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EROSION CONTROL MANUAL

GUIDELINES FOR DEVELOPING AND IMPLEMENTING EROSION AND
SEDIMENT CONTROLS

GEO-ENVIRONMENTAL SECTION
OREGON DEPARTMENT OF TRANSPORTATION

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SUMMARY OF CHANGES

Version	Summary of changes made	Date revised
1.0	Original Manual Drafted	4/1/2005
2.0	Updated All Chapters	3/7/2019

DISCLAIMER

This Erosion and Sediment Control Manual was developed by Harza Engineering Company in cooperation with the Oregon Department of Transportation. The Manual should not be construed as policy of the Oregon Department of Transportation but as a tool to minimize impacts of erosion on construction projects. The contents of this publication should not be interpreted as necessarily representing the policies or recommendations of other referenced agencies or organizations.

The mention of trade names, products or companies does not constitute an endorsement.

This manual was most recently updated in 2019, and will be updated periodically as new practices and technologies for erosion and sediment control become available.

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PREFACE

This manual is a guide on erosion and sediment control for Oregon Department of Transportation (ODOT) personnel involved in design and construction and maintenance. [Chapter 1](#) provides an introduction, background on regulations and other agencies, ODOT policies, and the responsibilities of involved parties. [Chapter 2](#) presents information on the processes of erosion and sedimentation and associated environmental impacts. [Chapter 3](#) presents erosion and sediment control measures and Best Management Practices (BMP's). [Chapter 4](#) covers additional pollution control measures and BMP's. [Chapter 5](#) presents erosion control planning, [Chapter 6](#) presents construction implementation, and [Chapter 7](#) presents guidelines for Erosion and Sediment Control Plan (ESCP) design.

This manual presents information for the most current erosion control management practices; however, no manual is comprehensive. Information on the subject of erosion and sediment control is available from numerous other sources, and readers are encouraged to refer to the documents listed in Glossary and Reference Section.

CHAPTER 1 EROSION PREVENTION AND SEDIMENT CONTROL



Figure 1-1 Fiber rolls shorten slope length and grass covers soil, preventing erosion

1.1 INTRODUCTION

The purpose of this manual is to present the Oregon Department of Transportation (ODOT) Erosion and Sediment Control program to prevent the degradation of landscapes caused by erosion and the pollution of water from sediment released by erosion. Pollution can result from the release of chemicals, waste materials, and soils into air or water. Soil that erodes from construction sites and is discharged into water is considered pollution. The term pollution control refers to methods and procedures used to prevent pollution of air and surface waters. Discharging pollution is against the law, and the laws preventing pollution are defined in the permits that allow construction.

Water pollution in the United States is regulated under the Federal Water Pollution Control Act of 1972, now known as the [Clean Water Act](#) (CWA). The CWA is in place to control point source pollution which is a discharge through a pipe, channel or other discrete source and nonpoint source pollution which is runoff from diffuse sources, such as sheet flow from pavement. Section 402 of the CWA provides the legal basis for the [National Pollutant Discharge Elimination System](#) (NPDES) permit program, which regulates point source and nonpoint source discharges.

Oregon is authorized by the U.S. Environmental Protection Agency (EPA) to implement the NPDES program through the [Oregon Department of Environmental Quality](#) (DEQ) administers the NPDES program through Oregon Revised Statute [\(ORS\) 468B](#) prohibits the discharge of wastes into waters of the state and prohibits violations permit conditions.

The NPDES permit that regulates storm water discharges from construction projects conducted by local agencies or private entities is the 1200-C general construction permit. Another NPDES permit regulates storm water discharges for multiple projects of similar types, this permit; the 1200-CA is used by ODOT and other agencies. The 1200-CA permit requires a site specific erosion control plan for construction activities which disturb a total of 1 acre or more. The 1200-CA permit also requires control of

construction site pollutants other than sediment, such as green concrete, oil, gasoline and solvents. In addition to Federal requirements, many local jurisdictions have developed storm water management programs that include erosion and sediment control requirements.

Using this manual in conjunction with ODOT [Standard Specifications](#) Sections 00280 (Erosion and Sediment Control - Appendix B) and 00290 (Environmental Protection) and ODOT's erosion control [Standard Drawings](#), (provided in the 1000s category) the designer can develop a project-specific erosion and sediment control plan that meets or exceeds Federal, State, and local requirements.

In order to prevent sediment pollution from its construction projects, ODOT requires an Erosion and Sediment Control Plan (ESCP) be submitted as part of each project's contract documents. The ODOT ESCP is frequently used as the basis for the Contractor's project-specific ESCP which is developed and implemented by the contractor during construction.

The ODOT ESCP consists of plans, details and specifications. The ESCP is intended to provide adequate measures to minimize erosion, and to control sediment resulting from construction activities within the project boundaries.

1.2 BACKGROUND AND POLICIES

It is state law and ODOT policy to comply with all conditions of the 1200-CA Permits and other Federal, State, County, and City regulatory requirements.

ODOT has elected to apply the permit requirements to all projects, regardless of size, when work is near sensitive areas such as wetlands or rivers. For projects that do not disturb 1 acre of ground, Technical Services advisory [GE12-01\(a\)](#) provides guidance on how to forego the 00280 Section of the Specifications yet still protect the environment.

Sediment once it enters waterways is considered pollution. It can smother salmon nests and have lethal, sub-lethal and behavioral effects that result in a decline in aquatic organisms. Oregon's waterways host some threatened and endangered species such as Chinook and Coho Salmon. ODOT's compliance with permit requirements assures its actions do not jeopardize threatened or endangered species. Permit compliance can be considered to be conservation measures identified by the US Fish and Wildlife Service and the National Marine Fisheries Service, to avoid adverse effects to such species.

On ODOT projects Contractors are the leads on implementing and monitoring erosion and sediment control. To keep erosion and sediment control measures, current with the contractor's work phasing and methods of operation, the contractor is required to develop their own project specific Construction ESCP to include schedules, modifications for different phases of work and additional measures for wet season work. The Construction ESCP is expected to be a "living document" that is updated periodically. This Construction ESCP must be provided at the Pre-construction Conference.

The contractor must be aware of, and adhere to, any limitations in the work area imposed by environmental permits such as no-work-areas or timing restrictions.

General design and construction considerations are as follows:

- ODOT will plan, site, and develop roads and highways in a manner that minimizes impacts to sensitive areas such as wetlands, open water or steep slopes.

- ODOT will, during the design process and construction, take into consideration minimizing land disturbance such as clearing and grading and cut and fill to reduce erosion and sediment loss.
- ODOT will employ measures to prevent pollutant sources (including sediment) from being discharged into drainage swales, wetlands, or water bodies. Protective measures such as erosion prevention, perimeter controls, sediment barriers, check dams, buffers and “no work” areas as identified on the plans will be implemented on a project-by-project basis.
- Cut and fill slopes will be as flat as practicable and consistent with soil stability. Slopes of 1:2 or steeper may require special design.
- During construction, maintenance of erosion and sediment control facilities is required to keep them functioning effectively. Sediment removed from during maintenance must be placed in non-critical areas such as slope areas and interchange quadrants. In no instances should the removed sediment be placed in a position where subsequent rainfall could return it to the sediment control devices or drainage ways.
- Erosion and sediment control is a conspicuous expression of the contractor’s respect of the environment, the project vicinity and the project’s neighbors.

1.2.1 NPDES PERMIT REQUIREMENTS

The NPDES permit used by ODOT is the 1200-CA and, to repeat, the purpose of this permit is to prevent pollution from entering water bodies. Sediment is considered pollution. As the administrator of the NPDES permit, DEQ has granted ODOT permits for construction activities including clearing, grading, excavation, and stockpiling. These permits authorize these construction activities that result in the disturbance of one acre or more (or phased projects where the combined disturbance is one acre or more). ODOT holds a 1200-CA permit in each of its five regions. ODOT is the permittee. Under this permit ODOT or its contractor, is authorized to construct, install, modify, or operate erosion and sediment control measures. Furthermore the permittee is authorized to discharge storm water to public waters in conformance with all the requirements, limitations, and conditions set forth within the NPDES 1200-CA permit. The permit conditions require storm water be treated to remove sediment prior to it leaving the project site. Erosion and sediment control measures used to conform to the permit requirements are called Best Management Practices (BMP’s). Unless authorized by another NPDES permit, all untreated discharges to public waters are prohibited. The primary NPDES mandated controls, limitations and plan requirements are as follows: (For complete permit language see Appendix A):

1. The permittee shall ensure that an adequate Erosion and Sediment Control Plan (ESCP) is prepared and implemented for each construction activity regulated by this permit.
2. A copy of the ESCP for each construction activity will be retained on-site and made available to the DEQ upon request.
3. The ESCP shall be developed and implemented to prevent the discharge of significant amounts of sediment to surface waters. Under the 1200-CA Permit the following are considered significant:
 - a. Earth slides or mud flows that leave the construction site.
 - b. Evidence of concentration flows of water causing erosion when such flows are not treated to remove sediment. Evidence includes rills, rivulets or channels. Flow to unfiltered storm water inlets will be considered “leaving the site”.
 - c. Turbid flows of water that are not treated to remove sediment prior to leaving the construction site.

- d. Deposits of sediment in areas that drain to unprotected storm water. Inlets with failing sediment controls due to lack of maintenance will be considered unprotected.
 - e. Deposits of sediment from the construction site on public or private streets outside of the permitted construction activity.
 - f. Deposits of sediment from the construction site on any adjacent property outside of the permitted construction activity.
4. DEQ may require modifications to the ESCP at any time if the ESCP is ineffective at preventing the discharge of significant amounts of sediment to surface waters.
 5. Significant amounts of sediment that leave the site shall be cleaned up within 24 hours and placed back on the site or disposed of properly. Any in-stream clean-up shall be coordinated with the DSL
 6. Under no conditions shall sediment from the construction site be washed into storm drain sewers or drainage ways.
 7. Each ESCP shall include any procedures necessary to meet local erosion and sediment control requirements or storm water management requirements.
 8. Each ESCP shall also, at a minimum, include a site description, site map, required controls and practices, additional controls and practices, inspection requirements, inspection requirements for inactive or inaccessible sites, and written records.

Also required is that active project sites be monitored weekly, that monitoring occur within 24 hours of a rain event of 1/2 inch or more and that inactive sites be monitored every two weeks. Monitoring reports are a required part of each monitoring inspection.

The penalties for water pollution, permit condition violations or falsification of monitoring reports are as follows:

- Oregon Law ([ORS 468.140](#)) allows the Director (DEQ) to impose civil penalties up to \$10,000 per day for violation of a term, condition, or requirement of a permit.
- Under [ORS 468.943](#), unlawful water pollution, if committed by a person with criminal negligence, is punishable by a fine of up to \$25,000 or by imprisonment for not more than one year, or by both. Each day on which a violation occurs or continues is a separately punishable offense.
- Under [ORS 468.953](#) It is a Class C felony punishable by up to \$100,000 for each violation, to supply false information to an Agency, or to omit required information, knowing it is required, or to conceal or fail to file documents required by Oregon Regulatory Statutes. Under [ORS 468.946](#), a person who knowingly discharges, places or causes to be placed any waste into the waters of the State or in a location where the waste is likely to escape into the waters of the State, is subject to a class B felony punishable by a fine not to exceed \$200,000 and up to 10 years in prison.

1.2.2 OTHER AGENCIES AND ACTS

The ODOT planning process requires coordination with other private groups and public agencies or jurisdictions that may either have an interest in, or control of, the impacts of proposed development. This process provides a means for other stakeholders to supply input regarding erosion and sediment controls, environmentally sensitive areas, and other regulated activities.

The development of an ESCP spans the entire planning, design and construction stages of a project. To be successful, it is imperative that communication among the stakeholders be established and maintained

throughout the project and in accordance with Federal, State, and local agencies and acts. Some of the principal agencies and acts are described in the following sections.

1.2.2.1 COASTAL ZONE MANAGEMENT ACT

[The Coastal Zone Management Act](#) of 1972 (CZMA) established a program for States and Territories to voluntarily develop programs to protect and manage coastal resources. To receive Federal approval and implementation funding, States and Territories had to demonstrate that they had programs, including enforceable policies, sufficiently comprehensive and specific to regulate land uses, water uses, and coastal development as well as to resolve conflicts between competing uses. Resource management and protection are accomplished through State laws, regulations, permits, and local plans and zoning ordinances.

The Coastal Zone Act Reauthorization Amendments of 1990 specifically changed the state coastal programs, as well as State nonpoint source programs, by addressing nonpoint source pollution affecting coastal water quality.

1.2.2.2 COASTAL ZONE ACT REAUTHORIZATION AMENDMENTS

In the [Coastal Zone Act Reauthorization Amendments](#) of 1990 (CZARA), Congress recognized that nonpoint pollution contributes to the degradation of coastal waters and established a new program to address this pollution source. Congress recognized that the solution to nonpoint source pollution lies in State and local action. Congress called upon States to develop and implement state Coastal Nonpoint Pollution Control Programs (CNPCP). These involve identifying nonpoint source categories, describing Best Management Practices and adopting enforceable policies. States are also required to provide technical assistance to local governments.

The amendments strengthen the links between Federal and State coastal zone programs. This enhances State efforts to manage land use activities that degrade coastal waters. DEQ committed to the implementation of a CNPCP as part of The [Oregon Plan for Salmon and Watersheds](#).

1.2.2.3 AASHTO HIGHWAY DRAINAGE MANUAL

The 2014 AASHTO Drainage Manual, Volumes 1 & 2 ([available for purchase](#) through the AASHTO bookstore) provides comprehensive and technical guidelines for all aspects of highway drainage including Erosion and Sediment Control

1.2.2.4 DSL/USACE PERMITS

[Section 401 of the CWA](#) requires that any applicant for a federal permit to conduct any activity that may result in a discharge to waters of the State must provide the permitting agency a certification from DEQ that the activity complies with water quality requirements and standards. A broad range of land uses commonly require DEQ 401 certification, including transportation projects. Projects in which the applicant will dredge, fill, conduct in-water work or otherwise alter a waterway require a permit from the DSL and from the USACE.

The two agencies have developed a joint permit application. Although the regulatory authorities of DSL and USACE are different, their roles, when considered together, include protecting navigable waters (and the ocean), ensuring wise and beneficial water use, maintaining and enhancing water quality, protecting fish and wildlife habitat and recreational resources, and in general, protecting the public interest.

After the DSL and USACE have received a joint permit application, they forward it to DEQ. When ODOT is preparing the permit applications, the applications are circulated to all appropriate agencies, including DEQ. The permit is reviewed by DEQ to ensure that it does not endanger Oregon's streams and wetlands and to confirm that the plans meet water quality laws and standards. Frequently, applicants are required to incorporate protective measures into their construction and operational plans, such as bank stabilization, treatment of storm water runoff, spill protection, and fish and wildlife protection.

1.2.2.5 SPECIFICATIONS

[ODOT Specifications](#) for erosion and sediment control are provided in the Oregon Standard Specifications for Construction and supplemental [Special Provisions](#). Specifications and Special Provisions are contract documents with high authority that define Contract requirements. The Standard Specifications, Section 00280 – Erosion and Sediment Control included in Appendix B, covers materials, installation, monitoring, maintaining, repairing and removing erosion control measures. Special provisions modify Standard Specification Section 00280 to make it project-specific. Specifications for seeding are in Section 01030, also provided in Appendix B.

Section 00290.30(a) – Pollution Control Measures, describes the contractor's responsibilities related to preventing water pollution. The 00290 (a) Section also covers the contractor's responsibility regarding control of construction site pollutants, including sediment, from contractor operations not included in the ESCP.

1.2.3 DESIGNER, INSPECTOR, AND CONTRACTOR RESPONSIBILITIES

ODOT requires an Agency's ESCP in Contract Plans. For the development of Erosion and Sediment Control Plans in the plan set the designer establishes the parameters, identifies the risks and provides guidance on the locations and installation of erosion and sediment control facilities for the duration of the construction project. The designer must be familiar with the requirements of the NPDES 1200-CA permit and the 00280 section of the Specifications as these clearly define the scope of erosion and sediment control work. Furthermore the designer edits the Special Provisions of the Specifications to address unique conditions to the project and provides a cost estimate and list of erosion and sediment control facilities sufficient to address all anticipated and most emergency situations.

Because ODOT does not dictate a contractor's means and methods of construction, a designer cannot fully anticipate the timing and consequences of contractor activities. During construction the responsibility shifts from the designer to the Contractor for the project's ESCP. The Specification Sections 00280.04 and 00280.30 outline some of the Contractor's responsibilities. ODOT, as the permittee, is ultimately responsible for compliance with permit conditions. The three principle parties involved in designing, implementing and monitoring an ESCP are the designer, inspector and contractor. Each party has specific roles and responsibilities, summarized below.

1.2.3.1 DESIGNER RESPONSIBILITIES

- Understand the permit requirements, the Standard Specifications (00280 Section) and the forces that cause erosion and sedimentation.
- Have extensive knowledge about practices, products and materials that can be used to prevent erosion and control sedimentation.
- Research construction project site conditions.
- Ensure topography and drainage are clearly delineated on ESCP.

- Understand the scope of the construction project including phasing, staging areas, borrow and disposal sites and detour facilities. Consider also the duration of construction, and consequences of working during the wet season.
- Develop Special Provisions that will address the necessary practices to control erosion and contain sediment on site.
- Provide an ESCP with sufficient variety and quantity of bid items to address erosion and sediment throughout project construction.
- Regularly update designers' knowledge of the latest technology in erosion control materials and methods.
- Ensure that the specified erosion control products are available on the ODOT Conditional and [Qualified Products List](#) (QPL).

1.2.3.2 INSPECTOR RESPONSIBILITIES

- Have knowledge and understanding the processes of erosion and sediment control and familiarity with erosion and sediment control BMPs and their proper use.
- Have knowledge and understanding of the Project ESCP and Pollution Control Plan (PCP).
- Ensure the contractor submits revisions to the ESCP prior to the pre-construction meeting.
- Ensure the contractor updates the ESCP as construction progresses.
- Ensure contractor installs and maintains the erosion control facilities in compliance with plans, specifications and permits.
- Verify that specified materials are provided, specified quantities are provided and that substitutions are approved prior to installation.
- Verify contractor conducts monitoring and completes monitoring reports as required. (ODOT Form [734-2361](#) Erosion Monitoring Form is provided in Appendix E).
- Verify that contractor makes changes to ESCP and PCP and ensure payment if beyond original bid estimate when necessary to control erosion.
- Know Standard Specifications for Construction, Section 00280 (Erosion and Sediment Control) and 01030 (Seeding) and the 00280 and 01030 Special Provisions for the project.
- Verify Contractor has installed BMPs correctly and is conducting necessary maintenance on erosion and sediment control facilities.
- Verify that contractor and project comply with NPDES 1200-CA Permit.
- Be familiar with Standard Erosion Details.
- Inspect slopes, drainage ways, BMPs and receiving waters and look for evidence of erosion, sedimentation, turbid runoff and BMPs that need maintenance.
- Require Contractor revise BMPs if they are not installed correctly or are not providing effective control.
- Report to regulatory agency anticipated non-compliance.
- Report to regulatory agency occurrences of untreated discharge into receiving waters or other non-compliance and include in that report the nature of the non-compliance, the cause, the remedial actions taken and the probability that the remedial actions will resolve the issue that caused the non-compliance.
- Report to regulatory agency within 24 hours any non-compliance that may endanger health or the environment.
- Verify temporary erosion and sediment control facilities are removed once permanent stabilization is established.

