, black steel, copper, cast iron, concrete and various plastics such as PVC, CPVC, polyethylene, and polybutylene, among others.

But like wood 2-by -4's which are not really 2 inches by 4 inches, piope is identified by "nominal" or "trade" names that are related only loosely to actual dimensions. For instance, a 2-inch galvanized steel pipe has an inside diameter of about 2-1/8 inches and an outside diameter of about 2-5/8 inches. It is called "2-inch pipe" only for the sake of convenience.

Since few, if any, pipe products have actual dimensions that are in even, round inch-pound numbers, there is no need to convert them to even, round metric numbers. Instead, only their names will change form inch-pound to metric. *Pipe cross sections will not change*. Fittings, flanges, couplings, valves, and other piping components will be renamed in like manner as will pipe threads.

There are the inch-pound names for pipe products (called NPS or "nominal pipe size") and their metric equivalents (called DN or "diameter nominal"). The International Standards Organization (ISO) usage and apply to all plumbing natural gas, heating oil, drainage, and miscellaneous piping used in buildings and civil works projects.

NPS	**DN**	**NPS**	**DN**
1/8"	6 mm	8"	200 mm
3/16"	7 mm	10"	250 mm
1/4"	8 mm	12"	300 mm
3/8"	10 mm	14"	350 mm
1/2"	15 mm	16"	400 mm
5/8"	18 mm	18"	450 mm
3/4"	20 mm	20"	500 mm
1"	25 mm	24"	600 mm
1-1/4"	32 mm	28"	700 mm
1-1/2"	40 mm	30"	750 mm
2"	50 mm	32"	800 mm
2-1/2"	65 mm	36"	900 mm
3"	80 mm	40"	1000 mm
3-1/2"	90 mm	44"	1100 mm
4"	100 mm	48"	1200 mm
4-1/2"	115 mm	52"	1300 mm
5"	125 mm	56"	1400 mm
6"	150 mm	60"	1500 mm

REBAR

Rebar will change in size per ASTM, A615M, A616M, and A706M. New metric bar sizes change form current bar sizes as follows:

No. 3 and No. 4 to 10
No. 5 to 15
No. 6 to 20
No. 7 and No. 8 to 25
No. 9 and No. 10 to 30
No. 11 to 35
No. 14 to 45
No. 18 to 55

Source: *Metric in Construction* newsletter of the Construction Metrication Council of the National Institute of Building Sciences. Washington, D.C.

STRAW MULCH

APPLICATION RATE*		
4.5 Mg/Hectare	(2 Ton/Acre)	No. of Bales
Area = 1 Hectare		200
1000 Square Meters		20
100 Square Meters		2
Area = 1 Acre **		80
1000 Square Feet		2
6.7 Mg/Hectare	(3 Ton/Acre)	No. of Bales
Area = 1 Hectare		300
1000 Square Meters		30
100 Square Meters		3
Area = 1 Acre **		120
1000 Square Feet		3

* Bale mass (weight) varies from approximately 19 Kg to 27 Kg (40 lbs to 60 lbs).

Chart based on approximately 23 Kg (50 lb average) Bale Mass (Weight).

Metric Units Formula

$$\frac{[\text{Application Rate (M/Ha)}] \times [\text{Area(Ha)}]}{[\text{Bale Mass (Kg/Bale)}] \times [1\text{M}/1000\text{Kg}]} = \text{No. of Bales}$$

English Units Formula

$$\frac{[\text{Application Rate (Ton/Ac)}] \times [\text{Area(Ac)}]}{[\text{Bale Weight (Lb/Bale)}] \times [1\text{ Ton}/2000\text{ Lb}]} = \text{No. of Bales}$$

** 2.47 Acres = 1 Hectare

Hydraulic Application Equations

Wood Fiber Mulch Hydraulic Application

Average Water Required for Application

English: V_{wa} (gal) = (W_{wf}) / (40lbs mulch / 100gal water)
Metric: V_{wa} (Liters) = (W_{wf}) / (18kg mulch / 379L water)

Maximum Water Required for Application

English: V_{wm} (gal) = (W_{wf}) / (50lbs mulch / 100gal water)
Metric: V_{wm} (Liters) = (W_{wf}) / (23kg mulch / 379L water)