1.2.3.3 CONTRACTOR RESPONSIBILITIES

- Be educated on the latest technology to control erosion and contain sediment.
- Have valid Erosion and Sediment Control Manager ([ESCM](#)) certification or certification from other accepted agencies.
- Have knowledge of the processes of erosion and sedimentation. Know project area's climate, soils, slopes and other factors that influence erosion and sedimentation.
- Bid on the job with full understanding of responsibilities and with intention to fulfill those responsibilities.
- Be knowledgeable of the 1200-CA permit requirements and the Specifications Sections 00280 (Erosion and Sediment Control) and 01030 (Seeding).
- Be knowledgeable about the ESCP.
- Revise the ESCP in the plan and on the ground, to meet conditions of construction, i.e. phasing, timing, weather.
- Develop a PCP that includes a site plan and narrative, describing methods of erosion and sediment control to be used to prevent erosion and sediment from contractor's operations related to disposal sites, borrow pit operations, haul roads, equipment storage sites, fueling operations and staging areas.
- Construct and install BMP's as described on the details and specifications.
- Mobilize staff to provide immediate repair to erosion control facilities.
- Minimize clearing of vegetation and look for opportunities to minimize erosion, offering ideas to ODOT inspectors for approval.
- Monitor weather and conduct inspection after each rainfall event of 1/2 inch or more.
- Monitor site and inspect each erosion control devices and accurately and fully record findings on ODOT Form [734-2361](#) weekly during active construction and every two weeks during inactive periods.
- Maintain erosion control facilities including removing sediment, repairing damaged BMP and modifying, or replacing them when needed to be provide effective functioning.
- Report to Agency Inspector discharges of sediment into receiving waters or any other non-compliance.
- Record repair and remediation actions on ODOT Form 734-2361.
- Update ESCP not less than monthly as work progresses and modify plan as conditions change. Revise ESCP to represent changes to facilities on the ground within 24 hours of making the change.
- Ensure that permanent seeding is performed in conformance with the seeding Specifications Section 01030.
- Ensure vegetative cover is provided as described in Section 01030.60.
- Remove temporary erosion control devices according to 00280.70

1.2.4 AGENCY RELATIONSHIPS

ODOT is a trusted partner with National Marine Fisheries Services (NMFS), Federal Highway Administration (FHWA), Oregon Department of Fish and Wildlife (ODFW), United States Forest Service (USFS), Oregon Department of Agriculture (ODA), Department of Environmental Quality (DEQ), United States Army Corps of Engineers (USAC) and with Native Tribes. These Agencies oversee impacts to fish, wildlife, clean water, clean air, natural landscapes and the overall health and well-being of the environment. ODOT embraces the values supported by these sister Agencies. Permit compliance reinforces ODOT's reputation as a trusted partner with regulatory agencies and other stakeholders.

CHAPTER 2 EROSION PROCESSES

2.1 CONCEPTS OF EROSION AND SEDIMENTATION

Erosion is a natural process by which soil and rock material is loosened and transported. Erosion by the action of water, wind, and ice has produced some of the earth's most spectacular landscapes. Natural erosion occurs primarily on a geologic time scale, but when human activities alter the landscape, the process of erosion can be greatly accelerated. Erosion is different from but related to sedimentation. Erosion is the removal of soil and sedimentation is the placement of the dislodged soil. Erosion is easier to prevent than it is to control of sediment once it is loosed.

Vegetation protects soil. Leaving vegetation in place is good erosion prevention. Since vegetation on an undisturbed site covers and protects the soil, the removal of that vegetation increases the site's susceptibility to erosion. Disturbed land may have an erosion rate 1,000 times greater than the undisturbed rate. Even though construction requires that soil be left exposed for periods of time, proper planning and use of erosion control measures can reduce the impact of man-induced accelerated erosion.



Figure 2-1 Good Sediment Control

An understanding of the processes of erosion and sedimentation is essential in the development of successful erosion and sediment control plans. The soils, slopes, and drainage patterns of a specific site influence the potential for soil erosion from that area. Drainage from off-site onto the work area can contribute to erosion. Identifying erosion problems at the planning stage and recognizing highly erodible areas, help in selecting effective erosion control practices and estimating storage volumes needed for sediment traps and basins.

Understand the process of water on undisturbed and well vegetated ground: Rain falls on vegetation and the plants absorb the energy of the falling water. Some water is actually absorbed into plant leaves. Decomposing organic matter (thatch and duff) absorb and retain water. Once the water holding capacity of the duff layer is exceeded, the water flows onto the soil. Undisturbed soil has pore space to accept infiltration and plant roots provide conduits along which water can penetrate the soil. When both the duff layer and the soil can hold no more water, it will begin to flow slowly through the duff. This duff mat is anchored in place by living vegetation and it resists being torn apart by moving water. In an undisturbed

condition where vegetation has developed a duff layer the organic material is being incorporated into the mineral soil by chemical, physical and biological forces so that the opposite of erosion is occurring, soil is being added.

When water volume exceeds the holding capacity of the duff layer and flows on the surface as a shallow sheet, blades of grass, and plant stems still keep water velocity slow and resist erosion. Once waters join into channels in undisturbed conditions the channels are naturally armored by rocks and by thickets of riparian vegetation and the plant roots that armor and bind the soil. In high flow events the tangle of stems slows the velocity of flowing water near the shore, reducing the erosive strength of the water against the banks, even when flows mid-channel may be rapids. When living riparian vegetation is damaged by bank erosion it is self-repairing. Erosion does occur naturally, but usually at a slow pace.

It is instructive to understand how nature addressed erosion and sediment control. Nature provides soft armor to the soil surface. It stores water in an organic layer at the surface and facilitates infiltration of the water into the soil, preventing runoff. Living plants remove water from the soil and once water is flowing nature has built-in erosion prevention in place. Erosion and sediment control measures used on construction sites strive to duplicate the functions provided by natural systems.

2.1.1 TYPES OF EROSION

Erosion results from surface processes (such as [water flow](#) or wind) that remove soil, rock, or dissolved material from one location on the earth's crust, then transport it away to another location.

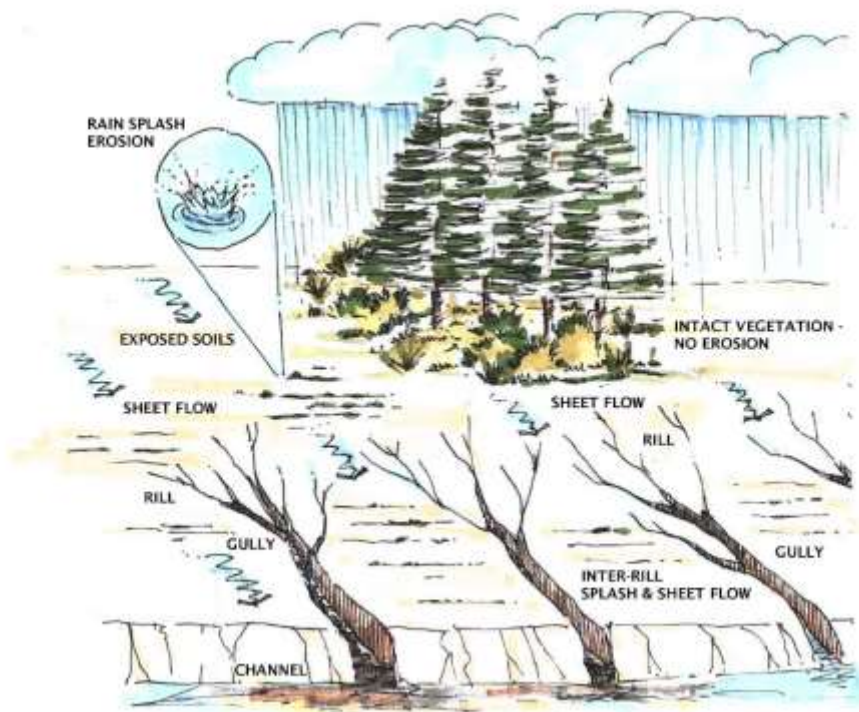


Figure 2-2 Major Types of Soil Erosion

2.1.1.1 WATER EROSION

The major types of erosion are:

- **Splash** – When vegetative cover is removed, the soil surface is exposed to raindrop impact. Raindrops fall at an approximate velocity of 20 miles per hour. Raindrops hit bare soil and detach soil particles that can easily be transported by runoff. This pounding action destroys the soil structure and often a hard crust forms when the soil dries. This crust inhibits water infiltration and plant establishment, increasing runoff and future erosion.
- **Sheet** – As rain saturates soil, a thin film of water spreads across the soil surface and flows down slope in shallow sheets. This sheet flow transports soil particles that have been detached by splash erosion. Soil particles carried in sheet flow are abrasive and can dislodge more soil particles. Sheet flow rarely moves as a uniform sheet for more than a few feet before concentrating by surface irregularities.
- **Rill** – The sheet flow organizes along the low spots of the soil surface, cutting grooves called rills into the soil surface. In rills the concentrated flow moves faster and the erosive power is greater. The energy of this concentrated flow can easily detach and transport more soil particles. Rills are small but well-defined channels that are only a few inches deep.
- **Gully** – Gullies are formed when stormwater runoff cuts rills deeper and wider or when several rills come together to form a gully. The erosive power of water flowing in gullies can be destructive. They can deepen, widen and enlarge in both uphill (headcutting) and downhill directions. If the flow of water is sufficient, large chunks of soil can fall from a gully headwall in a process called mass wasting. Once a gully is created, erosion is very difficult to control, and damage costly to repair.
- **Channel** – Natural streams have adjusted over time to the quantity and velocity of runoff released from a watershed at a steady rate over long duration. The vegetation and rocks lining the banks are sufficient to prevent erosion under these steady-state conditions. When a watershed is altered by removing vegetation runoff volumes and velocities are increased. This change makes the flow “flashy”, meaning the watershed releases greater volumes of water over a short duration. These high fast flows are destructive beyond what a natural channel is evolved to withstand. These aggressive flows remove streambank vegetation and the bank protection it



Figure 2-3 Splash



Figure 2-4 Rills on a Slope

provides, resulting in channel erosion. Flashy runoff may cause expansion of gullies into well-defined channels. These changes can disturb the equilibrium of the stream. Channel erosion is commonly found at stream bends, constrictions where built structures control the stream flow, or discharge points where storm drain culverts release storm water into a stream.

2.1.1.2 WIND EROSION

Wind erosion occurs in areas of exposed, dry, sandy soils; or where the soils are loose, dry and finely granulated. Construction activity can cause air borne sediments and blowing dust. Wind erosion damages land and natural vegetation by removing soil from one place and depositing it in another. Wind erosion causes deterioration of soil structure, soil nutrient losses and air pollution. Soil movement is initiated as a result of wind forces exerted against the surface of the ground. For each specific soil type and surface condition there is a minimum velocity required to move soil particles, this is called the threshold velocity. Once the velocity is reached, the quantity of soil moved is dependent upon particle size, the cloddiness of particles, and the wind velocity.

- **Suspension** – Suspension occurs when very fine dirt and dust particles are lifted into the wind. They can be thrown into the air through impact with other particles or by the wind itself. Once in the atmosphere, these particles can be carried very high and be transported over extremely long distances. Soil moved by suspension is the most conspicuous and easiest to recognize of the three forms of movement.
- **Saltation** – In saltation, fine soil particles are lifted into the air by the wind and drift horizontally across the surface increasing in velocity as they go. Soil particles moved in the process of saltation can cause severe damage to the soil surface and vegetation. They travel approximately four times longer in distance than in height. When they strike the surface again they either rebound back into the air or knock other particles into the air. Soil in saltation acquires a negative charge relative to the ground which in turn loosens more soil. This is significant because it is primarily the saltation of sand particles which dislodges smaller dust particles into the atmosphere. Many of us have experienced saltation as sand blasting our ankles as we walk on Oregon beaches during windy days.
- **Surface Creep** – The large particles which are too heavy to be lifted into the air are moved through a process called surface creep. In this process, the particles are rolled across the surface after coming into contact with the soil particles in saltation.

2.1.2 EROSION FACTORS

The four principal factors in soil erosion caused by water are: climate, soil characteristics, topography, and ground cover. These factors are interrelated in their effect on erosion potential. The variability in Oregon's climates, terrain, soils and vegetation make erosion control unique to each construction situation. Understanding the factors that affect the erosion process enables us to make useful predictions about the extent and consequences of on-site erosion. An empirical model developed for agriculture applications, the [Revised Universal Soil Loss Equation \(RUSLE\)](#), predicts soil loss resulting from splash, sheet and rill erosion. It considers both the effects of erosion control practice and the factors that influence erosion, so it is useful for evaluating erosion problems and potential solutions.

2.1.2.1 CLIMATE

Climate affects erosion potential both directly and indirectly. In the direct relationship, rain is the driving force of erosion. Raindrops dislodge soil particles, and runoff carries the particles away. The erosive power of rain is determined by rainfall intensity (inches of rain per hour) and droplet size. A

highly intense rainfall of relatively short duration, typical of a thunderstorm, can produce more erosion than a long duration storm of low intensity. In addition, storms with large raindrops are much more erosive than misty rain with small droplets. Oregon has considerable diversity of climate; rainfall intensity, duration and droplet sizes vary according to geographic location and type of storm.

2.1.2.2 SOIL

A soil's vulnerability to soil erosion or erodibility is a result of a number of soil characteristics which can be divided into two groups. The first are those characteristics that influence infiltration. The second are those affecting the resistance to detachment by rainfall and runoff. Key factors that affect erodibility are soil texture, amount of organic matter, soil structure and soil permeability.

- Soil texture refers to the sizes and proportions of the particles making up a particular soil. Sand, silt, and clay are the three major classes of soil particles. Soils high in sand content are coarse-textured. Because water readily infiltrates sandy soils, the runoff, and consequently the erosion potential, is relatively low. Sandy soils are not tightly bound together so that when saturated, sandy soils are easily eroded. Soils high in content of silts and clays are said to be fine-textured or heavy. Clay, because of its stickiness, binds soil particles together and makes a soil resistant to erosion. However, once clay soils erode the fine particles are hard to remove from the water.
- Organic matter consists of plant and animal litter in various stages of decomposition. Organic matter increases permeability, water holding capacity and soil fertility. Organic matter in an undisturbed soil reduces runoff and erosion potential.
- Soil structure is the arrangement of soil particles into aggregates. Soil structure affects the soil's ability to absorb water. When the soil is compacted, as is done with roadway construction, water tends to run off rather than infiltrate. Erosion hazard increases with increased runoff. A granular structure is the most desirable one. Loose granular soils absorb and retain water, which reduces runoff and encourages plant growth.
- Soil permeability refers to the ability of soil to allow air and water movement through the soil. Soil texture, structure, and organic matter all contribute to permeability. Soils that are least subject to erosion from rainfall and sheet flow runoff are deep soils with high permeability rates. Permeable soils reduce runoff. Surface texture affects how soils erode. Textured surfaces with ridges and dimples slow runoff. The small low spots hold pockets of water facilitating infiltration. Textured soils have a greater surface area than smooth soils providing a more ground to be wetted before runoff begins. Compaction diminishes permeability and increases runoff and smooth surfaces allow runoff to flow quickly.

2.1.2.3 TOPOGRAPHY

Topographic features strongly influence erosion potential. Watershed size and shape affect runoff rates and volumes. Swales and channels concentrate surface flow, which results in higher velocities and greater erosion potential. Slope length and slope steepness are critical factors in erosion potential, since they contribute to the velocity of runoff. Long, steep and continuous slopes allow runoff to add volume and, increase velocity over distance. High velocity runoff can produce rills and gullies.

The location on a slope also has a major bearing on erosion potential. The base of a slope is more susceptible to erosion than the top. The top of a slope receives only the water that lands as rainfall directly on it. The bottom of a slope receives rainfall plus the accumulated runoff from the slope above.

2.1.2.4 GROUND COVER

The term ground cover refers principally to vegetation. Vegetation is the most effective means of stabilizing soils and controlling erosion as a permanent erosion control measure. Other ground covers prevent splash erosion, retain moisture, promote infiltration and prevent erosion. Other ground covers include mulches, matting, plastic sheeting, wood chips, and crushed rock.

2.2 IMPACTS OF EROSION AND SEDIMENTATION

2.2.1 ENVIRONMENTAL IMPACTS

Many environmental impacts from sediment pollution are cumulative and the ultimate results and costs may not be evident until years later. Waters adjacent to ODOT managed lands contain fish that are federally listed endangered species. The listings increase the scrutiny of our projects by regulatory agencies. More significant, pollution's impact on endangered species can have unfortunate and permanent consequences. ODOT's responsible stewardship of its lands is important.

- Eroded soil contains nitrogen, phosphorus, and other nutrients. When carried into water bodies, these [nutrients](#) trigger several negative consequences.
- Erosion of streambanks and adjacent areas destroys streamside vegetation that provides aquatic and wildlife habitats.
- Down cut stream channels can lower water tables of surrounding floodplain to a depth below the root zones of native plants.
- Sediment deposited in streams can cover fish spawning gravels, eliminating habitat or smothering developing eggs.
- Sediments in streams can smother the bottom fauna, affecting the food web.
- Turbidity from sediment reduces in-stream photosynthesis, which leads to reduced food supply and habitat.
- Turbidity increases the amount of sunlight absorbed in water, raising stream temperatures.
- Turbid water carries abrasive particles that can damage the thin membranes of fish gills with sub-lethal or lethal results.
- Turbid water decreases visibility making it more difficult for predatory species to locate prey.
- Turbid water has a lower oxygen carrying capacity making it difficult for aquatic species to breathe.
- Erosion removes topsoil which is the biologically active strata of soil that best supports plant life.
- Erosion leaves scars of infertile mineral soil in the landscape. These have reduced aesthetic value and are slow to revegetate.



Woven coconut fiber matting (coir) with compacted coir “face” stabilizes stream bank soils. Embedded large wood deflects flows, slows velocity along shore margin and provides calmer micro-habitat for juvenile fish

Figure 2-5 Matting Product Provides Protection of Waterway from Erosion

2.2.2 ECONOMIC IMPACTS

Many economic impacts are hard to quantify. How can a dollar value be assigned to loss of aquatic habitat or poor aesthetics? Other impacts may be readily quantified: such as in a silted-up reservoir.

- Excessive sediment accumulation reduces reservoir storage capacity and more frequent sediment removal is required.
- The cost of building new reservoirs to replace lost reservoir capacity is high. Increasing land values and lack of available sites are making this alternative much less feasible.
- Nutrients carried in sediment can feed algal blooms which excrete toxins that are not easily removed from drinking water sources. Upgrading water quality facilities to treat these toxins is costly. Algal blooms in resort waters severely reduce tourism and recreation economies.
- Sediment deposited into streams reduces flow capacity, interferes with navigation, and increases the risks of flooding. Regular maintenance dredging is required.
- Erosion severely diminishes the ability of the soil to support plant growth; to restore this ability is costly.
- During construction, time spent cleaning up sediment and repairing and replacing neglected BMPs removes staff from construction activities and can affect schedule and budget.
- [Fines](#) for depositing sediment pollution can be significant and egregious violations can result in jail time.

2.2.3 POLLUTANTS

This section covers potential impacts on natural systems associated with pollutants from construction activities, and provides an overview of important pollutant categories and some of their effects on the environment. Pollutants are substances that can render water harmful to people, fish, or wildlife or impair recreation or other beneficial uses. Sediments, nutrients, bacteria, organic chemicals are the most important classes of pollutants. Heavy metals, petroleum-hydrocarbons and synthetic organics are frequently classified as toxic pollutants, depending on their characteristics.

2.2.3.1 *SEDIMENT*

Sediments and other suspended solids are the most common pollutant in storm water runoff. Deposited sediments can affect adjacent properties and clog catch basins and storm drains, causing flooding and higher maintenance costs. Sedimentation interferes with recreational use and has environmental impacts as noted above. In addition, sediments can transport many other pollutants, including nutrients, bacteria, metals and some organic pollutants. The prevention of sediment pollution is the primary focus of erosion and sediment control plans. Sediment discharge is conspicuous, it displays poor project “housekeeping” and it results in complaints from the public.



Figure 2-6 Sediment Non-Compliance

2.2.3.2 *NUTRIENT*

Plants require nutrients, such as phosphorus and nitrogen for growth, but nutrients in receiving waters can harm water quality. Excess nutrient levels overstimulate the growth of algae and other aquatic plants, potentially causing

unpleasant tastes, odors, unsightly conditions and lowered dissolved oxygen

levels from plant decay. Algae blooms, like blue-green algae, can result in the presence toxins in the water that are severe enough to kill aquatic life, disrupt drinking water supplies or cause prohibitions of water contact. Nutrients tend to be more of a problem in slow moving water such as lakes or sluggish streams. Sources of nutrients include organic and inorganic fertilizers, soils and decomposing vegetation.

2.2.3.3 *CONCRETE*

Wet concrete is highly alkaline and can be caustic and corrosive. If the slurry from washing concrete from tools or from the hoppers and chutes of trucks enters waterways, it can harm fish gills and eyes and interfere with reproduction. Concrete wash water can percolate through the soil and alter the soil chemistry, inhibiting plant growth and contaminating ground water.

2.2.3.4 *BACTERIA*

The presence of disease-bearing organisms in surface waters, such as bacteria and viruses, potentially threatens public health. The presence of fecal coliforms indicates that warm-blooded animal waste is present. The most common impacts associated with fecal coliform pollution is reduced recreational opportunity. Potential construction site sources of fecal coliforms include outhouses that are not maintained or pumped out on a regular basis. The clearing and grading process can also expose waste, deposited prior to construction, to runoff.