Area of Coverage

English: A (acre) = (W_{wf} / R_{wf})
A (ft^2) = (W_{wf} / R_{wf}) * (43,560 ft^2/acre)
Metric: A (ha) = (W_{wf} / R_{wf}) / (1,000 kg/Mg)
A (m^2) = ((W_{wf} / R_{wf}) / (1,000 kg/Mg)) *(10,000 m^2/ha)

Wood Fiber Application Rate (lb/acre) or (Mg/ha)	R_{wf}
Weight or Mass of Wood Fiber (lbs) or (kg)	W_{wf}
Average Water Requirement (gal) or (L)	V_{wa}
Maximum Water Requirement (gal) or (L)	V_{wm}
Area of Coverage (ft^2) & (acres) or (m^2) & (ha)	A

Seed or Fertilizer Hydraulic Application

Area of Coverage

English: A (acre) = (W_{sf} / R_{sf})
A (ft^2) = (W_{sf} / R_{sf}) * (43,560 ft^2/acre)
Metric: A (ha) = (W_{sf} / R_{sf})
A (m^2) = ((W_{sf} / R_{sf}) * (10,000 m^2/ha)

Seed or Fertilizer Application Rates (lb/acre) or (kg/ha)	R_{sf}
Weight or Mass of Seed or Fertilizer (lbs) or (kg)	W_{sf}
Area of Coverage (ft^2) & (acres) or (m^2) & (ha)	A

Table A-1

Seed or Fertilizer Hydraulic Application

Application Load	Area of Coverage (A)									
	Application Rates of Pure Live Seed (R_{sf})									
(W_{sf})	20 lb/acre		40 lb/acre		60 lb/acre		100 lb/acre		400 lb/acre	
Pounds	acre	ft^2	acre	ft^2	acre	ft^2	acre	ft^2	acre	ft^2
5	0.25	10,890	0.13	5,445	0.08	3,630	0.05	2,178	0.01	545
10	0.50	21,780	0.25	10,890	0.17	7,260	0.10	4,356	0.03	1,089
25	1.25	54,450	0.63	27,225	0.42	18,150	0.25	10,890	0.06	2,723
50	2.50	108,900	1.25	54,450	0.83	36,300	0.50	21,780	0.13	5,445
100	5.00	217,800	2.50	108,900	1.67	72,600	1.00	43,560	0.25	10,890
150	7.50	326,700	3.75	163,350	2.50	108,900	1.50	65,340	0.38	16,335
200	10.00	435,600	5.00	217,800	3.33	145,200	2.00	87,120	0.50	21,780
400	20.00	871,200	10.00	435,600	6.67	290,400	4.00	174,240	1.00	43,560

"Application Load" is in Pure Live Seed. Gross Weight of seed can be converted by the Pure Live Seed (PLS) Rate.
[%Purity x %Germination = %PLS ; Wsf = Gross Weight x %PLS]
To evaluate mulch tracer material, use Table C-1.

Table B-1

Seed or Fertilizer Hydraulic Application

Application Load	Area of Coverage (A)									
	Application Rates of Pure Live Seed (R_{sf})									
(W_{sf})	22 kg/ha		44 kg/ha		67 kg/ha		112 kg/ha		250 kg/ha	
Kilograms	ha	m^2	ha	m^2	ha	m^2	ha	m^2	ha	m^2
5	0.23	2,273	0.11	1,136	0.07	746	0.04	446	0.02	200
10	0.45	4,545	0.23	2,273	0.15	1,493	0.09	893	0.04	400
25	1.14	11,364	0.57	5,682	0.37	3,731	0.22	2,232	0.10	1,000
50	2.27	22,727	1.14	11,364	0.75	7,463	0.45	4,464	0.20	2,000
75	3.41	34,091	1.70	17,045	1.12	11,194	0.67	6,696	0.30	3,000
100	4.55	45,455	2.27	22,727	1.49	14,925	0.89	8,929	0.40	4,000
200	9.09	90,909	4.55	45,455	2.99	29,851	1.79	17,857	0.80	8,000
300	13.64	136,364	6.82	68,182	4.48	44,776	2.68	26,786	1.20	12,000

"Application Load" is in Pure Live Seed. Gross Mass of seed can be converted by the Pure Live Seed (PLS) Rate [%Purity x %Germination = %PLS ; Wsf = Gross Mass x %PLS]

To evaluate mulch tracer material, use Table D-1.