Bacterial decomposition of plant, animal and chemical wastes requires oxygen. When this process occurs in water, it reduces the oxygen available for fish and other aquatic organisms. If dissolved oxygen levels become too low, fish and other aquatic organisms may become stressed or die. Construction sites can be a source of oxygen-demanding substances. Cleared vegetation, exposed soils, spilled chemicals, and animal or human wastes can all contribute to lower oxygen levels in water.

2.2.3.5 HEAVY METALS

Many metals are toxic and are regulated by the Environmental Protection Agency (EPA). Specifically, EPA classifies eight metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium and silver) as hazardous and regulates their disposal.

Metals such as copper and zinc, which partially dissolve in water, may create toxic conditions for fish and other aquatic life. Metals in construction site runoff attach to sediments. Sediments carrying heavy metals often settle out from water and accumulate on stream and lake bottoms where they can remain for a long time. The metals accumulate in the tissue of organisms, which are then eaten by predators near the top of food chains. High concentrations of heavy metals can be found in these predators.

Construction materials or equipment that contain such metals include paints, preservatives, metal downspouts, brake linings and tires. Other metal sources are wastes such as used automotive liquids, fuels, dust from sanding or grinding metal and painted surfaces, and wash from roadways.

2.2.3.6 PETROLEUM HYDROCARBONS

Petroleum hydrocarbons include crude oil and any products derived from it, such as gasoline, diesel fuel, solvents, mold release compounds and lubricating oils. Petroleum products can be present in a number of forms on a construction site. If released to the environment, they can harm water quality. Certain petroleum products are acutely toxic and can kill fish and invertebrate life. Petroleum products also consume oxygen as they decay naturally and greatly reduce the aesthetic qualities of aquatic environments. As a result of these potentially severe impacts, petroleum products require special care during storage, transfer, and usage on construction sites.

Petroleum residue accumulates on paved roads from leaks in vehicles. Considering the negative impacts to the environment caused by petroleum products ODOT is required to treat stormwater runoff from pavement to remove those pollutants from the water. There are a number of mechanisms that do this, but the ones that affect erosion and sediment control use special soils and vegetation to address the issue. Dense vegetation, like a thick growth of grass will physically intercept and hold water borne oils. Microbes in soil can consume and break down petroleum products, providing another means of treating polluting runoff. Used in tandem these two mechanisms provide the treatment that is required.

There are five basic types of treatment: water quality structures, stormwater control ponds, water quality biofiltration swales, water quality bioslope and water quality filter strip. Although all of these require erosion and sediment control BMPs, the biofiltration swales, water quality bioslope and water quality filter strip present unique risks. These features deal with flowing water and rely on vegetation for permanent stabilization. It is common that stormwater runoff is directed to these features before the vegetation is established. It is important that designers and project managers know that permanent erosion and sediment control features may conflict with the standard procedures used by Maintenance to keep these water quality facilities functioning effectively. It is recommended that water quality features be fitted with matting to prevent erosion and with temporary sediment barriers/check dams that reduce runoff velocity.



Figure 2-7 Erosion control failure at water quality facility

2.2.3.7 SYNTHETIC ORGANICS

Synthetic organic substances include most pesticides, preservatives, solvents, and plasticizers, as well as incidental and unwanted by-products of fuel combustion. Many organics, depending on their composition, are slow to degrade and remain in the environment for long periods of time. Synthetic organics can be toxic to fish and other aquatic life and are sometimes classified as carcinogenic (cancer causing).

Organics can be liquid or solid products, or waste materials. Liquid and solid products may enter the environment when they leak or are spilled from containers during use, are carried away by rain water and wash water, or are spilled or dumped on the ground or down the storm drain. Therefore, they also warrant a special consideration for careful inspection at construction sites.

Table 2-1 Overview of Pollutant sources, impacts, and indicators

POLLUTANTS	MAJOR SOURCES	IMPACTS	INDICATORS
Sediments and other solids	Clearing/grading: Exposed soils	Cloudy water; smothering of fish eggs and insects; flooding	Total suspended solids; turbidity
Nutrients	Cleared vegetation; exposed soils; human/animal waste	Algal blooms; reduced oxygen; aquatic plant growth	Different forms of phosphorus and nitrogen
Bacteria	Human/animal wastes; sewer lines; septic tanks	Shellfish contamination; human health effects	Fecal coliforms

Oxygen demanding materials	Cleared vegetation; human/animal waste; chemical reactions	Reduce oxygen in water, stress/kill salmonid fish and other aquatic life	Biological Oxygen Demand (BOD); Chemical Oxygen Demand (COD); dissolved oxygen
Heavy metals	Paints, flashings, downspouts, tires, preservatives, solvents	Bioaccumulation in food chain; toxic to aquatic life, human health effects	Ar, Cd, Cu, Hg, Ni, Pb, Zn
Petroleum hydrocarbons	Oil, grease, fuels, lubricants	Decreased oxygen levels; aesthetics, human, aquatic and wildlife health effects	Oil & grease; total petroleum hydrocarbons
Synthetic organics	Pesticides, PCBs, combustion products, solvents	Bioaccumulation in food chain; toxic to aquatic life, wildlife and humans	Variety of organics analyses
Concrete	Spills, truck washout, overfull washout basins	Harm to aquatic species, stunted plant growth, ground water pollution	Concrete slurry, Hardened concrete crust surrounding washout

2.3 PRINCIPLES OF EROSION AND SEDIMENT CONTROL

Effective erosion and sedimentation control requires first that the soil surface be protected from the erosive forces to prevent erosion, and second that eroded sediment is captured on-site. Erosion control is the prevention of soil erosion. Sediment control is the trapping of suspended soil particles. Erosion control is easier than controlling sedimentation. Sediment control is necessary because some erosion is unavoidable. The following principles are simple but are effective. They should be integrated into a system of control measures and management techniques to control erosion and prevent off-site sedimentation.

- Fit site construction to the terrain. Review and consider all existing conditions in the initial site selection for the project. When construction is tailored to the natural contours of the land, little grading is necessary and erosion potential is consequently reduced.

- 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. In scheduling, take into account the season and the weather forecast. Schedule grading to coincide with a dry season. Stabilize disturbed areas as quickly as possible and if possible suspend work during wet season. The 1200-CA Permit and Specifications require that additional measures be employed to during the wet season to prevent erosion and sedimentation.



Figure 2-8 No erosion, stable channel & clear water

- **Retain existing vegetation whenever feasible.** Vegetative cover is an effective form of erosion control; very little erosion occurs on a soil covered with undisturbed natural vegetation. If possible, clear only the area where construction will actually occur, street and driveway lines, and cut and fill slopes. Try to integrate existing trees and other natural vegetation into the site improvement plan.
- **Vegetate and mulch denuded areas.** Newly planted vegetation begins to duplicate the functions of established vegetation. Seed and mulch denuded soils as soon as possible after grading is completed. Mulch helps seedlings to become established and protects the soil from raindrop splash until vegetation takes over. Soils may be seeded with temporary or permanent vegetation. If the soil will be exposed during the winter months, protective measures other than vegetation must be used.
- **Divert runoff away from denuded areas.** Manage and control runoff in areas that have been denuded. Route runoff into stabilized



Figure 2-9 Compost blankets provides erosion prevention

channels. Divert runoff from off-site around the work areas using temporary piping, diversion dikes or swales. For conveying runoff down steep slopes temporary slope drains or protected flumes should be used with energy dissipaters at the bottom of the slope. The runoff containing sediment should be directed to Baker Tanks, sediment traps or settling basin if turbid flows are anticipated.

- **Cover exposed soils.** Matting in the form of rolled erosion control products (RECPs), mulch, compost blankets or hydraulically applied matting will protect soils and provide immediate protection that does not rely on seed germination and plant establishment to provide cover.



Figure 2-10 Seeded perennial rye grass with wattles to shorten slope length

- **Minimize length and steepness of slopes.**

Slope length and steepness are among the most critical factors in determining erosion risk. Increasing slope length and steepness increase the velocity of runoff, which increases erosive energy. If slope steepness is doubled while other factors are held constant, soil loss potential is increased 2 ½ times. If both slope steepness and length are doubled, soil loss potential is nearly 4 times greater. To prevent erosive velocities from occurring on long, steep slopes, interrupt the slopes at regular intervals using sediment barriers, terracing or other means.

- **Keep runoff velocities low.** The energy of flowing water increases at the square of the velocity. For example, when the velocity doubles; the erosive force quadruples and the water can theoretically move particles 64 times larger by volume. Channel velocities can be kept low by lining drainage ways with rough surfaces such as vegetation and riprap, by designing broad, shallow flow areas, and by constructing check dams at frequent intervals. Concrete channels, although efficient and easy to maintain, convey runoff quickly, often resulting in downstream channel erosion and flooding.



Figure 2-11 Check Dams slow runoff velocity

- **Prepare drainage ways and outlets to handle concentrated or increased runoff.**

Construction changes the characteristics of runoff. The creation of impervious surfaces,

removal of plant cover, and compaction of soil allows less water to infiltrate into the soil and therefore increases the volume of runoff. Drainage channels should be designed to provide maintenance access for the removal of accumulated sediments. Alternatively, if a project can be designed so that runoff from development areas is allowed to infiltrate into the soil on-site, no off-site channel enlargement or protection should be necessary. To prevent channel erosion from occurring, design drainage ways to withstand the peak flows without erosion, select lining materials appropriate for peak flows, and de-energize concentrated flows at outlets using scour holes and energy dissipaters. If development substantially changes the natural drainage conditions in a watershed, merely protecting the drainage channels on a project site may not be sufficient to prevent erosion.



Figure 2-12 Stabilized Channel

- **Trap sediment on site.** Some erosion during construction is unavoidable. The function of a sediment barrier is to prevent sediment from leaving the Project site. Sediment laden runoff should be detained on-site so that the soil particles can settle out before the runoff enters receiving waters. Locate sediment basins and traps at low points below disturbed areas. Use earth dikes or swales to route drainage from disturbed areas into the basins. Sediment barriers and sediment fences can be placed below small-disturbed areas on gentle to moderate slopes. Storm water temporarily ponds up behind these barriers, allowing sediment to settle out.



Figure 2-13 Sediment Trap & Energy Dissipater W/ Level Spreader

- **Inspect and maintain control measures.** Inspection and maintenance of control measures are vital to the effective function of an erosion and sediment control facilities and they are required by both the specifications and the permit. Most control measures require regular maintenance. Problems often occur during the first storm of the season. Some problems, like

rills, develop slowly over time and can easily be prevented with inspection and maintenance. Effective functioning of each BMP is required by the permit and the Specifications. The permit requires the contractor inspect active sites weekly and within 24 hours of a storm event of one half inch or more. Correct problems as soon as they develop. Specification Section 00280.30 requires the Contractor assign an individual, knowledgeable in erosion and sediment control, to be responsible for routine inspections of operating erosion and sedimentation control practices. As project permittee, ODOT is ultimately responsible for compliance with permit requirements, including the inspections and monitoring reports.

- **Take Erosion and Sediment Control work seriously.** Erosion and Sediment Control is contracted work for which the Contractor is being paid. The Erosion and Sediment Control work is required in the permit conditions which are enforceable by law and punishable by severe penalties. This work should be conducted and managed with the same level of professionalism and oversight as is provided for other aspects of contracted work.

The principles of erosion and sediment control discussed above generally address issues that operates on the soil's surface. There are engineering practices that work on a larger scale of slope protection. The following practices are the domain of engineers and geotechnical engineers, but their use will improve erosion control results.

- **Slope Rounding and Contour Grading.**

The standard practice of rectilinear grading creates unnatural flat slopes, sharp angles and rapid runoff flow that resists infiltration.

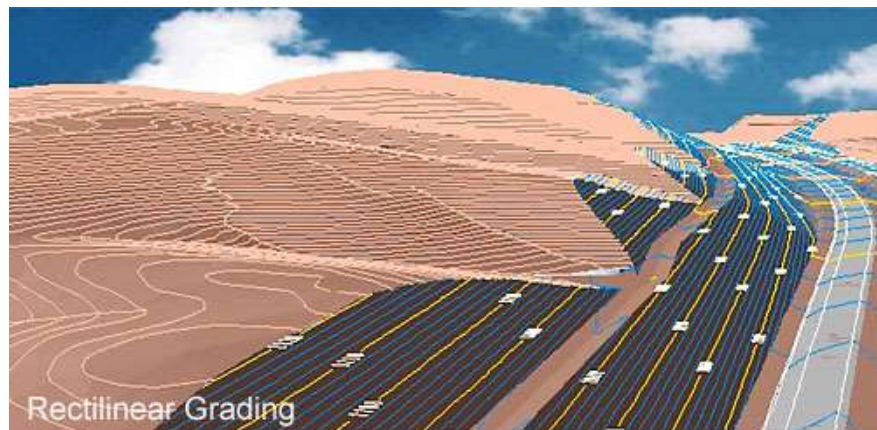
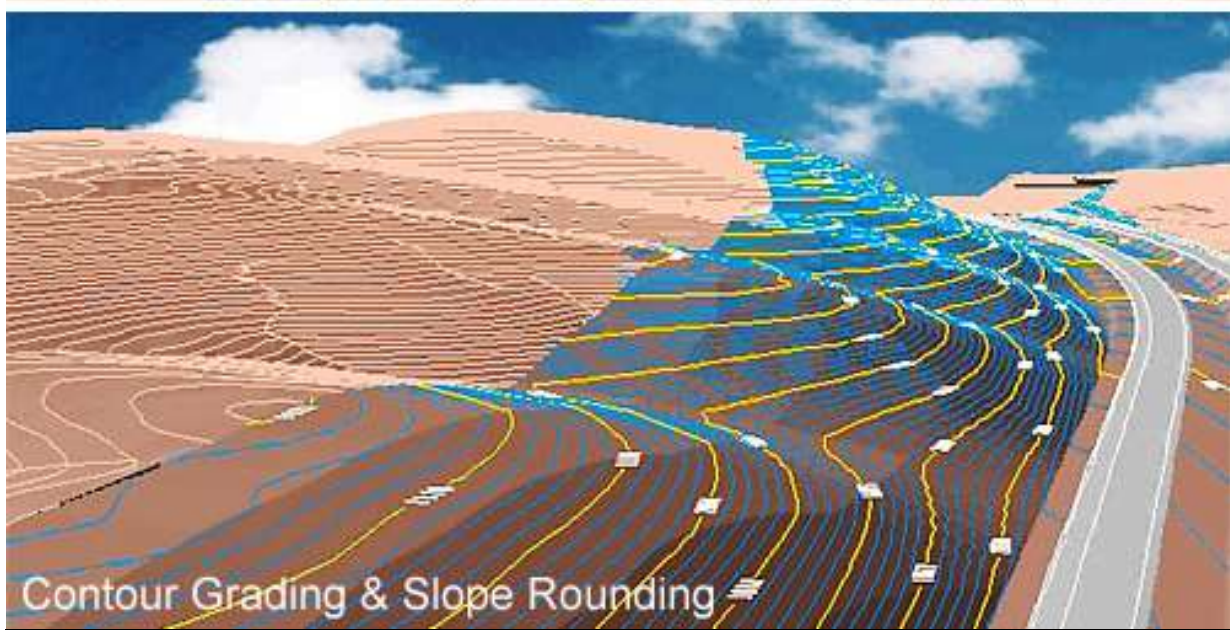


Figure 2-14 Rectilinear Grading



Contour grading with slope rounding results in natural landform shapes that break the slopes into smaller watersheds with runoff flow patterns that are more resistant to erosion. (photos courtesy of CalTrans)

Figure 2-15 Contour grading with slope rounding

- **Stepped Slope:**

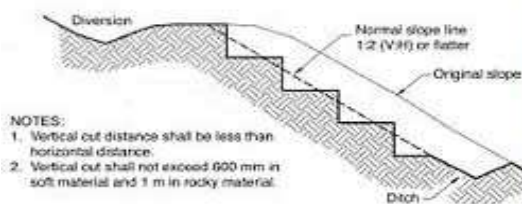


Figure 2-16 Stepped Slope

Constructing cut slopes that are terraced or stair-stepped slow stormwater runoff. Slowed water can infiltrate at each terrace. Material that is eroded off the surface will accumulate on each terrace providing seed bed material for vegetation to provide permanent erosion control. Cut slopes not stabilized by vegetation will ravel and erode in perpetuity and be an enduring source of maintenance tasks.

- **Layer geogrid into embankment slopes:**



Constructing embankment layered with reinforcing geogrid will prevent the mass landslide known as the deep rotational slump.

Figure 2-17 Geogrid

- **Dewater the hillslope:**



Water adds weight and lubrication to the structure of slopes that can result in landslides. Removing that water helps stabilize slopes especially in landslide prone locations. Horizontal drains (shown) can be drilled into hillsides. Drain boards can be layered into the construction of embankment slopes to help water exit those structures.

Figure 2-18 Horizontal Drains

CHAPTER 3 EROSION AND SEDIMENT CONTROL MEASURES AND BMP'S

3.1 EROSION PREVENTION AND SEDIMENT CONTROL

This chapter presents Best Management Practices (BMPs) for erosion and sediment control. The discussion for each BMP includes typical applications and design criteria. Additional information such as the advantages, disadvantages, maintenance requirements and common failures of each BMP are also included, and should help the designer to choose the most appropriate measure or control and to develop special provisions.

The best current thinking continuously evolves and new products to address erosion prevention and sediment control are constantly being introduced into the marketplace. The Agency strives to keep this manual updated to provide good and current information. Erosion control designers, contractors and project managers do well to keep apprised of new developments in erosion and sediment control products and technology.

The details of installation can and should vary in the field depending on the site conditions. Field variations for each type of BMP are encouraged. The substitution of other cost-effective products or methods that provide substantially equivalent or superior performance is allowed if approved by the Agency.

As implied by their name, Best Management Practices - BMP's are planning strategies, stabilization methods and structural erosion control measures that represent the best commonly accepted practices. Table 3-1 presents ratings for basic applications of commonly used erosion control measures.

ODOT has developed a suite of [Standard Drawings](#) that provide graphic examples of how BMPs are correctly used. These Standard Drawings, and the similar Standard Details are developed for all of the most commonly used products and practices and they are provided in this document in Appendix C. When noted as reference in Project Plans the standard drawings or details become contract documents that provide the correct and required method of installation or use of the BMP.

Table 3-1 Matrix of temporary and permanent erosion control measures and estimated effectiveness

ratings: E = Excellent, M = Moderate, P = Poor

BEST MANAGEMENT PRACTICE	TEMPORARY VS PERMANENT	RATING	PAGE
Erosion Prevention			
Preserve Natural Vegetation	P	E	3-44
Buffer Zone	P	E	3-46
Seeding	T/P	E	3-48
Mulch	T/P	E	3-60
Sod	T/P	M	3-67
Matting	T/P	E	3-70
Compost Blanket	T/P	E	3-75
Plastic sheeting	T	P	3-78
Dust Control	T	M	3-80

BEST MANAGEMENT PRACTICE	TEMPORARY VS PERMANENT	RATING	PAGE
Fiber Rolls (Wattles)	T/P	M	3-116
Compost Sock	T	E	3-118
Chemical Soil Stabilizer	T	M	3-80
Haul Road Stabilization	T	E	3-111
Check Dam	T	M	3-93
Runoff Control			
Slope Drain	T	E	3-84
Outlet Protection	T/P	E	3-88
Surface Roughening	P	E	3-90
Check Dam	T/P	M	3-93
Diversion Dikes and Swales	T	M	3-97
Sediment Control			
Construction Entrance	T	E	3-105
Tire Wash Facility	T	E	3-108
Road/Parking Stabilization	T	E	3-111
Biofilter Bags	T	M	3-114
Fiber Rolls (Wattles)	T	M	3-116
Compost Sock	T	E	3-118
Compost Berm	T/P	M	3-121
Check Dam	T/P	M	3-93
Sand Bags	T	M	3-123
Brush Barrier	T	M	3-125
Filter Berm	T	M	3-126
Pre-fabricated Barrier System	T	M	3-128
Sediment Fence	T	M	3-131
Inlet Protection	T	M	3-135
Sediment Trap	T	E	3-141
Flocculent Treatment	T	E	3-145
Temporary Settling Tanks	T	E	3-146

3.2 EROSION PREVENTION

Erosion prevention is the most effective and inexpensive method for reducing sediment pollution. A strong, but typical storm, dropping 1/2 inch of rain in 24 hours, over one acre has a volume of 67 cubic yards. The idea of removing sediment from that volume highlights why erosion control is more effective than removing sediment from turbid water. Limiting the amount of exposed soil, covering soil, controlling surface water runoff, shortening slope length and checking runoff velocity are ways to minimize erosion during construction. Permanent erosion control usually consists of stabilizing exposed soils with permanent vegetation. Prior to permanent stabilization temporary stabilization is

required. Reducing the erosion associated with construction vehicular traffic is also covered in this section. Many of these techniques can reduce erosion by 80 to 95 percent compared with exposed soils.

3.2.1 EROSION PREVENTION BEST MANAGEMENT PRACTICES

1. Preserve Natural Vegetation
2. Buffer Zone between work and resource
3. Temporary and Permanent Seeding
4. Hydraulically Applied Matting
5. Straw or Wood Chip Mulch
6. Compost Mulch
7. Sod
8. Matting
9. Plastic Sheeting
10. Shorten Slope Length
11. Check Dams
12. Haul Road Stabilization
13. Dust Control

3.2.1.1 PRESERVE NATURAL VEGETATION

This BMP involves preserving natural vegetation to the greatest extent possible during the construction process and after construction where appropriate. Maintaining natural vegetation is the most inexpensive form of erosion prevention control. This method is particularly important in sensitive areas such as wetlands, stream corridors, lakes, and near steep slopes. The project manager, inspector and contractor should address and discuss preserving natural vegetation during the Pre-Construction Conference.

Applications

- All areas where it is practicable, especially flood plains, wetlands, stream banks, steep slopes and other areas where erosion controls would be difficult to install and maintain.

Advantages

- Helps reduce soil erosion and runoff while retaining the aesthetics of an area.
- Existing vegetation is installed and paid for. This saves erosion control costs and revegetation costs
- Existing vegetation provides areas for wildlife, and provides visual screening.
- Vegetation provides shade, helping maintain cooler water temperature. Temperature moderation is especially important when associated with fish-bearing waters.
- Retains existing shade and cover habitat.
- Reduces issues with Migratory Bird Treaty Act.

Disadvantages

- Retaining older trees could create a safety hazard.
- May constrict area available for construction activities.

Special Considerations

- Requires coordination with environmental professionals such as landscape architect, forester and the construction Project Manager's office.
- Requires the Contractor to fence or flag the clearing limits or tree and shrub protection zones
- Tree removal must occur when not active nesting is occurring to comply with the Migratory Bird Treaty Act.
- Retained vegetation may require alterations to future maintenance activities.
- If possible, work with the contractor to establish a phased clearing and grading schedule at the beginning of the project.

Design Criteria

- Coordinate with the Landscape Architect and Environmental Professionals assigned to the project when determining what to save and how to save it.
- Vegetation can be preserved in natural clumps or as individual trees, shrubs and vines.
- Clearly flag or mark the ground disturbance limits outside the dripline of preserved trees.
- Protect vegetation from:
 - Construction equipment injury above or below the ground level. Injury occurs from scarring, cutting roots, or soil compaction.
 - Compaction: do not allow vehicle passage, parking, material storage or stockpiling within vegetation protection zone.
 - Grade changes, which affect the plants' root zone. Excavation should smoothly transition to existing grade no closer than at tree's drip line. Embankment around trees can be accommodated by placing a layer of round drain rock or open graded aggregate and a tile system over the roots before placing fill to allow air to circulate to root zone. Place no soil over root crown or on trunk of trees. Consult arborist when planning embankment around existing trees.
- In excavation, terracing the area around the plant, or leaving the plants on an undisturbed mound can increase the plants' survival chances.
 - Root exposure can negatively affect vegetation.
 - Change in established hydrology can negatively affect vegetation.
 - Root damage caused by trenching for drainage lines, water and sewer lines or electrical service can negatively affect vegetation.

Maintenance

- Inspect and repair flagging or fencing.
- Re-cover exposed plant roots.

Common Failures

The most common problems with this BMP are:

- Non-observance of clearing limits and clearing of the entire site prior to construction
- Poorly executed or ill-considered tree protection can result in vegetation dying.

3.2.1.2 *BUFFERZONE*

A buffer zone consists of an undisturbed area or strip of established vegetation adjacent to a disturbed area that reduces erosion and runoff. Permits or local ordinances may require buffer zones.

Applications

- Between disturbed areas and streams, other water bodies or wetlands.
- Between natural swales and wetlands.
- Where required.

Advantages

- Filters Sediment.
- Promotes infiltration.
- Provides habitat.
- Provides shade
- Reduces velocity and quantity of runoff, dissipates energy.
- Provides visual screening.
- Can be used to stabilize stream banks.
- Low maintenance.

Disadvantages

- Requires keeping all construction equipment, debris and soils out of the natural areas.
- Extensive buffers can cover large areas of land that are not available for project development.

Special Considerations

- Constrains work area and equipment movement.
- Requires the Inspector or Contractor to fence or flag the clearing limits.
- Requires the Inspector or Contractor to fence or flag outside tree and shrub driplines.
- If possible, work with the contractor to establish a phased grading plan that includes buffer zones.

Design Criteria

- Preserve natural vegetation in clumps, blocks or strips.
- Preserve natural vegetation on unstable, steep slopes.
- Vegetative buffer zones for streams, lakes or other waterways should be 100 ft. wide between ground disturbance and the feature. The width can increase depending on other onsite conditions, existing vegetative conditions and erosion potential.

Maintenance

- Inspect flagging and fencing frequently and repair as needed.

Common Failures

- The most common problem with this BMP is:
- Non-observance of buffer zone delineation and clearing of the entire site prior to construction

3.2.1.3 SEEDING

A well-established vegetative cover is one of the most effective methods of preventing erosion. The most effective practice is to establish vegetation on most construction sites as the slopes are finished, rather than waiting until all the grading is complete. This and other requirements are described in Section 01030 of the [Oregon Standard Specifications For Construction](#). It is often the case that the seeding provided to the project will be the final treatment for roadsides. Beside erosion control, this treatment will be the

aesthetic finish and the environmental piece that ties the project to the context of the location. It is worth doing well. The [Roadside Development Manual](#) goes into depth regarding seeding. Within that Manual there is guidance and several resources to assist in decision making regarding seeding.

Applications

- On disturbed areas that require seeding either because the area has reached final grade (permanent seeding) or because the area will remain undisturbed for over 2 months (temporary seeding). Refer to Section 01030.43, or [Chapter 6](#) of this manual for soil exposure limitations and seeding dates.
- Stockpiles
- Reclaimed access/haul roads and staging areas
- In vegetation-lined channels, seed and then protect with matting.
- In retention/detention ponds.

Advantages

- Prevents erosion and also traps sediment.
- Promotes infiltration.
- Improves appearance of the site.
- Reduces runoff.
- Provides excellent stabilization.
- Relatively inexpensive erosion control measure.

Disadvantages

- Needs sufficient time for seed to establish.
- Requires mulch or other cover to keep soil/seeds in place during seed germination and establishment.
- Compacted surfaces require ripping or tilling to break up compacted soil for site prep.
- May require soil conditioners, amendments and/or bio-amendments on poor soils.
- May require irrigation.
- Must be removed prior to applying fill material.

Design and Selection Criteria

Because of the variety of climates, elevations and eco-regions in Oregon no single standard seed mix is appropriate. Because the plants that result from erosion control seeding remain long after construction is done and risk of erosion is abated, the designers should know the species origin of and characteristics of the plants they are seeding. Seed mixes should be designed for the climate and conditions of the project site. A seeding designer should be familiar with the characteristics of the plants being seeded. When erosion control seeding is used for permanent seeding, issues of concern are:

- What is the soil type and condition? Haul road or site access routes may require loosening of the surface soils to eliminate compaction.
- Soils on cut slopes require loosening along contour as described in 01040.48(d).
- Soil surfaces are to be textured by "track walking" as described in Section 00280.43. (this is not for the purposes of compaction)
- Is the seeded plant low growing and low maintenance?
- Is an annual or perennial, deep or shallow rooted?

- Does the seed need cold stratification or other treatment to germinate?
- Does it germinate in spring or whenever it is watered?
- Is it forage or cover for large wildlife that are not desirable adjacent to roadways.
- Is it a noxious weed or otherwise aggressive, dominant, invasive, toxic or otherwise inappropriate?
- Does the seeding need to satisfy other goals such as treating stormwater runoff, provide pollinator habitat, restoring a native plant community or provide a showy floral display?
- Does the site have a regulatory requirement of native plant cover?

Furthermore ODOT's goal of being a responsible environmental steward requires that thoughtful consideration be given to the use of native grass and plant seeds when developing seed mixes.

Seed mixes are either temporary or permanent.

Temporary seeding is appropriate for areas that are planned for future disturbance. Temporary seeding is often rye grass that is fast growing and inexpensive. Although it quickly develops a thick green carpet of top growth, initially, the roots are neither deep nor strong. Rye grass is not a native grass. With its aggressive growth habits, rye grass can out-compete native plants for sunlight, water and nutrients and because it persists after introduction many experts consider it undesirable as the permanent ground cover.

Frequently a permanent seed mix is used as the temporary, erosion control seeding. This dual use is requires including a sterile, short lived "nurse crop" to provide quick cover. When other erosion prevention is provided the nurse crop is not necessary. Sometimes the temporary seed mix will consist exclusively of one of the nurse crop species. Some nurse crop species are the sterile wheat grasses "Regreen®" or "Quickguard®".

These are agriculturally produced and copyrighted varieties. During years of large or multiple wild fires or other natural disasters, these

This photo shows the grain, cereal rye. This was seeded without approval. It grows tall enough to hide wildlife or obscure sight lines, it releases chemicals that inhibit the growth of other plants and it is a listed weed in Washington State.

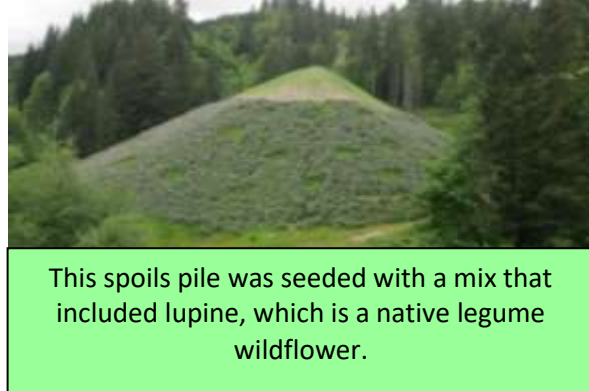


Figure 3-1 Cereal Rye

patented erosion control grasses may be sold out and unavailable. Another fast germinating grass that does not persist in the landscape is "Poco" barley. This is a short growing grain barley that dies out after a few years. These 3 nurse crop species have coarse top growth and large seeds. Noting the large seed size is important as a greater weight of seeds is needed to achieve a desired seeds per square foot. Some grasses are listed weeds or have growth habits that make them undesirable. Accept no substitutions for specified seed mixes without written approval from the professional of record.

There are Oregon native grasses that have characteristics desirable in erosion control seeding. Two are small fescue (*Vulpia microstachys*) and slender wheatgrass (*Elymus trachycaulus*). Both germinate quickly and display vigor in growth. The small fescue is a low growing grass that can persist in the landscape. The slender wheatgrass is an annual grass that tends to diminish in the landscape over time. Always verify seed availability prior to specifying.

A few decades ago the standard for permanent seeding was a simple blend of grass species, usually nonnative, selected to be self-sustaining and provide soil cover. The few, simple requirements for roadside seeding did not consider a project's environmental context or take advantage of site opportunities. In the best current thinking, permanent seeding would consist of a mix of native grass, legume and forb seeds. This is consistent with ODOT's vision of being a responsible steward of State lands. Native species are suited to the climate and conditions of the region. Native species also have evolved with insects, birds and animals that depend



This spoils pile was seeded with a mix that included lupine, which is a native legume wildflower.

Figure 3-2 Spoils Pile

on them for food and habitat, and these plants depend on the animals for pollination and distribution of seeds. Including legumes in a seed mix enables these plants to fix nitrogen, a natural fertilizer, into the soil. Including forbs and wildflowers provides pollinator habitat and enlivens the roadsides with flowers. The use of native plant seeds should be approached with the foreknowledge that some native species germinate and establish slowly and may not provide vegetative cover in the 45 days required by the Specifications, hence the need for a nurse crop to be included in the mix. A diversity of native seeds should result in a plant community that is stable, self-sustaining and that provides long term soil stabilization.

There is no requirement that native seed be used on projects. In many areas exotic plants/grasses already dominate the plant communities. In some agricultural areas some native grasses are undesirable due to the possibility that they could corrupt pure stands of an agricultural crop. The design intent of a project may require that a homogenous stand of turf grass be developed. Each project is different and different design styles are valid. It is important for designers to know site conditions, including adjacent lands and know the plant characteristics of the species being seeded.

A well designed seed mix would have a few native grasses of different genus so that different rooting depths and growth habits would be provided. The inclusion of wildflowers is desirable and has multiple benefits including beautifying roadsides for travelers. Permanent seeding should include nurse crop species if means are not provided to stabilize the ground during the time it takes for germination and cover. Depending on the project, tree and/or shrub seeds may be included. Do not introduce tree species in the roadway Clear Zone (distance varies) and be aware of potential conflicts with sight lines and maintenance operations when designing permanent seed mixes.

Seed mixes for erosion control and permanent cover are developed by a consultant designer or landscape architect, the ODOT Geo/Environmental section or the erosion control designer of record. Seed mixes and seeding rates are provided in the project Special Provisions in the Section 01030.

Seedling vigor is an important plant characteristic for erosion control seeding to rapidly establishment thick top growth and a dense fibrous root system. Even the fastest growing seeds do not provide stabilization during germination, so other means of protecting the soil is necessary during germination.

Seedling vigor is not the only criteria by which to select seeds. Vigor after germination may be indicative of aggressive plant growth through maturity which can out-compete other, desirable species. Some grasses such as rye grass develop dense top growth quickly but are slower to develop robust root systems. Some species that germinate early, like the weed, cheatgrass (*Bromus tectorum*), make resources unavailable to later germinating species.

Other characteristics that are important for erosion control are the methods by which the grass develops, grows and spreads. Grasses can be rhizomatous, where the plant sends out runners that start new growth; a bunch grass; or a sod-forming grass. Rooting depth is important and for erosion control purposes grasses are characterized as being deep, moderate or shallow rooting. Selection of seeds for a mixture of rooting depths provides optimum support for soils and best enables the removal of water by the roots at the various zones in the soil.

Seed Qualities and Characteristics

Seed is normally specified by Pure Live Seed (PLS). Pure live seed refers to the portion of a seed lot that is live seed of the desired kind. The purpose of measuring seed on a PLS basis is so that debris and dead seeds do not diminish the seeding application rate. Wildflowers seed may be field collected and not agriculturally produced and have characteristics that fit poorly into the PLS model. When this is the case, Special Provisions should identify the issue and modify the PLS requirement for that specie.

Seed mixes are specified with the quantity of each seed species determined first by number of seeds per area, usually by square foot. Knowing the number of seeds per pound allow the formulation to be converted to weight of pounds per acre. Sizes of seeds of different species vary widely so it is necessary to formulate seed mixes using the seeds-per-pound as primary to the calculation. A simple spreadsheet seed mix calculator is shown in the Appendix and linked in the [Guidance Materials](#) of the Roadside Development section of the ODOT web page.

Seed furnished for a project must meet the labeling requirements of the Standard Specifications, Section 01030.13. They must meet the requirements of state and federal seed law which, among other things, spells out exact seed labeling requirements. (See [Oregon Revised Statute 633.520](#)). For a brief summary of typical information that must be on the seed label, see Construction [subsection 7.3.3](#).

The seed label must be dated and provide the purity, germination rate and other information on the tag must be backed by a seed lab analysis report. High quality seed germinates well, has a high purity percentage, and is free of chaff, noxious weeds or unintended species. The identity, purity and uniformity of the seed being used on projects must be maintained at all times by continuing to monitor seed delivered to the project for proper labeling.

Certified Seed is a special category of seed that are agriculturally produced named varieties. This program assures seed growers and the industry that a seed variety is true to its original type so the type can be successfully kept true when grown for production by seed growers. The Oregon Certified Seed program is administered by the Oregon Department of Agriculture and Oregon State University. A list of seed varieties that are currently certified can be found in the [Oregon Seed Certification Service Handbook](#). Certified seed may be derived from select native species, or hybrids crafted for desired characteristics. Certified seeds provide a high level of assurance that the seed will be free from weeds or unintended species.

Native seed may be divided into two major distinctions, they are: agriculturally-produced seed and collected seed. The definition of "native" can vary from national to local, so be sure the desired definition is being used. Oregon has a robust marketplace in native seeds and a wide variety of species are available. Some native seeds can be scarce and expensive so seed mix designers should always verify seed cost and availability prior to specifying. When specifying native seeds; identify the functions and values that are desired from that species. It may be bloom period, community association or other characteristics that are desired. Once the desired characteristics are identified then select species that satisfy the characteristics that are strong growers that are available in the marketplace and that are reasonably priced. For erosion control seeding and for permanent seeding, even with wildflowers, it is not an agency goal to vegetate roadsides with rare or expensive plant species.

Timing of Seeding

The timing windows for seeding are provided in the Specifications in Section 01030.43. These seeding windows are arrived upon because they occur when the growing season coincides with available moisture. Often projects continue construction right up until late in the seeding window. The last day of the seeding window in Western Oregon is October 31. If seeding is late, it may get too cold for seeds to germinate and provide cover by the 45 day establishment period. 45 days from October 31 is the middle of December, so it is easy to anticipate that it will be necessary to stabilize the soil by means that do not rely upon germination. Similarly the spring seeding window west of the Cascades ends May 15th. At that time of year the weather may allow germination but not get too hot or dry to support plant growth. Regardless of when seeding is applied, soil stabilization is required

- Apply permanent seeding on areas to be left dormant for 1 year or more.
- Apply permanent seeding when no further disturbances are planned.
- Within the seeding window, seed immediately after seedbed preparation, while the soil is loose and moist.
- Seed before applying mulch according to Section 01030.48.
- When matting is specified, apply seed before matting.
- The approved dates for seeding are provided in Section 01030.43. Seeding outside the dates shown require written authorization from Agency.
- The best time to apply seed is early in the fall seeding window. The spring seeding window carries more risk as weather can turn hot and dry even prior to the close of that window. Irrigation may be required for areas establishing during the hot summer months.
- When approved with written authorization, 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 that do not rely on germination need to be applied to provide temporary stabilization.
- Apply temporary seeding to stabilize disturbed soils and slopes that are not at finished grade and which will be exposed for 2 months or longer before being disturbed again.

Site Preparation

- Site preparation methods for seeding and for planting are listed in Section 01040.48.
- Bring the seed bed to final grade, remove all rocks and debris, and smooth surface undulations larger than 2 inches.
- Divert concentrated flows away from the seeded area.

- For optimum seeding conditions salvage and stockpile topsoil until final grades are established. Then spread topsoil over new grades.
- Conduct soil test to determine pH and nutrient content and to determine types and amounts of fertilizer and soil amendments.
- Apply soil amendments as needed to satisfy the soil test result recommendations. Incorporate these amendments into the soil.
- Roughen the soil surface by harrowing, tracking, grooving and furrowing so ridges or indents are parallel to the slope contours. Avoid compacting soils. See Section 00280.43
- East of the Cascades, track walking surfaces can compact soils beyond a seed's ability to set roots.
- Remove deep compaction in areas such as haul roads or road bed under pavement-removal. Compacted soils should be ripped or tilled to a depth of 12".
- The seedbed should be firm but not compact. The top 1 to 2 inches of soil should be loose, moist and free of large clods and stones.
- If the seedbed has been idle long enough for the soil to become compact, the topsoil should be harrowed with a disk, spring tooth drag, spike tooth drag, or other equipment designed to condition the soil for seeding.
- The topsoil surface should be in reasonably close conformity to the lines, grades and cross sections shown on the construction plans.
- Consult a Geotechnical Engineer prior to placing topsoil on slopes 1:2 or steeper. Tackifier or physical means may be required to hold the material in place.
- A compost blanket of coarse or medium compost applied at a depth of 2" and applied with tackifier has been proven to adhere on slopes of 1:2, of providing a good seed bed and of providing erosion prevention that does not rely on germination.
- Herbicide use must be approved by Project PM prior to use.
- Seed bed must be weed free prior to seeding
- Pre-Emergent herbicides form as layer on the soil surface that prevent root penetration from seeds, but have no effect on existing vegetation.