Wood Fiber Mulch Hydraulic Application

Table C-1	500lb/acre Application Rate (R_{wf})			
Wood Fiber	**Water Required for Application**		**Area of Coverage (A)**	
(W_{wf})	Average (V_{wa})	Maximum (V_{wm})		
	40lbs mulch / 100gal water	50lbs mulch / 100gal water		
Pounds	*Gallons	*Gallons	ft^2	Acres
500	1,250	1,000	43,560	1.00
600	1,500	1,200	52,272	1.20
700	1,750	1,400	60,984	1.40
800	2,000	1,600	69,696	1.60
900	2,250	1,800	78,408	1.80
1,000	2,500	2,000	87,120	2.00
1,100	2,750	2,200	95,832	2.20
1,200	3,000	2,400	104,544	2.40
1,300	----	2,600	113,256	2.60
1,400	----	2,800	121,968	2.80
1,500	----	3,000	130,680	3.00

* Largest Typical Hydro seeding equipment has a 3,000 gallon working volume.

Wood Fiber Mulch Hydraulic Application

Table C-2	1500lb/acre Application Rate (R_{wf})			
Wood Fiber	**Water Required for Application**		**Area of Coverage (A)**	
(W_{wf})	Average (V_{wa})	Maximum (V_{wm})		
	40lbs mulch / 100gal water	50lbs mulch / 100gal water		
Pounds	*Gallons	*Gallons	ft^2	Acres
500	1,250	1,000	14,520	0.33
600	1,500	1,200	17,424	0.40
700	1,750	1,400	20,328	0.47
800	2,000	1,600	23,232	0.53
900	2,250	1,800	26,136	0.60
1,000	2,500	2,000	29,040	0.67
1,100	2,750	2,200	31,944	0.73
1,200	3,000	2,400	34,848	0.80
1,300	----	2,600	37,752	0.87
1,400	----	2,800	40,656	0.93
1,500	----	3,000	43,560	1.00

* Largest Typical Hydro seeding equipment has a 3,000 gallon working volume.

Wood Fiber Mulch Hydraulic Application

Table C-3	2000lb/acre Application Rate (R_{wf})			
Wood Fiber	**Water Required for Application**		**Area of Coverage (A)**	
(W_{wf})	Average (V_{wa})	Maximum (V_{wm})		
	40lbs mulch / 100gal water	50lbs mulch / 100gal water		
Pounds	*Gallons	*Gallons	ft^2	Acres
500	1,250	1,000	10,890	0.25
600	1,500	1,200	13,068	0.30
700	1,750	1,400	15,246	0.35
800	2,000	1,600	17,424	0.40
900	2,250	1,800	19,602	0.45
1,000	2,500	2,000	21,780	0.50
1,100	2,750	2,200	23,958	0.55
1,200	3,000	2,400	26,136	0.60
1,300	----	2,600	28,314	0.65
1,400	----	2,800	30,492	0.70
1,500	----	3,000	32,670	0.75

* Largest Typical Hydro seeding equipment has a 3,000 gallon working volume.

Wood Fiber Mulch Hydraulic Application

Table C-4	2500lb/acre Application Rate (R_{wf})			
Wood Fiber	**Water Required for Application**		**Area of Coverage (A)**	
(W_{wf})	Average (V_{wa})	Maximum (V_{wm})		
	40lbs mulch / 100gal water	50lbs mulch / 100gal water		
Pounds	*Gallons	*Gallons	ft^2	Acres
500	1,250	1,000	8,712	0.20
600	1,500	1,200	10,454	0.24
700	1,750	1,400	12,197	0.28
800	2,000	1,600	13,939	0.32
900	2,250	1,800	15,682	0.36
1,000	2,500	2,000	17,424	0.40
1,100	2,750	2,200	19,166	0.44
1,200	3,000	2,400	20,909	0.48
1,300	----	2,600	22,651	0.52
1,400	----	2,800	24,394	0.56
1,500	----	3,000	26,136	0.60

* Largest Typical Hydro seeding equipment has a 3,000 gallon working volume.