Figure 3-3 Roughened Soil Surface

Seeding

- Apply seed as specified in Section 01030.
- Seed to soil contact is the key to good germination. Seeding after installation of matting or straw mulch inhibits seed to soil contact and should be avoided. Compost provides a good seed bed.

- Apply seed at the rates specified using calibrated seed spreaders, cyclone seeders, mechanical drills, compost blowers with calibrated seed injection or hydroseeder so the seed is applied uniformly on the site.
- Hydroseeding should be applied from two different directions so that surface irregularities do not prevent full coverage.
- Broadcast seed should be incorporated into the soil by raking or chain dragging, and then lightly tamped to provide good seed-soil contact.



Figure 3-4 Seeding & mulch applied with Hydroseeder

- Apply mulch and tackifier or matting, as specified, over the seeded areas.
- To prevent seed from being washed away, confirm installation of erosion prevention measures.
- When hydroseeding, a mulch or dye tracer is required as a visual application aid.
- On slopes steeper than 1:2, hydroseeding requires an increased rate of tackifier to be applied.
- For additional discussion of hydroseeding, refer to subsection 3.2.1.5 in this Chapter.

Fertilizer

Best practice is to use no more fertilizer than is necessary. Good soils should not need much if any fertilizer. Fertilizer application should be based on recommendations provided with soil test results.

- Use soil test results to determine the exact type and quantity of fertilizer needed to prevent the over-application of fertilizer.
- Apply fertilizer as specified in Section 01030.
- When seeding is applied with compost blanket use no fertilizer.
- Use low phosphorous fertilizer when work is near water bodies and wetlands.
- Use no fertilizer within 50' of water bodies (dependent on permit conditions).
- Slow-release fertilizers remain in place and continue to function after seeds have germinated and during growth.
- The use of select topsoil (01040.14(a)) or compost can reduce the need for fertilizer and improves the overall soil quality.
- Provide project-specific application rates in Specifications, Section 01030.

Soil Bio-Amendments

Soil bio-amendments are not fertilizers or mineral soil enhancements. Bio amendments are living spores and food for the soil micro-biology that is integral to vital soils and healthy plant growth.

- Soil bio-amendments are described in Section 01040.17.
- Bacterial Food Amendments help support vital soil biological activity
- Fungal Food Amendments aid the support of mycorrhizal fungus which in turn provides water and nutrients to plants
- Protozoa food amendments help support another soil biological activity
- Mycorrhizal inoculants introduce a fungus into disturbed soils that develops a symbiotic relationship with plants. Mycorrhizal inoculates are not necessary in established topsoils.
- Manufactured products are available that combine multiple bio-amendments and organic mulches. They are designed to be easily and quickly applied with hydroseeding equipment. These advertise as being equal in results to compost mulch. Although they are an improvement over a no bio-amendment treatment, comparison testing conducted by ODOT indicates that seeding on compost blankets provides superior results.
- Currently, specifications list soil amendments including soil bio-amendments as incidental to planting. When specified with seeding, provide a pay item for these products to be fair to contractors.
- Peat in bulk or used in some manufactured bio-amendment products is a resource mined from living wetlands. Depending on extraction method, it may not be a renewable resource.

Mulching

- Refer to Specification Sections 00280.44 for mulch installation requirements for erosion control.
- Refer Specification Sections 01030.15 for mulch materials associated with seeding and Specification Section 01030.48 for application requirements regarding mulch with seeding.
- Hydraulically applied matting such as bonded fiber matrix, when used for seeding, may have a specified application rate that results in a thickness of mulch up to 3/16 of an inch. These products can provide erosion protection during plant germination and establishment equal to rolled erosion control products.
- Refer to Specification Sections 01040.20 for mulch materials associated with planting and Specification Section 01040.53 for application requirements regarding mulch with planting.
- Refer to Section 3.2.1.4 of this Chapter.
- Straw mulch in loose conditions is preferred for temporary seeding during the wet season on slopes 1:2 or flatter.



Figure 3-5 Straw Mulch being blown on site

- Soil exposure limitations are described in Section 00280.42. Generally, exposed soils, not under active construction must be covered within 14 days and at least one day prior to anticipated rain events. Other limitations apply. Mulch may be required during the dry season if:
 - Vegetative cover is not expected to meet success criteria within the 45 day establishment period;
 - Work prevented seeding during the spring seeding window.
 - Temporary soil cover is required that does not rely on germination;
 - There is a water body or other sensitive area close to the disturbed area; or
 - Significant precipitation is anticipated before the grass will provide effective cover.
- Apply mulch on top of the seed or, in some situations as specified or approved, apply mulch with the seed during hydroseeding. The application rate of seed should be increased if seed and mulch are applied in a single application.

Compost Mulch

Compost mulch is highly regarded for seeding and erosion control as is discussed below in this manual's section 3.2.1.4. Application of compost blanket is specified in Section 00280.44(f). Seeding the by hydroseeding on top of an installed compost blanket as described in Specification Section 01030.48(b)(2) provides good results. Other means of seeding compost can be performed using a metered seed injector with the compost blower. When properly installed with tackifier, a compost blanket will adhere to cut slopes of 1V:2H which are often the most difficult areas on which to get vegetation established. Do not install compost blanket on slopes steeper than 1:1.

Compost

- Compost mulch shall conform to criteria shown in Section 03020.
- Construct compost blanket as shown in [Standard Detail DET6017](#)
- Coarse or medium compost are the only material textures permitted for erosion control. Blend tackifier with compost during installation. (Fine textured compost may be used as soil conditioner or as mulch with planting.)
- Install compost with tackifier at thickness of 2 inches as shown in standard detail DET6017.

- Applying compost too thick can bury seed too deep, or hold seed too far from soil.
- Applying compost too thick on slopes can result in material slipping off slope if it becomes saturated.
- Applying compost of too fine a texture on slopes can result in material not draining and slipping off slope if it becomes saturated.
- Apply compost on surfaces that have been roughened by track walking or loosened in shallow furrows similar method.
- Compost can dry out more quickly than soil.

Maintenance

- Newly seeded areas need to be inspected frequently to ensure the grass is growing and area is kept weed free.
- If the seeded area is damaged due to runoff, additional storm water management measures may be needed. Repair erosion damaged areas and re-seed and mulch damaged areas.
- Spot seeding can be done on small areas to fill bare spots where grass did not grow properly.
- If spot seeding is ineffective, use an alternate method, such as sodding or matting.
- 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.
- Contractor is responsible to provide the vegetation coverage specified in Section 01030.60.

Common Failures

The most common problems with seeding are failure of the seed to grow and for this there could be multiple reasons and they are:

- Erosion of seedbed soils before plants become established because soils were not stabilized prior to germination.
- Seeding outside of the optimum growing season. Seeding late in either the spring or fall seeding window may result in poor seed growing conditions.
- Improper selection of seed, using the wrong seeding method for the site.
- Inadequate application of seed or insufficient coverage of mulch and tackifier.
- Substitution of seed variety without prior approval by the Agency
- Erosion of seeded areas without immediate repair.

3.2.1.4 MULCH

Mulching is the application of a protective layer of suitable mulch material to the soil surface. Straw mulch, compost mulch and/or hydromulch or Bonded Fiber Matrix (BFM) are also used in conjunction with seeding of critical areas for the establishment of vegetation. Mulching soils provides immediate protection from erosion. Mulch also enhances plant establishment by conserving moisture, holding fertilizer, seed, and topsoil in place, and moderating soil temperatures. For multi-year projects temporary mulch is a valuable resource for stabilizing soils during seasonally suspended work.

Applications

- Seed cover (as discussed in previous section).
- 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 Section 00280, for specific requirements.
- On slope greater than 1V:2H, or where the mulch is susceptible to movement by wind or water, the mulch (straw, compost or other) should be fixed in place with hydraulically applied tackifier or mulch could be anchored mechanically.

Advantages

- Provides rapid protection.
- Conserves moisture.
- Allows vegetation growth through the mulch.
- Protects seeding from heat, moisture loss and transport due to runoff.
- Straw mulch is inexpensive and easy to install (even by hand).
- Straw mulch is an excellent emergency material.
- Compost mulch's dark color captures heat, aiding germination.
- Compost mulch adds nutrients and soil biology
- Compost mulch will provide erosion prevention during dry season and remain a good seed bed for permanent seeding when seeding window opens.
- Compost mulch removes material from "waste stream".

Disadvantages

- Thick mulches can delay germination.
- Can be blown or washed away if not adequately tackified.
- Temporary mulches must be removed prior to applying fill material.
- Straw mulch may provide road hazard if cattle or wildlife graze on straw mulch applied to roadsides.
- Straw mulch will contain seeds of parent crop which may be undesirable with permanent seeding.
- Straw mulch when used as temporary mulch must be removed prior to application of permanent seeding.

Design Criteria

- Divert concentrated runoff from mulched areas.
- Specific material and application criteria are included in Section 00280 and 01030.
- Refer to Appendix D for Mulch Application Rate Worksheet.

Organic Mulches

- Straw mulch provides immediate temporary protection lasting approximately three months. Straw can be spread mechanically or by hand and may require anchoring for wind protection. Correct application of straw mulch will leave no exposed soils. Common anchoring methods include crimping, disking, rolling; spraying with a tackifier; or keeping it moist. The combination straw mulch and tackifier is well suited to provide temporary stabilization on steep slopes, critical areas and severe climate conditions. Because straw mulch will contain seeds of its parent crop, straw mulch is not recommended for use with permanent seeding. If used for temporary cover it is recommended that straw mulch be removed prior to seeding
- Use no straw that is moldy, caked, decayed or of otherwise low quality. Submit verification from the supplier that the straw is free of noxious weeds. Acceptable documentation submitted shall 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 minimum requirements of Oregon Certified Seed are as published in the current year's [Oregon Certified Seed Handbook](#), and lists of farms with certified fields that sell to the public are available from County Extension Offices or Oregon State University.
- Paper fiber hydromulch products are generally little more than a carrier for hydraulically applied seed. These should not be relied upon to provide any erosion protection prior to seeded plant establishment. Paper fiber mulch is for seed application on relatively flat sites that are not located near sensitive areas. Paper fiber mulch should be free of printing ink or any component harmful to plant growth.
- Wood cellulose, straw cellulose and other natural fiber hydromulch products are commonly combined with tracer dye and tackifier and applied hydraulically. They provide limited soil protection for a short duration and are weakened when wet and provide no protection against flowing water.
- Bonded Fiber Matrix (BFM) and High Performance Growth Media are robust mulches that provide stabilization that does not rely on seed germination to provide protection. The installed product has loft, pore space and the ability to hold moisture, all features that contribute to seed germination. These mulches are manufactured so the fibers interlink and form a hydraulically applied matting. They have heavier application rates and provide a longer period of protection to exposed soils than other hydraulically applied mulches. These hydraulically applied mattings do resist sheet flow runoff but are not able to provide protection against concentrated flows. These products are usually pre-packaged to include tracer dye and tackifier. Seeding with BFM or similar robust mulch can, with Project Manager's approval be applied prior to the fall seeding window to shield the soil from weeds.
- Wood chips and bark are suitable mulches soil covers for areas that will not be mowed and areas around ornamental plantings. Chips decompose slowly and require nitrogen application to



Figure 3-6 Good cover with straw mulch

prevent nutrient deficiency in plantings. Both wood and bark chips float and will wash down slopes when subjected to flowing water.

- Corn stalks, may be used with Engineer's approval for temporary soil cover.
- Manure mulches have applications in planting and as fertilizer, but are not recommended for use in erosion control applications.
- Compost mulch or compost blanket is commonly used both as erosion protection and as a growing media for seeding. Use coarse or medium compost conforming to the criteria described in Section 03020. Compost is specified in Specification 00280. Seeding on compost is specified in Section 01030. Compost mulch described in Section 01040 regards its use during planting. It is important to use the compost texture (particle size) specified. Compost that is too fine retains water and is shown to slip off slopes when heavy and lubricated with water. The benefits of using compost for mulch are many:
 - Construct compost blanket as shown in [Standard Detail DET6017](#)
 - Compost blanket dissipate rain splash energy, protecting the soil.
 - Compost retains water, diminishing runoff volume.
 - Compost slows runoff velocity and facilitates infiltration into the soil which further diminishes the volume of runoff.
 - Compost's dark color captures heat which aids germination and helps extend growing season into the autumn.
 - Compost helps soil retain moisture.
 - Seed, tackifier and bio-amendments can be applied concurrently with application of compost using metering material mixer with compost blower.
 - Compost provides nutrients for plants and jump-starts soil biology in soils.
 - Compost is a repurposed waste product that removes material from the waste stream.
 - Compost with tackifier can adhere to slopes 1V:2H that are too steep to receive soil preparation.
 - Compost blanket can be installed at any time to cover soil to prevent erosion (conditions permitting). Seeding can be applied to previously applied compost with good success once the seeding window opens.

Maintenance of Mulches

- Maintain the thickness of the cover in all areas.
- Inspect mulched areas after installation and periodically inspect thereafter as required by NPDES permit
- Specification Subsection 00280.61 requires any areas that experience erosion be repaired to reestablish effective functioning of BMPs. If the erosion problem is drainage related, fix the drainage problem and re-mulch the eroded area.
- If sheet flow or other erosion damages mulch cover, then cause of erosion must be addressed then repair of mulch treatments is necessary.
- If mulch was applied without seed for erosion and dust control, the material must remain effective for the length of time the soil will remain without vegetation.
- Mulched and seeded areas that fail to establish vegetative cover adequate to prevent erosion shall be re-mulched as soon as such areas are identified, or other BMP used to address issue.
- Mulch does not protect against flowing water. If mulched areas are damaged by concentrated runoff, then prompt implementation of additional practices and BMP's to address the source of erosion are necessary.

Common Failures

The most common problems with mulches are:

- Inadequate coverage
- Poor installation and maintenance
- Improper selection of mulch and tackifier
- Deterioration from wind
- Removal by water without replacement.

3.2.1.5 HYDRAULIC APPLICATION

Hydraulic application is an efficient, fast and a proven method of application for certain mulches. Hydroseeding is a standard method for the application of seed and mulch. Hydroseeders can be used to uniformly apply materials such as mulch, tackifier, dust control chemicals, soil amendments, and others onto slopes. Mulches used for hydroseeding are commonly packaged to include tracer/dye and tackifier with the mulch fiber. Bonded Fiber Matrix mulch or other robust hydromulches are expensive. Considering this, contractors may benefit if they apply the mulches at less than the specified application rate. When hydromulch is installed the correct application is to spray from two different directions so that surface irregularities do not block the complete coverage of the soil.

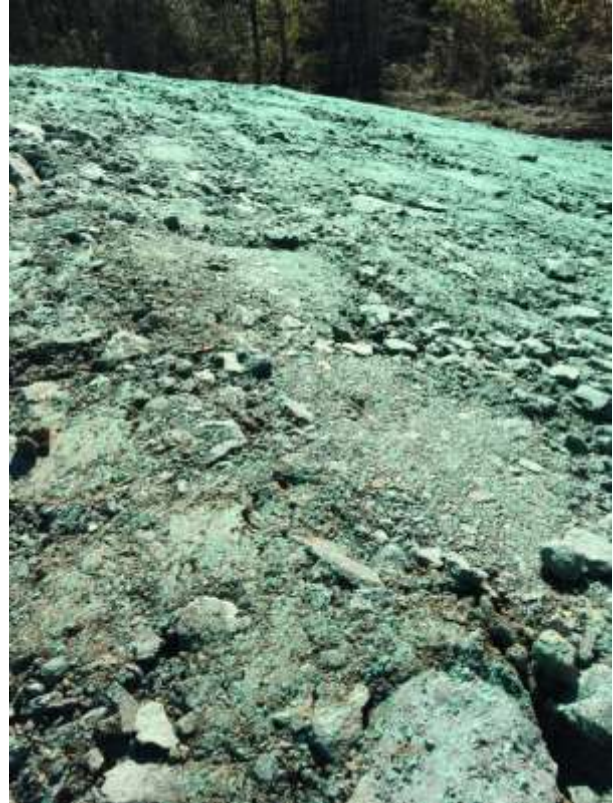


Figure 3-7 Thin hydromulch application

Applications

- For applying seed, fertilizer, mulch, tackifier, soil amendments, bonded fiber matrix, and chemical stabilization.
- On sites where hydraulically applied matting (without seed) is desired for temporary erosion prevention.
- Slopes steeper than 1:3 that cannot receive adequate seedbed preparation.
- On sites where the application of a hydraulically applied bonded fiber matrix or high performance growth media systems are 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 desired.
- For seed application over compost blanket.
- Refer to Appendix D for the [Hydroseeding Mixture Worksheet](#).

Advantages

- Provides rapid installation.
- Less expensive than broadcast or seed drilling operations.
- Requires less seedbed preparation.
- Uniformly distributes seed and mulch material when applied correctly.
- Increases favorable conditions for quick germination and growth.
- Can be used effectively on steep slopes and other areas where access is limited.

Disadvantages

- Requires mobilization and use of specialized equipment.
- Thick mulch applications can delay germination.
- Thin mulch applications do not provide adequate soil protection. If seed is included in hydromulch, that seeding application rate may not meet specifications.
- Can be blown or washed away if not adequately tackified.
- Know the distance that a hydroseeding gun can spray. Slopes may be longer than that equipment can reach (see photo above). Phased hydroseeding during construction can allow equipment access before slopes get larger than the capability of the hydroseeder.
- It may be necessary to apply in phases with applications installed prior to work areas becoming inaccessible.
- Required application rates can vary significantly dependent type of mulch used, site conditions, methods of preparation and slope.

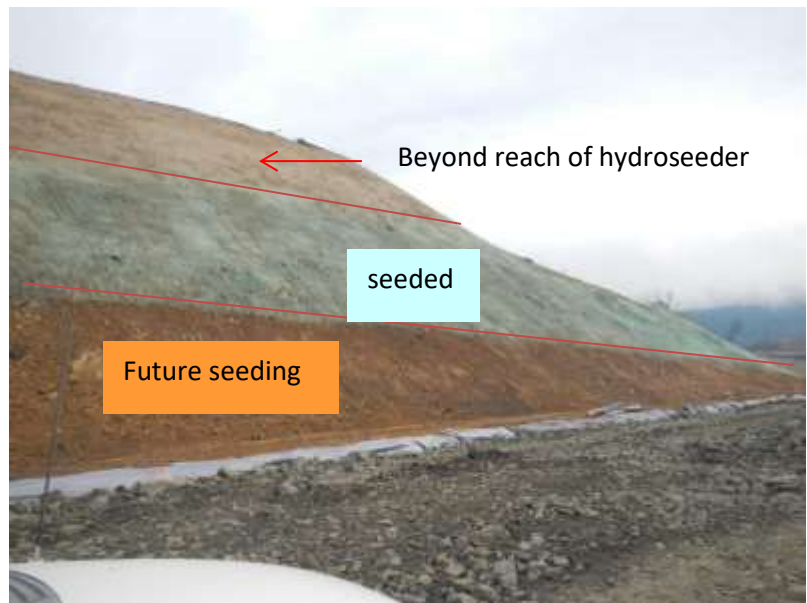


Figure 3-8 Plan for seeding/mulching long slopes

3.2.1.6 Sod

Establishes permanent vegetation for immediate erosion protection and stabilizes drainage ways. Sod is usually comprised of turf grass, however contract-grown sod, for specific purposes, can contain plants for wetlands, bio-swales, wildflower meadows or other types of immediate vegetative cover. Turfgrass installed as sod is a premium product that is used in high visibility areas or where immediate grass coverage is necessary.

Applications

- Disturbed areas requiring short-term or long-term cover.
- Areas that require immediate permanent turf grass cover.
- Disturbed areas requiring immediate vegetative cover.
- Waterways carrying intermittent flow (except biofiltration swales) and requiring immediate stabilization or aesthetic mitigation.
- When used around field or ditch inlets, sod will slow runoff and settle out sediment. For Sod Protection see [Standard Drawing RD1010](#) located on the ODOT web page on the Engineering Standards page in the [Roadway Section](#).



Figure 3-9 Installation of wetland sod

Advantages

- Provides immediate, effective protection, and is aesthetically pleasing.
- Provides high-density vegetation, which is superior to a recently seeded area.
- Density of sod vegetation prevents weed seeds from contacting soil, discouraging weed infestations. Areas with permits that require coverage with native plants, may find contract grown native plant sod to be the best option.
- Placement can occur any time that soil moisture is adequate and the ground is not frozen.

Disadvantages

- Expensive.
- Maintenance intensive.
- Availability is seasonal.
- Rarely integral to permanent landscape treatment and may require removal.
- 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.
- Requires good site preparation.