Wood Fiber Mulch Hydraulic Application

Table D-1	0.56Mg/ha Application Rate (R_{wf})			
Wood Fiber	**Water Required for Application**		**Area of Coverage (A)**	
(W_{wf})	Average (V_{wa})	Maximum (V_{wm})		
	18kg mulch / 379L water	23kg mulch / 379L water		
Kilograms	*Liters	*Liters	m^2	Hectare
200	4,168	3,335	3,567	0.36
250	5,211	4,169	4,459	0.45
300	6,253	5,003	5,351	0.54
350	7,295	5,836	6,243	0.62
400	8,337	6,670	7,135	0.71
450	9,379	7,504	8,027	0.80
500	10,421	8,338	8,918	0.89
545	11,356	9,088	9,721	0.97
550	----	9,171	9,810	0.98
600	----	10,005	10,702	1.07
650	----	10,839	11,594	1.16
681	----	11,356	12,147	1.21

* Largest Typical Hydro seeding equipment has a 11,356 liter working volume.

Wood Fiber Mulch Hydraulic Application

Table D-2	1.7Mg/ha Application Rate (R_{wf})			
Wood Fiber	**Water Required for Application**		**Area of Coverage (A)**	
(W_{wf})	Average (V_{wa})	Maximum (V_{wm})		
	18kg mulch/ 379L water	23kg mulch / 379L water		
Kilograms	*Liters	*Liters	m^2	Hectare
200	4,168	3,335	1,189	0.12
250	5,211	4,169	1,486	0.15
300	6,253	5,003	1,784	0.18
350	7,295	5,836	2,081	0.21
400	8,337	6,670	2,378	0.24
450	9,379	7,504	2,675	0.27
500	10,421	8,338	2,973	0.30
545	11,356	9,088	3,240	0.32
550	----	9,171	3,270	0.33
600	----	10,005	3,567	0.36
650	----	10,839	3,865	0.39
681	----	11,356	4,049	0.40

* Largest Typical Hydro seeding equipment has a 11,356 liter working volume.

Wood Fiber Mulch Hydraulic Application

Table D-3 — **2.2Mg/ha Application Rate (R_{wf})**

Wood Fiber	Water Required for Application		Area of Coverage (A)	
(W_{wf})	Average (V_{wa})	Maximum (V_{wm})		
	18kg mulch / 379L water	23kg mulch / 379L water		
Kilograms	*Liters	*Liters	m^2	Hectare
200	4,168	3,335	892	0.09
250	5,211	4,169	1,115	0.11
300	6,253	5,003	1,338	0.13
350	7,295	5,836	1,561	0.16
400	8,337	6,670	1,784	0.18
450	9,379	7,504	2,007	0.20
500	10,421	8,338	2,230	0.22
545	11,356	9,088	2,430	0.24
550	----	9,171	2,453	0.25
600	----	10,005	2,675	0.27
650	----	10,839	2,898	0.29
681	----	11,356	3,037	0.30

* Largest Typical Hydro seeding equipment has a 11,356 liter working volume.

Wood Fiber Mulch Hydraulic Application

Table D-4	2.8Mg/ha Application Rate (R_{wf})			
Wood Fiber	**Water Required for Application**		**Area of Coverage (A)**	
(W_{wf})	Average (V_{wa})	Maximum (V_{wm})		
	18kg mulch / 379L water	23kg mulch / 379L water		
Kilograms	*Liters	*Liters	m^2	Hectare
200	4,168	3,335	713	0.07
250	5,211	4,169	892	0.09
300	6,253	5,003	1,070	0.11
350	7,295	5,836	1,249	0.12
400	8,337	6,670	1,427	0.14
450	9,379	7,504	1,605	0.16
500	10,421	8,338	1,784	0.18
545	11,356	9,088	1,944	0.19
550	----	9,171	1,962	0.20
600	----	10,005	2,140	0.21
650	----	10,839	2,319	0.23
681	----	11,356	2,429	0.24

* Largest Typical Hydro seeding equipment has a 11,356 liter working volume.

Hydraulic Application Example Problems

(English Units)

Example #1 (Mulch - Area of Coverage)

Given: Required mulch application rate 2,000 lb/acre.
Hydro Seeder with 1,800 gal working capacity.
900 lbs of Wood Fiber to be applied over seeded area.

Find: Range of Area of Coverage.

Answer: Find the 2,000 lb/acre Application Rate Chart, Table C-3.

Using a 50 lbs/100 gal mulch/water ratio:
Find 1,800 gal in the Maximum Water Required for Application column.
Follow this row over to the area columns.
One tank can cover **0.45 acre (19,602 ft^2)**

Using a 40 lbs/100 gal mulch/water ratio:
Find 1,800 gal in the Average Water Required for Application column.
There isn't an 1,800 gal row, so interpolate between 1,750 gal and 2,000 gal.
Follow the 1,750 gal and 2,000 gal row over to the area columns.
At 1,750 gal, one tank can cover 0.35 acre (15,246 ft^2).
At 2,000 gal, one tank can cover 0.40 acre (17,424 ft^2).
One tank can cover 1,800 lb * ((0.40 acre = 0.35 acre)/(2,000 gal -1,750 gal))

0.36 acre (15,682 ft).

Hydraulic Application Example Problems

(English Units)

Example #2 (Mulch - Materials Used)

Given: 0.80 acre (34,848 ft) area to be seeded.
Required mulch application rate 1,500 lb/acre.
Hydro Seeder with 2,500 gal working capacity.

Find: A) Amount of Mulch Required in lbs.
B) Range of Water Required in gal.
C) Number of Trips Required.

Answer: Find the 1,500 lb/acre Application Rate Chart, Table C-2.

A) Find 0.80 acre under the Area of Coverage column.
Follow the row over to the Wood Fiber column.
The wood fiber required by the area is 1,200 lb.

B) Find 0.80 acre under the Area of Coverage column.
Follow the row to the Required Water for Application
column.
Using a 50 lbs I 100 gal mulch/water ratio:
The water required for the area is 2,400 gal.
Using a 40 lbs/100 gal mulchwater ratio:
The water required for the area is **3,000** gal.

C) Using a 50 lbs/ 100 gal mulch/water ratio:
(2,400 gal I (2,500 gal/trip)) = 1 trip.
Using a 40 lbs I 100 gal mulch/water ratio:
(3,000 gal 1 (2,500 gal/trip)) = 1.2 trips, so use 2 trips.

Hydraulic Application Example Problems

(English Units)

<u>Example #3</u> (Seed - Area of Coverage)

Given: Seed Application Rate 40 lb/acre.
200 lb of Seed is to be applied.

Find: Area of Coverage.

Answer: Use the Seed or Fertilizer Hydraulic Application Chart, Table A-1.
Find the 40 lb/acre application rate column.
Find the 200 lb seed row.
Determine where the column and the row intersect and record the area.
For 40 lb/acre, the area of coverage is 5 acre **(217,800 ft).**
Or

Use the Formula on the Hydraulic Application Equations Sheet.
Find the area of coverage equation under the title Seed or Fertilizer Hydraulic Application.
The English unit, area equation is A (acre) = W_s, / R_{sf}
Area (acre) = (200 lb) / (40 lb/acre) = 5 acre.
Area (ft) = [(200 lb) / (40 lb/acre)] * (43,560 ft^2/acre) =
217,800 ft^2.

Hydraulic Application Example Problems

(English Units)

<u>Example #4</u> (Seed - Materials Needed)

Given: Required Area of Coverage 0.13 acre (5,662.8 ft).
Seed Application Rate 200 lb/acre.

Find: Amount of Seed Required in lbs.

Answer: Use the Seed or Fertilizer Hydraulic Application Chart, Table A-1.
Find the 200 lb/acre application rate column.
Move down the list of areas to 0.13 acre.
0.13 acre is not in this column, so interpolate.
Find the area above and below 0.13 acre.
Follow the row from the area to the Amount of Seed column.
For 0.10 acre (4,356 ft^2), the amount of seed is 20 lbs.
For 0.15 acre (6,534 ft^2), the amount of seed is 30 lbs.
At 0.13 acre (5,662.8 ft), the amount of seed is:
0.13 acre * ((30 lb - 20 lb)/(0.15 acre-0.10 acre)) =26 lbs.

Or

Use the Formula on the Hydraulic Application Equations Sheet.
Find the area of coverage equation under the title Seed or Fertilizer
Hydraulic Application.
The english unit, area equation is A (acre) = W_s, / R_{sf}
Rearrange the equation so W_{sf} (lb) = (A) * (R_s,)
W_{sf} (lb) = (0.13 acre) * (200 lb/acre) = 26 lbs.