- Time necessary for root establishment may be lengthy.

Design Criteria

- Use sod that is weed free, has uniform thickness (approximately 1 in. thick) and dense root mat for mechanical strength.
- Turf sod is inappropriate for bioswales. Sod can be used for lining ditches to prevent erosion, but will provide limited water quality benefit during the wet season.
- The following steps are general recommendations for sod installation. Refer to Specification Section 01040 for specific installation criteria.
 - Shape and smooth the surface to final grade in accordance with the approved grading plan.
 - Fertilize, amend and condition soil per soil test recommendations. Use only non-phosphorous fertilizer near water bodies and wetlands.
 - Lay sod strips perpendicular to the direction of water flow, beginning at the lowest area to be sodded. Wedge strips securely into place and square the ends of each strip to provide for a close, tight fit. Stagger joints at least 1 ft. Staple sod onto 1:3 and steeper slopes.
 - Roll the sodded area with a water filled roller and irrigate.
 - When sodding is carried out in alternating strips or other patterns, seed the areas between the sod immediately after sodding.

Maintenance

- Inspect sodded area frequently for soil moisture content and root establishment. Drying sod will have a dull appearance and not spring back when stepped upon.
- 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.

Common Failures

The most common problems with this BMP are:

- Poor site preparation
- Insufficient watering
- Poor soil contact
- Improper selection of sod type
- Poor soil fertility.

3.2.1.7 *MATTING*

Figure 3-10 fully biodegradable slope protection matting

Numerous rolled erosion control products (RECPs) are available that use the names matting, blankets, fabric and nets. In ODOT they are all called matting. A wide range of materials and combination of materials are used to produce matting including, but not limited to: straw, jute, wood fiber, coir (coconut fiber), plastic netting, geosynthetic matrixes. Bonded Fiber Matrix and high performance growth media are hydraulically applied products that satisfy the requirements of matting. ODOT has recently revised our specification requirements to make products the first 5 (lightest duty) categories fully biodegradable.

This revision eliminates matting types that are constructed in layers with random natural fibers stitched between two layers of plastic netting. The monofilament plastic netting was ensnaring small animals and not breaking down in the landscape.

Equivalent products that are fully biodegradable are readily available at similar cost. Some use natural fiber netting to sandwich the fiber scrim. Others make a single layer matting of woven construction using biodegradable fibers. There are an abundance of biodegradable products to satisfy almost every level of protection.

Matting provides robust slope protection. Slope matting is engineered to allow vegetation to grow through it. Matting provides slope protection during the time needed to establish vegetation. Matting includes also a family of products called Turf Reinforcement Mats. These are high strength geosynthetic (plastic) products that provide permanent reinforcement of soil



Figure 3-11 Plastic netting at 5 years

against flowing water and allow plants to grow through the material. This results in armored slopes/channels that blend with the appearance of the surrounding landscape.

The type of matting used for a site can make a significant difference in the effectiveness of the BMP. ODOT accepts matting materials that have been tested and approved by the Texas DOT/TTI Hydraulics and Erosion Control Laboratory meeting performance criteria for the following categories as listed in Section 00280.14(e):

- Type A – Fully biodegradable slope protection mat for slopes 1:3 or flatter – clay soils.
- Type B – Fully biodegradable slope protection mat for slopes 1:3 or flatter – sandy soils.
- Type C – Fully biodegradable slope protection mat for slopes steeper than 1:3 – clay soils.
- Type D – Fully biodegradable slope protection mat for slopes steeper than 1:3 – clay soils.
- Type E – Fully biodegradable flexible channel liner for shear stress from 0-2 pounds per square foot.
- Type F – Flexible channel liner for shear stress from 0-4 pounds per square foot.
- Type G – Flexible channel liner for shear stress from 0-6 pounds per square foot.
- Type H – Flexible channel liner for shear stress from 0-8 pounds per square foot.
- The current [Qualified Products List](#) includes approved matting materials and other erosion control materials that have been vetted as appropriate.
- Install matting according to Standard Drawing [RD 1055](#).

Applications

- On disturbed areas that require cover for more than 30 days.
- For robust and long term (up to 2 years) stabilization of slopes 1V:2H or steeper and with long slope lengths to provide vegetation to become fully established.
- 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 used in drainage ditches and swales can protect bare soil while vegetation is being established.
- On steep slopes and in channels to prevent erosion and hold seed and mulch in place.

Advantages

- Immediate cushioning against splash erosion from raindrop impact.
- Slows runoff velocity.
- Retains moisture – reducing runoff
- Provides temporary slope protection during seeding establishment.
- Captures sediment in its open, porous structure.
- Vegetation can grow through products
- Usually easy to install.
- Products can be cost effective

Disadvantages

- Soil surface must be graded smooth to provide complete contact between soil and matting.
- Correct installation is critical to the effectiveness of these products. Good ground contact prevents runoff from rilling under the matting. Check slots, designed to check rills, are difficult to construct.
- Products can be expensive.
- When used as flexible channel liner the right material must be selected. Flowing water can strip fibers from between netting on lighter duty netting.

Design Criteria

- Apply seed and fertilizer prior to matting
- Apply matting according to Section 00280.44(e) and [Standard Drawing RD1055](#). This requires removal of all debris and undulations larger than 2 in. in any dimension and smoothing of soil surface.
- When selecting matting consider the following questions:
 - How long will the matting be required to provide protection?
 - How steep is the slope?
 - What is the soil type?
 - What is the anticipated shear stress of concentrated flows of water?
- Add check slots on long slopes to prevent rilling under matting. A double band of staples, staggered, 4 inches apart across the slope will also prevent rilling underneath the matting.
- Natural fiber matting materials (excelsior, jute, burlap, cotton and coir) are biodegradable and provide stabilization for up to two years. Jute and straw when used in sandwich type matting have relatively short functional lives. Excelsior lasts longer and coir products can remain functionally effective for two years or more. Natural fiber matting provides all the functions of synthetic blend matting but also retains moisture and provides organic matter to the soil.
 - Jute netting can be used in conjunction with mulch in order to prevent erosion that could result from the net's open structure.
 - Excelsior (aspen wood fiber), straw, and coir (coconut fiber) blankets may be installed without mulch because they provide complete surface protection.
 - Strong protection is provided by woven coir matting which is available in multiple levels of strength and protection.
 - Synthetic mats are made from non-biodegradable material. Use purely synthetic blankets for long-term stabilization of waterways where permanent reinforcement of the channel vegetation is required.
 - Turf Reinforcement Mats (TRM) are made from geosynthetics formed into a 3-dimensional mat. TRM's protect seeds to facilitate germination and also intertwine with the plant's root structure; giving the turf higher strength.
 - Hybrid products exist of TRM that is pinned to the soil surface using steel cables and dart type earth anchors. This system prevents shallow planar slides.
 - Erosion Control and Revegetation Mats (ECRM) are commonly used in slope protection. They are composed of random scrim of natural fibers stitched between netting, also made from natural fibers. ECRM acts as mulch, protecting the soil and holding seeds in place. ODOT's specification Section 00280.14(e) require ECRMs to be fully biodegradable.

- Channel Liner Matting or swale applications ([Standard Drawing RD1055](#)):
- Seed prior to installation of matting (install live plants through installed matting where specified)
- Lengthwise overlap: Min. 12" shingle type overlap starting at bottom of channel. Crosswise overlap: Min. 6 in.
- Staple all matting edges at 12" O.C. Staple matting field in triangle pattern at 24" O.C.
- Anchor upstream end of mat in anchor trench.
- Do not join material in center of ditch or swale.
- Slope application ([Standard Drawing RD1055](#)):
 - Seed prior to installation of matting.
 - Lengthwise overlap: Min. 2 ft.
 - Crosswise overlap: Min. 6 in.
 - At top of slope, entrench material in an anchor trench per the Standard Drawing RD1055.
 - At bottom of slope, extend mat 2 ft. beyond the toe of the slope, turn material under 4 in.
 - Staple all matting edges at 12" O.C. Staple matting field in triangle pattern at 24" O.C.
 - On slopes flatter than 1:3, roles can be placed in horizontal strips.
 - Install matting so it has intimate contact with the soil surface.

Maintenance

- Inspect periodically, especially following severe storms.
- Repair any damaged areas of the net or blanket and staple into the ground any areas not in close contact with the ground surface.
- If erosion occurs, repair and protect the eroded area.

Common Failures

The most common problems are:

- Poor site preparation
- Leaving irregularities that prop matting above the soil surface (tenting)
- Poor installation, not following the manufacturer specifications
- Insufficient maintenance
- Improper blanket selection
- Improper placement of soil staples
- Concentrated flows under matting (rills)
- Subsurface flows (seeps) causing erosion under matting.
- Bonded fiber matrix (hydraulically applied matting) may fail if installed during wet weather.

3.2.1.8 COMPOST BLANKETS

Compost Blanket is a layer of medium compost installed to a thickness of 2 inches on exposed soil. This soil cover is installed as an erosion prevention material, but it is also a good seeding bed and it introduces soil biology into the poor soils that are common on roadsides. It is important to use the texture of compost specified in Section 00280.14(f) as compost that is too fine in texture will not be free draining and can

slough off slopes when saturated. It is important also to install compost blankets with a tackifier. Properly installed a compost blanket will adhere to slopes as steep as 1V:1H and provide erosion prevention and good seed bed while protecting the slope.

Applications:

- On disturbed areas that require cover for more than 30 days.
- For robust stabilization of slopes 1V:2H and with long slope lengths to provide vegetation to become fully established.
- On long slopes, can be installed in conjunction with fiber rolls.
- On sterile mineral soil slopes to jump-start soil biology.
- For a fertile seed bed for permanent seeding.
- Instead of matting where no flowing water is anticipated.
- On steep slopes or flat areas to prevent erosion.

Advantages

- Immediate cushioning against splash erosion from raindrop impact.
- Slows runoff velocity.
- Retains moisture, reducing runoff volume
- Provides temporary slope protection during seeding establishment.
- Compost provides soil stabilization during seed germination and establishment.
- Captures sediment in its open, porous structure.
- Provides soil nutrients. Fertilizer not necessary when using compost blanket
- Vegetation germinates readily and sends roots easily into compost
- Dark color captures heat which aids in germination during cooler months
- Easy to install using pneumatic blower or high speed conveyor.
- Sequesters carbon
- Product is repurposed waste material, removing volume from the waste stream.

Disadvantages

- Correct texture of compost may not be in stock in materials yards (Suppliers will screen correct texture lots when asked).
- Can slough off slopes if fine texture is used, or if compost is not installed with tackifier.
- Requires specialized equipment to install.
- Does not offer protection against flowing water.
- Aroma during installation not considered pleasant.

Design Criteria

- Apply compost blanket after loosening surface soils. Compacted soils must be loosened to allow seed root penetration prior to installation of compost blanket and roughened surface diminishes slip plane between materials.
- Apply seed concurrently with compost installation or after using hydroseeder.

- Apply compost blanket according to Section 00280.44(f) and [Standard Detail 6017](#). When used with seeding reference the 01030 Section. Install Compost Blankets on roughened soil surfaces as described in 00280.43.
- When selecting compost blankets consider the following questions:
 - How steep is the slope?
 - How long is the slope?
 - What is the soil type?
 - Will composted area be receiving stormwater runoff as well as rainfall?

Maintenance

- Inspect periodically, especially following severe storms.
- Install new compost and seed in areas damaged by flowing water or other damage.
- If erosion occurs, repair and protect the eroded area.

Common Failures

The most common problems are:

- Wrong compost texture used.
- Tackifier not used. Compost slides off slope.
- Stormwater runoff not sufficiently controlled upslope of compost blanket
- Compacted soils underneath compost did not allow root penetration.
- Smooth soil underneath compost forms slip plane that allows compost to slide off slope.



Figure 3-12 Compost blankets provides erosion prevention

3.2.1.9 PLASTIC SHEETING

Plastic sheeting provides immediate, short-term protection to slopes and disturbed areas that cannot be mulched. Plastic sheeting has been known to transfer erosion problems because water will sheet flow off the plastic at high velocity, requiring BMPs at the bottom of plastic covered slopes. Plastic sheeting is an excellent material to have on site as an emergency material. For general erosion prevention, use alternatives to plastic sheeting whenever possible.

- Refer to [Standard Detail: DET 6001](#) Plastic Sheetting, located on the ODOT web page on the Engineering Standards page in the [Roadway Section](#).

Applications

- On disturbed areas that require cover for less than 30 days.
- On cut and fill slopes and stockpiles.

- To construct a flume to convey concentrated flow down slope. Requires energy dissipater at toe of slope.
- Use when vegetation cannot be established to protect soil during rainy season on small areas. For larger areas consider matting (Section 3.1.1.7 of this Chapter).
- Can be used alone or in conjunction with sediment fences, and/or diversion dikes.
- As emergency material to stabilize pop-out failures, rilling or other erosion issues.
- Plastic sheeting can be used in conjunction with flocculent sediment treatment in channels.
- Plastic sheeting can be used to isolate trench drains or blanket drains from surface water flows that carry potentially sediment laden water.
- When using straw bales as the structure, plastic sheeting can line structure to be water tight concrete washout basin



Figure 3-13 Plastic sheeting runoff control on slope matting

Advantages

- Provides immediate, short-term erosion protection to slopes and disturbed areas.
- Fairly quick and easy to install.
- Plastic sheeting is inexpensive.

Disadvantages

- Plastic sheeting may concentrate sunrays and burn the vegetation beneath it.
- Material generates high velocity runoff.
- Plastic breaks down quickly and becomes more fragile 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 shred plastic and litter the landscape, perhaps onto roadways, creating traffic hazard.
- Plastic never fully degrades but degenerate into smaller pieces. Small particles can enter the food chain where they are harmful. In the best case plastic enters the waste stream and is disposed of according to Section 00290.20.

Design Criteria

- Install plastic sheeting as shown in [Standard Detail DET6001](#)

- Do not use plastic covering upslope of areas such as steep and/or unstable slopes that might be adversely affected by concentrated runoff.
- When used, construct perimeter control or energy dissipation at the bottom of slopes that are covered with plastic sheeting.
- When possible, install an inceptor dike at the top of the plastic to divert flows away from the plastic.
- Anchor top of the sheeting in a 6 in. x 6 in. trench backfilled with compacted native material.
- Weight the plastic sheeting in place using sandbags or other suitable tethered anchoring system spaced not less than on a 10 ft. grid spacing.
- Overlap seams 1 ft. to 2 ft.; tape, roll and staple the seams and then weigh down the entire length.

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.
- Verify effective functioning of BMP at toe of slope

Common Failures

The most common problems with plastic sheeting are:

- Improper plastic sheeting selection
- Failure to anchor plastic sheeting into place
- Failure to place of suitable protection at the slope toe.
- Wind or UV radiation damage plastic sheeting.

3.2.1.10 SHORTEN SLOPE LENGTH

Flowing water on slopes grows more erosive over distance. The runoff combines with water on already saturated ground and with the additional moisture of falling rain gains volume. As the water flows downslope it picks up more abrasive sediment and its velocity increases, making it more erosive. To address these forces sediment barriers are installed on the face of slopes parallel to contours at prescribed intervals. The sediment barriers intercept flowing water, checking its velocity and stop rills from forming. Among the sediment barriers that are used to shorten slope length are: fiber rolls, sediment fences, compost socks and compost berms. They are listed in the Section of this Manual dealing with sediment control – 3.4.4. Sediment barriers that impound water on slopes can over-saturate soils and contribute to the development of shallow planar slides.

3.2.1.11 DUST CONTROL

Preventative measures to minimize the wind transport of soil. Dust clouds are a nuisance, they can affect the health of persons with breathing problems and dust commonly results in complaints from the public. Some of the worst dust issues result from on-site haul routes or worse, dirt tracked onto pavement and churned into dust by construction traffic. ODOT strives to be a good neighbor so prevention of fugitive dust is important.

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

- Reduces movement of soil to offsite areas.
- Increases visibility.

Disadvantages

- Over watering may cause erosion.
- Most methods require immediate reapplication if disturbed.

Design Criteria

- Minimizing the area of exposed soil reduces the potential source of dust.
- Dust control is covered in Sections 00280, 00340 and 01030 of the ODOT Specifications; the designer can provide project-specific dust control Special Provisions for the contractor to apply. Measures include:
 - Seeding – Dust season (usually summer) rarely coincides with the seeding window. Seeding with mulch and tackifier will provide some dust control during the time it takes for vegetation to become established but watering (and PM's approval) is necessary to establish seeded vegetation during dry and dusty weather.
 - Mulching – Straw tacked or crimped in place will provide dust control. Straw must be removed prior to seeding. Compost blankets tacked in place provide dust control and can be seeded directly when seeding window arrives.
 - Matting – Matting can be expensive, but is excellent dust abatement.
 - Rocking Access Roads – Dirt roads will generate less dust if surfaced with aggregate.
 - Water – Common dust abatement measure. Needs repeated applications. Water delivery systems are difficult on slopes. Watering access roads is a successful BMP.
 - Tackifier – Chemical tackifier; polyacrylamide, can be applied with hydroseeding equipment or on roads, water truck.
 - Chemical Soil Stabilizers or Liquid Stabilized Emulsions – see [ODOT Qualified Product List](#). In some areas, these must be approved prior to use. Some of these products form crust on soil that must be broken prior to seeding.
 - Installation construction entrances and stabilizing construction haul roads with crushed rock.
 - Removal of dust generating material from pavement using vacuum sweeper.
 - Schedule construction operations so that the least amount of project area is disturbed at one time.

Install temporary or permanent dust abatement measures immediately after completing land grading. Soil exposure limitations are described in Specifications Section 00280.42. Stabilize soils disturbed by construction within 7 days if within 100' of water and within 14 days otherwise. East of the Cascades, during summer, Project Manager can waive soil exposure requirements if conditions warrant.

Maintenance

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

Common Failures

The most common problem occurs when using water to control dust:

- Over watering which may cause erosion
- Failure to re-apply dust control measures after initial application is disturbed
- Failure to vacuum sweep dirty pavement

3.3 RUNOFF CONTROL PRACTICES

The erosive potential of flowing water and its ability to carry sediment is increased on the exposed soils of construction sites. High volume and velocity flows easily move sediment and other pollutants into streams, wetlands, and lakes. Stormwater flowing through a project could originate off site or on site. Controlling stormwater runoff that flows through a site, regardless of its origin can be accomplished through basic strategies. These are controlling the location of stormwater runoff and decreasing runoff velocities.

Controlling the location of stormwater will occur during earthwork, whether it is planned or not. Grading will determine the catchment area of on-site watersheds, the direction of stormwater flow and the volume and velocity of runoff. Earthwork conducted with purposeful shaping of the land, considering runoff control, can simplify erosion control and diminish risk.

Runoff control BMP's that control the location of runoff include pipe slope drains and diversion swales. During construction, planning the shaping of the land to control of runoff can make the implementation of runoff control BMPs more successful. Runoff control BMP's that reduce runoff velocities include check dams and sediment traps.

Best Management Practices

1. Temporary Slope Drain
2. Lined Channel
3. Outlet Protection
4. Surface Roughening
5. Check Dam
6. Interceptor Dike and Interceptor Swale
7. Stormwater Control

3.3.1 TEMPORARY SLOPE DRAIN



Figure 3-14 Temporary Slope Drains

To control the location of stormwater runoff, temporary Slope Drains are pipes extending from the top to the bottom of a slope and discharging into an energy dissipater or scour hole that is strengthened to withstand erosion. The pipe slope drain carries concentrated runoff down steep slopes without causing erosion, or saturation of slide-prone soils. Another method to convey runoff down a steep slope is to construct a flume with plastic sheeting.

- Refer to details: [RD1045](#) Temporary Slope Drain, located on the ODOT web page on the Engineering Standards page in the [Roadway Section](#).



Figure 3-15 Plastic sheeting used as Temporary Slope Drains

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

- Effective method of conveying water down steep slopes.
- Reduces or eliminates erosion.
- Easy installation and little maintenance.

DISADVANTAGES

- Drain can be under-designed or incorrectly located.
- Area cleared for drain installation requires stabilization to prevent erosion occurring under the pipe.
- Outfall systems constructed of pipe segments, which are banded and/or gasketed together, could develop leaks causing erosion and failure of the system. Failures on erodible or steep slopes can cause downstream sedimentation or even mudflows.
- Adjustment of pipe lengths is necessary as cut and fill slopes are extended.