Hydraulic Application Example Problems

(Metric Units)

<u>Example #1</u> (Mulch - Area of Coverage)

Given: Required mulch application rate 1.7 Mg/ha.
Hydro Seeder with 9,088 L working capacity.
545 kg of Wood Fiber to be applied over seeded area.

Find: Range of Area of Coverage

Answer: Find the 1.7 Mg/ha Application Rate Chart, Table D-2.

Using a 23 kg / 379 L mulch/water ratio:

Find 9,088 L in the Maximum Water Required for Application Column.

Follow this row over to the area columns. One tank can cover **0.32 ha (3,240 m^2)**.

Using a 18 kg / 379 L mulch/water ratio:

Find 9,088 L in the Average Water Required for Application column.

There isn't an 9,088 L row, so interpolate between 8,337 L and 9,379 L.

Follow the 8,337 L and 9,379 L row over to the area columns.

At 8,337 L, one tank can cover **0.24 ha (2,378 m^2).**

At 9,379 L, one tank can cover **0.27 ha (2,675 m^2).**

One tank can cover 9,088 L * ((0.27 ha - 0.24 ha)/(9,379 L - 8,337 L))

0.26 ha (2,617 m^2).

Hydraulic Application Example Problems
(Metric Units)

<u>Example #2</u> (Mulch - Materials Needed)

Given: 0.11 ha (1,070 m^2) area to be seeded.
Required mulch application rate 2.8 Mg/ha.
Hydro Seeder with 6000 L working capacity.

Find:
A) Amount of Mulch Required in kg.
B) Range of Water Required in L.
C) Number of Trips Required.

Answer: Find the 2.8 Mg/ha Application Rate Chart, Table D-4

A) Find 0.11 ha under the Area of Coverage column.
Follow the row over to the Wood Fiber column.
The wood fiber required by the area is **300** kg.

B) Find 0.11 ha under the Area of Coverage column.
Follow the row to the Required Water for Application column.

Using a 23 kg / 279 L mulch/water ratio:
The water required for the area is **5,003 L.**

Using a 18 kg / 379 L mulch/water ratio:
The water required for the area is **6,253 L**.

C) Using a 23 kg / 379 L mulch/water ratio:
(5,003 L / (6,000 L/trip)) = 1 trip.

Using a 18 kg / 379 L mulch/water ratio:
(6,253 L / (6,000 L/trip)) = 1.04 trips, so use 2 trips.

Hydraulic Application Example Problems

(Metric Units)

<u>Example #3</u> (Seed - Area of Coverage)

Given: Seed Application Rate 225 kg/ha.
10 kg of Seed is to be Applied.

Find: Area of Coverage.

Answer: Use the Seed or Fertilizer Hydraulic Application Chart, Table B-1.
Find the 225 kg/ha application rate column.
Find the 10 kg seed row.
Determine where the columns and the row intersect and record the areas.
For 225 kg/ha, the area of coverage is **0.04 ha (444m^2)**.

Or

Use the Formula on the Hydraulic Application Equation Sheet.
Find the area of coverage equation under the title Seed or Fert. Hydraulic App.
The metric unit, area equation is A (ha) = W~, / Rd.
Area (ha) _ (10 kg) / (225) kg/ha) = 0.04 ha.
Area (m^2) _ [(10 kg) / (225 kg/ha)] * (10,000 M2/ha) = **444 m^2**

Hydraulic Application Example Problems

(Metric Units)

Example #4 (Seed - Materials Needed)

Given: Required Area of Coverage 1.55 ha (15,500 m^2)
Seed Application Rate 44 kg/ha.

Find: Amount of Seed Required in kg.

Answer: Use the Seed or Fertilizer Hydraulic Application Chart, Table B-1.
Find the 44 kg/ha application rate column.
Move down the list of areas until 1.55 ha is found.
1.55 ha is not in this column, so interpolate.
Find the area above and below 1.55 ha.
Follow the row from the area to the Amount of Seed column.
For 1.36 ha (13,636 m2), the amount of seed is 60 kg.
For 1.59 ha (15,909 m2), the amount of seed is 70 kg.
At 1.55 ha (15,500 m2), the amount of seed is:
1.55 ha * ((70 kg - 60 kg)/(1.59 ha - 1.36 ha))
= 67.4 kg, round to **68 kg**..

Or

Use the Formula on the Hydraulic Application Equation Sheet.
Find the area of coverage equation under the title Seed or Fert Hydraulic App.
The metric unit, area equation is A (ha) = W5, / $_R$~,_
Rearrange the equation so $_{wf}$ (kg) = (A) * ($R5_f$).
W_{sf} (kg) = (1.55 ha) * (44 kg/ha) = 68.2 kg.

INSPECTOR CHECKLIST FOR EROSION CONTROL

SCHEDULE

- ✓ Have you looked at the Contractors Schedule and determined any conflicts?
- ✓ Install necessary Best Management Practices (BMP's) prior to any earthwork beginning.
- ✓ Are earthwork operations being performed in October with soils that are highly erosive?
- ✓ Grubbing of areas that will be worked on much later should be delayed.
- ✓ Staging of project may require staging of erosion control measures.
- ✓ Is seeding scheduled before the end of the seed dates?
- ✓ Are there "In-Stream" work areas that may alter contractor's schedule?
- ✓ When will the contractor remove BMP's? Don't remove until seeded slopes are established.

EROSION AND SEDIMENT CONTROL PLAN (ESCP)

- ✓ Walk project during preliminary or advanced plan review and look for potential erosion problems.
- ✓ Have you reviewed the Contractor’s Erosion Control Plan to determine if it is adequate or makes sense? The ESCP included in the bid package may need modification to address site conditions or staging.
- ✓ Walk project with EPCM prior to any earthwork looking for needed modifications to ESCP.
- ✓ Is the ESCP being kept up-to-date?
- ✓ Is the ESCP kept on-site? Where?
- ✓ What is contractor's erosion control plan for offsite borrow sources and waste areas?

EROSION AND SEDIMENT CONTROL MANAGER (ESCM)

- ✓ Have you met with and talked with the person identified as the ESCM?
- ✓ Do you believe this person has adequate knowledge to perform this work?
- ✓ Does this person understand all the required duties of the ESCM?
- ✓ Does this person have the authority to direct resources and make changes in an emergency situation?

SENSITIVE AREAS

- ✓ Are there any sensitive areas which require extra attention?
- ✓ Have they been adequately addressed on the ESCP?
- ✓ Will these sensitive areas require more monitoring?

CONTINGENCY PLAN

- ✓ Is there a contingency plan for unexpected events?
- ✓ What is the plan for stabilization of earthwork performed after seeding dates?

MATERIALS ON-HAND

- ✓ It may be difficult to get Erosion Control materials in the middle of the wet season. It is easier to deal with erosion before it happens rather than after.
- ✓ Does the Contractor have adequate materials on hand to cover each phase of work they plan on performing?

Inspector Checklist for Erosion Control—Cont.

MAINTENANCE

- ✓ Consider access for maintenance of BMP.s. Place where they are easy to maintain if you have a choice.
- ✓ Are installed erosion and sediment controls in good working order?
- ✓ Are catch basins cleaned out when more than 150 mm of sediment depth accumulates?
- ✓ At silt fence, straw bale barriers, check dams, inlet protection cleaned out when sediment reaches 1/3 of the storage depth?
- ✓ Are construction entrances maintained with fresh rock to prevent tracking of sediment onto pavement?

MONITORING FORMS

- ✓ Are you getting Erosion Control Weekly reports as often as they should be filed from the EPCM?
- ✓ Are the forms complete and adequately represent site conditions and work performed?
- ✓ Is precipitation being monitored and recorded?
- ✓ Are forms on-site with the "Up-to-Date Plan"?

SLOPE PROTECTION & STABILIZATION

- ✓ Are areas within 100 feet of waterways, wetlands, or other sensitive resources stabilized with 7 days of exposure?
- ✓ Are other areas stabilized within 14 days of exposure (except in Eastern Oregon)?
- ✓ Permanently finish slopes from top down and seed as you go!
- ✓ Track walk slopes to provide loosened soil and hold seed.
- ✓ Temporarily stabilize unfinished earthwork scheduled for re-disturbance at a later date (i.e. straw mulch, chemical soil stabilizers, plastic sheeting, matting, etc.).