DESIGN CRITERIA

- Size and space pipe slope drains to convey the peak flow from a 2-year design storm using the rational method found in [ODOT Hydraulics Manual](#). Estimate pipe diameter from the following table.

Table 3-2 Slope drain sizes

Contributing (Maximum)	Drainage Area	Pipe Diameter
	½ acre	12 in.
	1 ½ acre	18 in.
	3 ½ acre	24 in.

- Consider using continuously fused, welded or flange-bolted mechanical joint systems with proper anchoring or HDPP (high-density polyethylene pipe) for outfalls on steep slopes.
- Stabilize the area sloping toward the pipe inlet.
- At the inlet, show interceptor dikes that are at least 1 ft. higher at all points than the top of the inlet pipe and placed to direct water into the pipe.
- If the pipe slope drain will convey sediment-laden runoff, direct the runoff to a sediment basin/trap facility.
- In the runoff is not from a disturbed area or is conveyed from a sediment trap or pond, convey the runoff to a stabilized discharge point.

- Energy Dissipation – Outlet Protection consisting of Scour holes or riprap-lined stilling basins prevent most scour problems at outfalls (refer to Section 3.3.2 of this chapter).
- Consider site conditions to determine if a more complex energy dissipater may be required. Consult the [ODOT Hydraulics Manual](#).
- The special provisions and typical notes should include the following installation directions:
 - Minimize disturbance during installation. In some circumstances this requires HDPP installed by hand.
 - Slope anchor details.
 - Immediately stabilize any area disturbed during installation or maintenance.
 - Securely connect the standard flared end section at the entrance to the slope drain, using watertight connecting bands.
- Pipe should be staked securely to prevent movement.
 - Securely fasten together the slope drain sections with gasketed watertight fittings, and securely anchor the sections into the soil.
 - Stabilize the area below the outlet following the energy dissipater.

MAINTENANCE

- Adjust lengths of pipe when cut and fill slopes are extended.
- Regularly check 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 check 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.

COMMON FAILURES

Common problems occur when:

- Connections are not watertight
- Stabilization along the slope at the inlet or outlet was incorrectly installed
- When pipes that are undersized
- When pipes are incorrectly located for flow actually occurring onsite.

3.3.2 OUTLET PROTECTION

Culvert, drain pipe, and other stormwater conveyance discharge locations require energy dissipaters to diminish the erosive force of the water exiting the pipes. A scour basin constructed from riprap (or other durable materials) at the discharge point of the pipe will reduce the speed of concentrated flow and prevent scour erosion at the conveyance outlets. By dissipating energy, the temporary scour basin lowers the potential for downstream erosion.

- Refer to Standard Drawing [RD1050](#) Temporary Scour Basin / Energy Dissipater, located on the ODOT web page on the Engineering Standards page in the [Roadway Section](#).

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.

ADVANTAGES

- Many techniques are effective, relatively inexpensive, and easy to install.
- Reduces velocity and erosive energy.

DISADVANTAGES

- May be difficult to remove sediment without removing and replacing the structure itself.
- Rock outlets with high velocity flows may require frequent maintenance.

DESIGN CRITERIA

- Use the standard drawing [RD1050](#) for outlet protection as a minimum. Consider site conditions to determine if a larger or more complex energy dissipater may be required.
- Water from outlet protection should discharge into a stabilized channel or over a level spreader to eliminate the concentrated flow.
- Refer to the [ODOT Hydraulics Manual](#) for specific criteria.

MAINTENANCE

- If there is scour at the outlet, repair and revise by increasing the size of the energy dissipater facility.
- Remove accumulated sediment frequently.

COMMON FAILURES

The most common problem with outlet protection is:

- Underdesign
- Failure to remove accumulated sediment
- Rock that is too small and/or is not angular enough for the runoff velocities (river run or rounded rock is not adequate).



Figure 3-16 Energy Dissipater (permanent installation)

3.3.3 SURFACE ROUGHENING

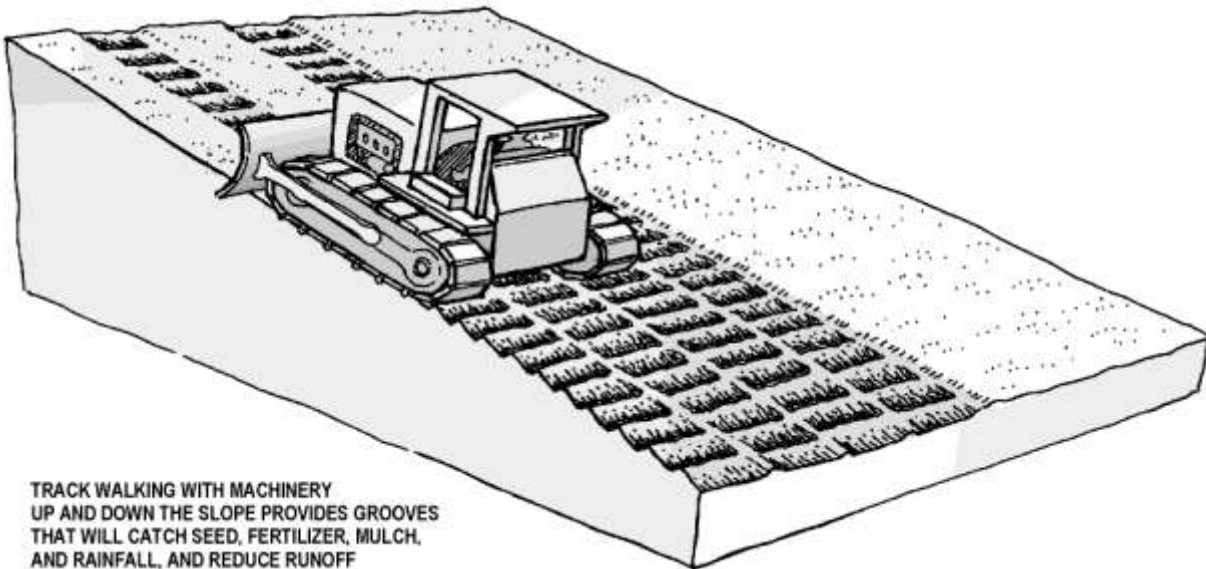


Figure 3-17 Surface Roughening

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. Depressions or grooves must be parallel to contours. The most convenient method of surface roughening is 'track walking' slopes with tracked equipment. This does however compact the soil to a degree and may inhibit root penetration by vegetation. Other roughening methods use a serrated wing blade attached to the side of a bulldozer, or by other agricultural equipment capable of loosening the soil to a depth between 3 and 6 inches. This activity is a site preparation prior to seeding and is not to be considered a finished or temporary treatment. Surface roughening provides no protection against flowing water.

Surface roughening is not to be confused with soil compaction. Use tracked equipment when surface roughening that is small and light enough that it will not appreciably compact the soil. East of the Cascades, minor compaction from track walking can negatively impact seed germination and growth. Compaction of the soil will limit seed germination and growth. Do not roughen surface of areas that are to be stabilized with matting. Matting must be applied to smooth surfaces.

APPLICATIONS

- All embankment slopes to be seeded.
- On cut slopes 1V:1.5H or flatter (01040.48(d))
- Prior to installation of compost blanket
- All slopes steeper than 1:3 having a vertical rise of 5 ft. or greater.

ADVANTAGES

- Grooves trap seed.
- Increased vegetation establishment.
- Reduces runoff velocity, increases infiltration.
- Traps soil eroded from the slopes above.

DISADVANTAGES

- Vegetated slopes cannot always be easily maintained by mowing.
- Tracking with a bulldozer or tracked equipment may compact the soil.
- Do not rely upon as means of erosion control.

DESIGN CRITERIA

- Slope roughening is required as site preparation in Standard Specifications sections 00280.43 and 01040.48 for areas to be seeded for both temporary and permanent seeding
- Immediately seed and mulch roughened areas to obtain optimum seed germination and growth.
- Texture surface using track grousers not less than 1 3/8 in. or greater.
- Track walking should be accomplished by driving equipment up and down slope to create depression parallel to contours.

CUT SLOPE ROUGHENING

- Stair-step grade or groove the cut slopes that are steeper than 1:3
- Use stair-step grading on erodible material soft enough to be ripped with a bulldozer. Slopes consisting of soft, uniform texture, rock 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 ft. high in soft materials or more than 3 ft. in rocky materials.
- On cut slopes 1V:1.5H or flatter, roughen the surface with furrows parallel with slope contours and loosen the soil to a depth between 3 inches and 6 inches (01040.48(d)).

- Install compost blanket with tackifier.
- Hydroseed using bonded fiber matrix as mulch.

FILL SLOPE ROUGHENING

- Place fill slopes with a gradient steeper than 1:3 in lifts not to exceed 8 in., and make sure each lift is properly compacted.
- Ensure that the face of the slope consists of loose, uncompacted fill 4 to 6 in. deep. Use horizontal grooving along the contour or tracking to roughen the face of the slopes, if necessary.
- Install compost blanket with tackifier to slope using pneumatic blower or high speed bulk material conveyor.
- Hydroseed using bonded fiber matrix as mulch.

CUTS, FILLS, AND GRADED AREAS

- Use Special Provision subsection 00330.42(c)(3) requiring that the outer 12 inches of embankments are constructed with material suitable for the establishment of seeded vegetation.
- Make slopes intended to be mowed no steeper than 1V:3H.
- Roughen these areas to shallow grooves by normal tilling, disking, harrowing, or use a cultipacker-seeder. Make the final pass of any such tillage on the contour.
- Make grooves formed by such implements close together, 12 in. maximum spacing, and not less than 1 in. deep.
- Excessive roughness is undesirable where mowing is planned.
- Compost blanket with seeding provides a smooth surface that can be mown once grass and vegetation have established.

MAINTENANCE

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

COMMON FAILURES

The most common problem with surface roughening:

- Excessive soil compaction
- Inadequate vegetation establishment
- High velocity runoff causing rill or gully erosion
- Tracking in wrong direction.

3.3.4 CHECK DAM



Effective functioning check dams with sediment impounded behind each dam.

Figure 3-18 Check Dam

Small dams constructed across a swale or ditch to check the velocities of concentrated flows. Check dams prevent erosion in the channel where they are installed by preventing erosive flow velocities. Check dams reduce sediment leaving the site by allowing sediment to fall out of suspension in the slower water. Note that check dams using straw bales are not approved for use.

- Check Dams can be constructed from a variety of materials.
 - Type 1 – Aggregate: Aggregate material.
 - Type 2 – Straw Wattle or Fiber Roll staked ground (with or without a sediment catchment sump).
 - Type 3 – Bio-filter Bags: Bio-filter bags staked to the ground.
 - 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. Also, Pre-fabricated systems may be designed to filter stormwater, retaining sediment and allowing treated water to pass. Field-fabricated systems are not allowed.
 - Type 6 – Compost Filter Sock staked to ground (with or without a sediment catchment sump).
- Refer to Standard Details [RD1005](#) and [RD1006](#) - located on the ODOT web page on the Engineering Standards page in the [Roadway Section](#).

APPLICATIONS

- In temporary or permanent channels not yet vegetated.
- In small open channels that drain 10 acres or less.
- Install temporary check dams in Water Quality Treatment Swales and maintain until vegetation fully stabilizes facility.

- Do not place check dams in streams or rivers.
- Types 2, 3, 4 and 5 are suitable for use as emergency materials

ADVANTAGES

- Prevent gully erosion and promote settling of sediment in runoff.
- When thoughtfully located and correctly constructed, check dams may function as permanent installations.
- Inexpensive and easy to install.
- May aerate water as it passes the check dams.
- 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.

DISADVANTAGES

- 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 if incorrectly installed.
- Effective functioning check dams require maintenance to remove captured sediment.
- Pondered water or accumulated sediment may kill grass in grass-lined channels.
- May be an obstruction to construction equipment.

DESIGN CRITERIA

- Check dams are spaced so that the bottom of an upslope check dam is at the same elevation as the top of the next downslope check dam. This results in slow water pools behind each check dam where sediment can fall out of suspension. Space check dams according to the following table.

Table 3-3 Spacing for check dams

Ditch Grade	H=8"	H=12"	H=18"	H=24"
Maximum Check Dam Spacing "L"				
10%	**	**	15'	20'
9%	**	**	16'	22'
8%	**	**	18'	25'
7%	**	**	21'	28'
6%	**	16'	25'	33'

Ditch Grade	H=8"	H=12"	H=18"	H=24"
Maximum Check Dam Spacing "L"				
5%	**	20'	30'	40'
4%	16'	25'	37'	50'
3%	22'	33'	50'	66'
2%	33'	50'	75'	100'

** Not Allowed

- Construct rock check dams of angular, durable aggregate sized to stay in place given the expected design flow velocity, typically 1 in. to 4 in. diameter as described in Section 00280.15(a). Place rock or aggregate by hand or by mechanical means rather than dumping the rock.
- Completely cross the ditch or swale width and ensure the center of the dam is 6 inches lower than the wings of the dam to prevent side-cutting erosion and keep flows centered in the channel.
- Remove check dams from grass-lined ditches and swales once the grass is established.
- Seed and mulch the area where the check dams were located immediately following removal.

MAINTENANCE

- Periodically inspect check dams for performance and sediment accumulation.
- Remove sediment once it reaches one-third the depth of the check dam. Place removed sediment where it will not reenter the channel

COMMON FAILURES

Common problems with check dam performance are:

- Incorrect spacing and installation
- Inadequate rock size or angularity
- Low point of check dam not centered
- Inadequate maintenance - sediment removal
- Sidecutting around the wings of the check dam
- Compost sock material made of biodegradable fabric may be insufficiently strong to be moved/removed intact.
- Large contributing watershed may discharge enough water to overwhelm check dam system.
- Not maintaining check dam integrity.

3.3.5 DIVERSION DIKE/DIVERSION SWALE

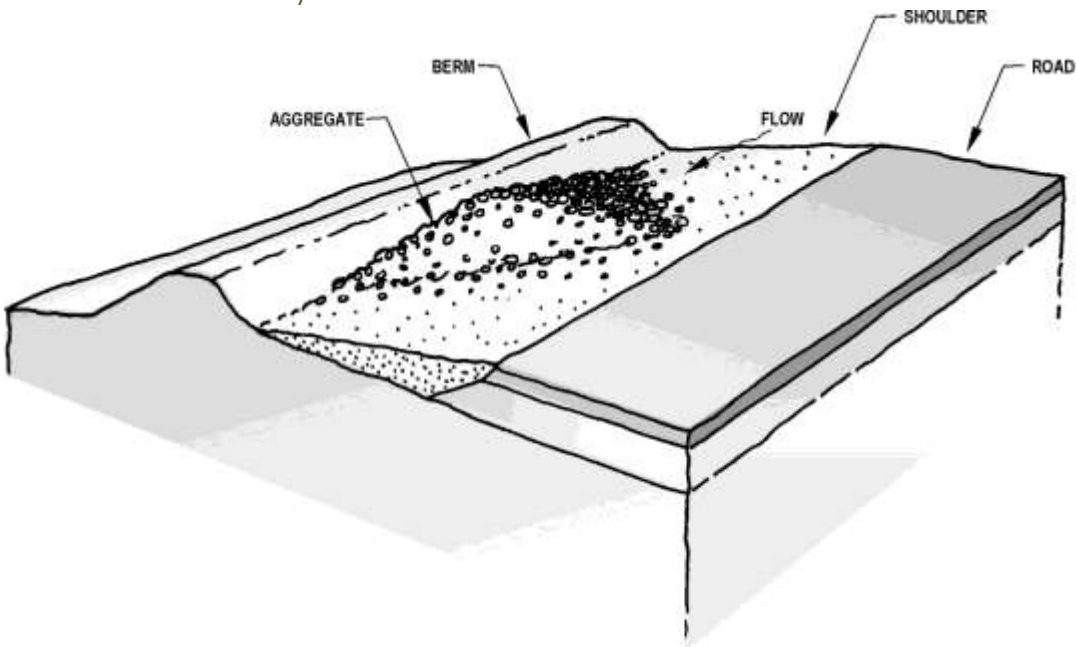


Figure 3-19 Interceptor Dike/Interceptor Swale

A ridge of compacted soil or a stabilized swale 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.

Refer to details:

- [DET 6007 Temporary Interceptor Dike Type 1,](#)
- [DET 6008 Temporary Interceptor Dike Type 2,](#)
- [DET 6009 Temporary Interceptor Dike Type 3,](#)
- [DET 6010 Temporary Interceptor Swale Type 1,](#)
- [DET 6011 Temporary Interceptor Dike/Swale Type 3,](#)

Details are located on the ODOT web page on the Engineering Standards page in the [Roadway Section](#).

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

- Provides a practical, inexpensive method to divert runoff.
- Can handle flows from large drainage areas.
- Use onsite material and equipment to construct.

DISADVANTAGES

- If improperly constructed, can contribute to erosion caused by concentrating the flow.
- High flow velocity can damage vegetation.

DESIGN CRITERIA

- Refer to Table [3-4](#) Dike Design Criteria and Table [3-5](#) Swale Design Criteria.
- Install the dike and/or swale horizontally at intervals across a disturbed slope.
- Space horizontal interceptor dikes and swales according to Tables 3-4 and 3-5.
- For slopes of erodible soils, steeper than 1:2 with more than 10 ft. of vertical relief, construct benches or shorten distance between dikes and swales.
- If the dike or swale intercepts runoff from disturbed areas, discharge the runoff to a stable conveyance that routes the runoff to a sediment trap or basin.
- If the dike or swale intercepts runoff that originates from undisturbed areas, discharge the runoff to a stable conveyance that will route the runoff downslope of any disturbed areas and release the water at a stabilized outlet.
- Do not use sediment fence to divert flows.
- Pipe collected flow under roads.

Table 3-4 Interceptor Dike/Interceptor Swale

Top Width	24 in. minimum	
Height	20 in. minimum Measured from upslope toe and at a 90% standard proctor compaction ASTM D698.	
Side Slopes	1:2 or flatter	
Grade	Topography Dependent	
Dike Grade	Between 0.5-1%	
Slope of Disturbed Area vs. Horizontal Spacing	<5%	300 ft.
	5-10%	200 ft.
	10-25%	100 ft.
	25-50%	50 ft.

Slope Stabilization	<5%	
	Seed and mulch within 5 days of dike of disturbed construction area.	
Outlet	Upslope side of dike provides positive drainage to the outlet. Provide energy dissipation as necessary to prevent erosion. Release sediment-laden runoff to a sediment trapping facility.	

Table 3-5 Interceptor swale design criteria

Bottom Width	24 in. minimum. The bottom should be level across the swale.	
Depth	12 in.	
Side Slopes	1:2 or flatter	
Grade	Maximum 5% with positive drainage to a suitable outlet.	
Slope of Disturbed Area vs. Horizontal Spacing	<5%	300 ft.
	5-10%	200 ft.
	10-25%	100 ft.
	25-50%	50 ft.
Slope Stabilization	Temporarily seed, line with matting or line with riprap 12 in. thick and press into the bank approximately 3 in. to 4 in.	
Outlet	Level spreader or riprap to stabilize outlet/sedimentation pond.	

Table 3-6 Interceptor swale spacing design criteria

Slope	Swale Spacing
3 – 5%	300 ft.
5 – 10%	200 ft.
10 – 25%	100 ft.
25 – 50%	50 ft.

MAINTENANCE

- Immediately repair damage resulting from runoff or construction activity.
- If the dike or swale regularly overflows, increase the capacity and/or frequency of the dikes/swales.
- 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.

COMMON FAILURES

The most common problems with interceptor dikes and swales result from:

- Inadequate stabilization causing erosion along the base of a dike or the bottom of a swale
- Undersized construction for flows actually occurring onsite.

3.3.6 STORMWATER CONTROL:

- Ponds
- Water Quality Bio-Filtration Swale
- Water Quality Bio-Slope
- Water Quality Filter Strip

These four features are designed permanent features to treat stormwater runoff to remove pollutants from finished projects. These are not erosion or sediment control BMPs, but the overlap in their functions with the intent of this manual rightly includes them in the list. The purposes of these features is to use vegetation, infiltration and the action of microbes in the soil to treat pollutants in the stormwater runoff from pavement. The need for these features is prompted by the endangered species act and the presence of federally listed salmon species in waters of the Pacific Northwest. Each of these features is a unique design fitted to the project conditions by a hydraulic engineer.

Appreciate that these features receive stormwater runoff that is sometimes high volume and velocity. When used on project plans work with hydraulic engineer to ensure that suitable erosion control measures are in place to protect these features.