PLANS ARE ONLY A GUIDE

- ✓ What's best for your project is what works on your project. No designer can sit in an office and determine what works on your project. It may require trial and error. The plans are a toolbox with available tools. You may have to create or modify these tools to satisfy your conditions.

IT'S NOT WORKING!!!

- ✓ Are the BMP's working? If not, are erosion prevention BMPs needed?

TECHNICAL RESOURCES

- ✓ Remember the ODOT resources you have available in design offices to review proposed plans and evaluate and recommend solutions to difficult situations:
- ✓ Erosion Control contract plans professional of record (internal or external)
- ✓ ODOT Region erosion control point-of-contact
- ✓ Local government NPDES Permit office contact (typically larger cities or agencies)
- ✓ ODOT Erosion Control Program Coordinator

ADDITIONAL ITEMS

- ✓ Go back to newly installed BMP's to check their performance.
- ✓ How will contractor handle dust control or wind erosion?
- ✓ Will snow melt change runoff and drainage patterns?

WINTERIZATION CHECKLIST

SCHEDULE

- ✓ Retain a hydroseed contractor to avoid the October rush.
- ✓ Limit disturbance of surface area to no more than a few acres after September 1st.

- ✓ If you have to open up a large area, only clear and grub small areas. You can clear larger areas if you don't grub. Roots and slash help protect the bare soil from raindrop impacts and erosion.
- ✓ Is seeding scheduled before the end of the seed dates?

EPCM

- ✓ Discuss with EPCM required duties during rainy season.
- ✓ Conduct the required regular inspections of the erosion prevention and sediment control measures during the rainy season.
- ✓ Daily: During rainy periods where 15 mm or more rain in a 24-hour period.
- ✓ Weekly: Active sites
- ✓ Bi-Weekly: Inactive sites.
- ✓ Prepare monitoring forms and updated erosion and sediment control plan.
- ✓ Assure erosion and sediment control facilities are properly maintained.
- ✓ Prepare Contingency Plan for performance of regular and timely maintenance on the erosion prevention and sediment control measures during the rainy season.

WALK SITE

- ✓ Take the time to walk the site thinking only about erosion prevention. Try to identify areas where there might be an erosion problem during the rainy season. If necessary, seek advice on how to correct the problems you have identified. Prepare punch list of things to be corrected or enhanced.
- ✓ Locate all existing water flows in and around your project and find out where they drain. What erosion prevention techniques can be used to prevent sediment from entering into the water flow?
- ✓ Temporary slope drains at bridge ends if the permanent drainage system and curbs are not in place. Collect water from the bridge using non-erodible material and divert to pipe inlet.
- ✓ Sediment fence should be installed on contour with the ends flared up-slope a few feet. If not on contour, install supported sediment fence or check dam at low spots.
- ✓ Make sure all catch basins within the project boundary are protected with inserts, fence surrounds, or other methods to keep sediment out. Find

catch basins outside the project boundaries that may receive water from your construction site and protect them.

- ✓ Provide extra protection near wetlands or streams.

PERMANENT STABILIZATION

- ✓ Final grades can be covered with hydroseed, erosion blankets, straw, or whatever final cover is planned for the project. Seed and mulch all bare soil on final grade according to plan.
- ✓ Track the slopes up and down slope, not across slope. Tracking up and down slope helps to prevent erosion; tracking along the slope speeds it up.
- ✓ Use a water truck and water seeded areas weekly to get faster seed germination and plant growth.
- ✓ Re-seed small areas by hand where seed has not germinated or where grass is not growing well. Remobilize the hydroseed contractor for larger areas.

TEMPORARY STABILIZATION

- ✓ Seed or cover, as appropriate, all stockpile sites and bare soil still in need of grading with temporary erosion prevention measures (e.g., straw mulch, plastic, hydroseed, etc.).

MATERIALS ON-HAND

- ✓ Get erosion prevention and sediment control materials on site now to avoid the October rush. Stockpile enough straw, plastic, sediment fence, flex pipe, sand bags, seed, and rock to cover all bare soil.

EMERGENCY PROCEDURES

- ✓ Set up emergency procedures now. Who should be called in emergencies? Brief your workers on what to do and who to call if they see muddy water.