The Stormwater Control Pond is over excavated, then (usually) fitted with an underdrain and brought to finished grade with a highly organic, well-drained Water Quality Soil Mixture. The surface is armored with open cell pervious pavers and the cells are infilled with more soil mixture. A stabilized outfall prevents erosion from water leaving these ponds. The soil is then planted or seeded. The Boilerplate Special Provision for Stormwater Control Ponds is [Section 01011](#).

The Stormwater Control Bio-Filtration Swale is over excavated, then (usually) fitted with an underdrain and brought to finished grade with highly organic, well drained Water Quality Soil Mixture. The surface is armored with open cell pervious pavers and the cells are infilled with more soil mixture. Weirs may be used to control flow velocity in the swale. A stabilized swale outfall prevents scour from water leaving these swales. The soil in the open cell pavers is then planted or seeded. The Boilerplate Special Provision for Stormwater Control Ponds is [Section 01012](#).

The Stormwater Control Bio-Slope is over excavated, then (usually) fitted with an underdrain and brought to finished grade with a mineral Ecology Mix "soil". Bio-Slopes are built into surfaces down slope from pavement and treat sheet flow from the pavement. The Boilerplate Special Provision for Stormwater Bio-Slopes is [Section 01013](#).

The Stormwater Control Filter Strip is over excavated, brought to finished grade with a highly organic, well-drained Water Quality Soil Mixture. Filter Strips are built into surfaces down slope from pavement and use infiltration, vegetation and microbial activity to treat sheet flow from the pavement. The Boilerplate Special Provision for Stormwater Filter Strips is [Section 01014](#).

Three of these four features is over excavated and backfilled with a well-drained soil mixture. This soil mixture is lightweight, porous and very erodible. The mineral "Ecology Mix" is likewise fine textured and erodible. Permanent stabilization is provided by vegetation, either seeded or planted, but there is always

a strong likelihood that significant volumes and high-energy velocities of stormwater runoff will be routed into these facilities prior to vegetative stabilization. These features require erosion prevention that does not rely on plant establishment. ODOT has recently introduced salt as a means to address ice on roads. It is unknown how road salt effects water quality facilities or the plants that help provide treatment. Coordinate Erosion Control design with hydraulic engineer. Stormwater control design can be made more durable against erosion with the use of Turf Reinforcement Mats (TRM), which are among the high performance matting types, Types F, G and H.

APPLICATIONS

- Areas where concentrated runoff contain pollutants from pavement and have the potential to cause damage from erosion or flooding.
- Areas where sheet flow runoff contain pollutants from pavement and have the potential flow untreated into waterways
- Areas where volumes of stormwater runoff containing pollutants from pavement have the potential to exceed the volumes of runoff of pre-construction conditions.

ADVANTAGES

- Features can moderate high velocity runoff.
- Vegetation (once established) provides channel protection and treats pollutants
- Captures sediment due to the filtering effect of vegetation.
- Aquatic ecosystems benefit from diminished pollution.
- Permit requirements are satisfied by implementation.

DISADVANTAGES

- Rain events that occur prior to vegetation establishment can result in erosion damage strong enough to dismantle feature.
- May require temporary irrigation to establish vegetation.
- May require channel liner matting and/or check dams during vegetation establishment
- Vegetation may become buried in sediment if upslope watershed does not have sufficient erosion prevention in place.
- Unless reinforced with matting, cannot be used until vegetation is established.
- Features require ongoing maintenance

MAINTENANCE

- Maintenance and operations manual should be provided by designer.
- During the initial establishment, damaged vegetation should be repaired and re-established if necessary.
- After vegetation has become established, the feature should be checked periodically to verify effective functioning and stability of feature.
- Check the feature for debris, scour, or erosion and immediately make repairs. It is particularly important to check the feature outfall for evidence of piping or scour holes and make repairs immediately.

- Remove all significant sediment accumulations to maintain the designed carrying capacity.
- Keep the vegetation in a healthy, vigorous condition at all times, since it is the primary erosion protection for the channel.
- Permanent vegetated waterways should be seasonally maintained by mowing and/or irrigating, depending on the type of vegetation selected.
- Newly seeded areas need to be inspected frequently to ensure the vegetation 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.

COMMON FAILURES

- Improper seed selection with species selection either being too water loving or too drought tolerant for site conditions.
- Vegetation not adequately established to provide erosion prevention prior to the introduction of stormwater
- Inadequate site preparation
- Unmet maintenance increases and risk of failure.

3.4 SEDIMENT CONTROL PRACTICES

Once soil erosion occurs, sediment trapping or removal techniques can reduce the amount of sediment that leaves the site. Sediment is pollution so its removal protects receiving rivers, wetlands, and lakes. Sediment controls are usually placed around the perimeter of a disturbed area and where concentrated water leaves the site. Sediment control BMP's 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.

Best Management Practices

- 1) Construction Entrance
- 2) Tire Wash Facility
- 3) Road/Staging Area Stabilization
- 4) Sediment Barrier / Perimeter Control
 - a) Biofilter Bags
 - b) Straw Rolls (Wattles)
 - c) Compost Socks
 - d) Compost Berm
 - e) Sand Bags
 - f) Brush Barrier
 - g) Filter Berm
 - h) Pre-fabricated Barrier System
- 5) Sediment Fence / Perimeter Control
- 6) Flocculent treatment
- 7) Inlet Protection
- 8) Sediment Trap
- 9) Sediment Basin

3.4.1 CONSTRUCTION ENTRANCE

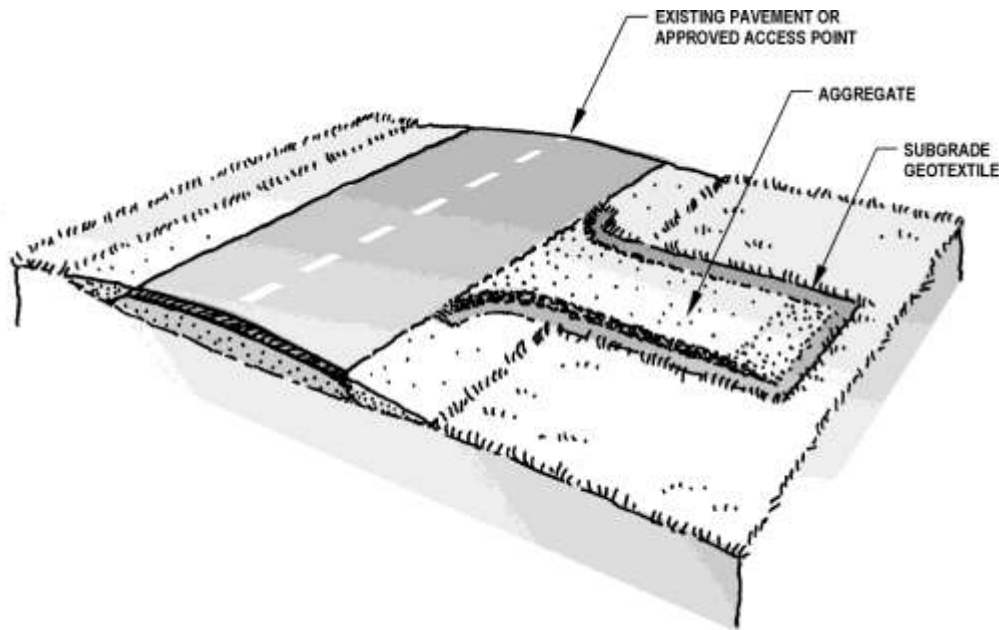


Figure 3-20 Construction Entrance

A stabilized aggregate pad, placed at construction site ingress/egress locations. Construction entrances reduce the amount of sediment transported onto paved roads by vehicles. Manufactured or custom-built rumble strips or shaker plates can function as construction entrances. Pre-fabricated construction entrance panels are available that are manufactured from bright yellow, high-molecular-weight polyethylene. These panels are reusable, recyclable, will not become clogged with sediment and are easily cleaned.

- Refer to detail: [RD1000](#) Construction Entrance Temporary, located on the ODOT web page on the Engineering Standards page in the [Roadway Section](#).

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 ft. of the site.
- The 1200-CA Permit (Schedule A. Subsection 3.c.i) requires that each site shall have graveled, paved or constructed entrances, exits and parking areas to reduce the tracking of sediments onto public or private roads.

ADVANTAGES

- Reduces traffic hazards caused by debris on public roadways.
- Reduces sediment on roadways that can wash into the storm sewer system.
- Reduces public nuisance and misperceptions regarding Agency "housekeeping".

DISADVANTAGES

- Only effective if erosion and sediment control employed elsewhere onsite.
- Only works if installed at every location where significant construction traffic leaves the site.
- Fills with sediment quickly and requires frequent maintenance and/or replacement of rock.

DESIGN CRITERIA

- Length:
 - 20 ft. for drainage areas having less than 0.25 acre of exposed soil.
 - 50 ft. for drainage areas having between 0.25 and 1 acre of exposed soil.
 - 100 ft. for drainage areas having more than 1 acre of exposed soil
- Minimum width: 20 ft.
- Minimum Aggregate Depth: 8 in.
- Coarse, open graded, durable aggregate sized as described in Section 00280.16(a)
- Install at construction entrances before beginning grading.
- Whenever possible, construct the pad on a firm, compacted subgrade.
- Place a geotextile under the aggregate when fine sediment under the pad could “pump” up and into the pad.
- Do not install aggregate on paved surfaces.
- Install fencing as necessary to restrict construction vehicle traffic to the construction entrance.
- Include a tire wash if the entrance does not prove effective in retaining sediment onsite.

MAINTENANCE

- When aggregate becomes clogged with sediment perform maintenance by replacing rock, topping construction entrance with new, clean rock or by “stirring” the construction entrance aggregates with bladed equipment to reopen voids between the rocks and to maintain the effective functioning of the construction entrance
- Immediately sweep up and remove any sediment that is tracked onto pavement. Vacuum sweeper trucks can perform this task.
- 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. Never wash sediment into stormwater systems or into ditches or waterways.
- Add aggregate, replace aggregate or with a bladed piece of equipment “stir” the aggregate to renew void space as needed to maintain the specified dimensions and.
- Immediately remove any aggregate, which gets carried from the pad to the roadway.
- Maintain fencing installed as traffic control.

COMMON FAILURES

- The most common problem with this BMP is the failure to provide correct type of rock and adequate depth and length of rock entrance.
- Failure to perform maintenance to keep construction entrance effective functioning.
- Failure of truck operators to correctly use construction entrance.

3.4.2 TIRE WASH FACILITY

Washing equipment tires not only prevents mud from tracking onto pavement, this practice can prevent the spread of noxious weeds that might have seeds stuck in the soil on tires. Two types of tire wash facilities are shown as Standard Drawings that can be used based on the severity of sediment tracking and the size of the project. Type 1 is a stabilized aggregate 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. The Type 1 facility includes a steel rumble strip or cattle guard structure to shake sediment from tires and a water supply and hose with which to wash vehicle tires. Type 2 consists of a shallow water-holding basin partially filled with water, through which exiting vehicles drive. Prefabricated tire wash facilities or purpose built tire wash facilities that include pumps, and water spray directed to truck or equipment tires can provide superior tire wash results. Prefabricated tire wash facilities are available for rent or purchase. For purpose built facilities, provide shop drawings for approval prior to installation.

- Refer to [Standard Drawing RD1060](#) Tire Wash Facility, located on the ODOT web page on the Engineering Standards page in the [Roadway Section](#).

Applications

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

ADVANTAGES

- Reduces traffic hazards caused by debris on public roadways.
- Reduces sediment on roadways, which can wash into the storm sewer system.
- Type 1 is easy to construct and is relatively inexpensive.
- Type 2 is useful for high traffic volumes or large projects of long duration.

DISADVANTAGES

- 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 having to drive through wash area.
- Type 1 requires labor to wash the tires of all vehicles exiting the site.
- Type 2 is costly to construct.
- Type 2 will generate large volumes of sediment-laden water, requiring treatment elsewhere on site.

DESIGN CRITERIA

- Type 1
 - Minimum length: 81 ft.
 - Minimum width: 10 ft.
 - Minimum Aggregate Depth: 12 in.

- Fit with cattle guard as rumble strip
- Place subgrade geotextile under the aggregate.
- Provide with water supply and hose.
- Install fencing as necessary to restrict existing construction vehicle traffic to the tire wash.
- Grade the pad to drain to suitable collection and treatment facility.
- Type 2
 - Basin dimensions 41 ft. long by 15 ft. wide with sloping ingress and egress, and 50 ft. long impervious runout area at egress, which drains into basin.
 - Line bottom of basin with geotextile and 1 ft. of open graded aggregate.
 - Provide water supply.
 - Provide outlet for sediment-laden water discharge to treatment facility or provide pumps and tanks for water treatment.

MAINTENANCE

- Type 1
 - 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.
 - Ensure that wash water drainage, collection and treatment system is functioning.
- Type 2
 - Remove/discharge wash water as needed.
 - Remove accumulated sediment from bottom of basin.
 - Ensure that wash water collection and treatment system is functioning.

COMMON FAILURES

- The most common problem with this BMP is failure to use or maintain the facility.
- Failure to control turbid wash water that drains off vehicle leaving the tire wash.

3.4.3 CONSTRUCTION ROAD/PARKING AREA STABILIZATION

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

APPLICATIONS

Permanent or temporary roads or parking areas used by construction traffic.

- The 1200-CA Permit requires that all unpaved roads located onsite shall be graveled. Other effective erosion and sediment control measures either on the road or down gradient may be used in place of gravel.



Figure 3-21 Stabilized Haul Road

ADVANTAGES

- Reduces onsite erosion, dust, and offsite tracking of soils.
- Can speed and enhance efficiency of onsite work.

DISADVANTAGES

- Temporarily stabilized construction roads can be expensive to install and maintain.
- At the end of their use, temporary haul routes must be tilled to eliminate compaction prior to seeding.

DESIGN CRITERIA

- Road and parking area stabilization may not be necessary during the dry season (unless dust is a concern) or if the site is underlain by coarse-grained soils.
- ODOT usually leaves temporary road locations and construction criteria to the contractor's discretion. The following is general information regarding road and parking stabilization:
 - Stabilize roads and parking areas immediately after initial grading.
 - Whenever possible, construction roads and parking areas should be placed on firm, compacted subgrade.
 - Engineers designing haul roads should work to keep road grades as flat as is practicable. Erosion control designers are not qualified to design haul roads.
 - Where on-site roads are cut into slope faces, construct water bars or diversion ditches to move water down slope at sufficiently frequent intervals so that concentrated flows are avoided.
- Grade roadways to encourage sheet flow runoff to a roadside ditch or to a heavily vegetated area. Do not direct runoff into vegetated wetlands or landscaped areas. Discharge runoff through at least 50 ft. of vegetation to treat the sheet flow runoff. Treating sheet flow runoff from temporary roads is preferred to using a sediment pond or trap.

MAINTENANCE

- Immediately following grading, apply crushed rock, gravel base or crushed surfacing base course. A course of asphalt-treated base (ATB) or cement may also be used.

- Install fencing, if necessary, to limit vehicle access to stabilized roads and parking areas.
- Add crushed rock, gravel base, as required to maintain a stable driving surface and to stabilize any eroded areas.

COMMON FAILURES

- The most common problem with this BMP is the failure to include adequate depth and length of rock, failure to maintain the rock depth for supporting heavy vehicles, and poor installation. Unpaved routes that function with no issues in dry weather can become soft and generate sediment pollution when weather becomes wet.
- Another common failure occurs after construction is completed. This failure is to abandon the haul route without loosening the soil or eliminating the compaction caused by heavy vehicle traffic. Compacted soils resist infiltration, increasing runoff and roots of plants cannot penetrate compacted soils and often die from not being able to access resources.

3.4.5 SEDIMENT BARRIER

Sediment barriers can be constructed from a variety of materials. Sediment barriers are most frequently used as perimeter control, as the last line of protection to keep sediment from leaving project sites. Sediment barriers are also used as intermediate protection and as the erosion prevention measure to shorten slope length. Sediment barriers function by stopping the downslope flow of sediment-laden water, allowing the suspended solids to settle out. Some sediment barriers function by impounding water so sediment can fall out of suspension. Other sediment barriers function by filtering out sediment. A listing of barrier types according to ODOT specifications and drawings follows:

- Type 1 – Straw Bales are not approved for use as sediment barriers.
- Type 2 – Biofilter Bags: Embedded biofilter bags staked to the ground.
- Type 3 – Fiber Rolls (Wattles): Embedded fiber 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 – Aggregate Berm: Entrenched aggregate, mounded.
- Type 7 – Pre-fabricated Barrier System: A manufactured system specifically designed for temporary sediment control applications. Field fabricated systems are not allowed.
- Type 8 – Compost Filter Sock: Netting sleeve filled on-site with coarse compost.
- Type 9 – Compost Filter Berm: Low berm formed on-site using coarse compost.

Table 3-7 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.

3.4.5.1 STRAW BALE – SEDIMENT BARRIER TYPE 1

Not Approved for use as Sediment Barrier

3.4.5.2 BIOFILTER BAGS – SEDIMENT BARRIER TYPE 2

Biofilter bags are manufactured from 100% recycled wood-product waste placed in plastic mesh bags. They are typically 30 in. long by 18 in. wide and weigh approximately 45 lb. Biofilter bags are very pervious and are most effective in settling out larger particle size sediments.

- Refer to detail: [RD1030](#) Sediment Barrier – Type 3 (and Type 2 & 4 Biofilter or Sandbags), located on the ODOT web page on the Engineering Standards page in the [Roadway Section](#).

Applications

- To capture and retain sediment on slopes.
- To capture sediment around drain inlets (see Inlet Protection, Type 4).
- 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.

Advantages

- Relatively low cost.
- Installation is simple, can be transported and installed 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).
- Good BMP to store as emergency materials.
- Wood material can be dispersed on site so only the mesh needs disposal.

Disadvantages

- Provides minimal sediment control
- Generally effective for only a few months.
- Can be easily damaged or displaced 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.
- Lightweight results in higher buoyancy if not properly installed.
- Low sediment retention capacity may require frequent maintenance.

Design Criteria

- On slope applications should be installed on contour.
- See Table 3-7 Barrier spacing for general application.
- Ends of bags must be tightly abutted and overlapped to direct flow away from bag joints.

- Install two stakes per bag when installed on soil.
- In paved areas weight in-place using sand bags (staking not feasible).

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 (parallel to row of bags).
- Check that bags are not displaced.
- Inspect plastic mesh bags for tears.
- Remove sediment when 1/3 height of bag has accumulated.
- Replace damaged bags as needed. Remove wood chips spilled from damaged bags.

Common Failures

Failures most commonly result from biofilter bags not being tightly abutted together, which allows sediment-laden flow between or under the bags. This also occurs when bags are not properly staked. Another common failure is caused when the bags are not installed on contour and water flow becomes channeled behind the bags. Bags are easily displaced when used on pavement and are easily broken when driven over.

3.4.5.3 FIBER ROLLS (WATTLES) – SEDIMENT BARRIER TYPE 3

Fiber rolls are manufactured from straw that is wrapped in tubular photodegradable plastic or (preferably) biodegradable netting. They are approximately 8 in. in diameter by 25 ft. to 30 ft. long. Fiber rolls are placed in shallow trenches and staked along the contour of newly constructed or disturbed slopes.

- Refer to detail: [RD 1030](#) Sediment Barrier (Type 3).

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.
- As perimeter control to prevent turbid water from leaving project site, entering waterways or paved areas.
- Suitable as emergency material



Figure 3-22 Fiber Rolls (Wattles) – Sediment Barrier Type 3

Fiber rolls installed correctly:

- Installed on contour
- Shallow embedment
- End turned up-slope to prevent channeling runoff from flowing downslope (in this photo, turned up more than necessary)

- Fully biodegradable fiber rolls do not need to be removed

Advantages

- Easier to deploy than sediment fences on steep slopes.
- Fiber rolls are a short-term solution to help establish native vegetation.
- Fiber rolls store moisture for vegetation planted immediately downslope.
- All natural fiber rolls may be left in place to biodegrade.
- Straw becomes incorporated into the soil with time, adding organic material to the soil and retaining moisture for vegetation.
- Reduces runoff velocity and shortens slope length (erosion prevention).
- Requires minimal ground disturbance to install.
- Lightweight and easy to install.
- Rocks rolling down slope usually do not damage straw wattles.
- Good BMP to keep on-site as emergency material.

Disadvantages

- Rolls only function for one or two seasons.
- Shallow trenching for the installation of fiber roll may be difficult on rocky ground.
- If not installed properly with sufficient trench, water may undercut roll.
- Fiber 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.
- Fiber rolls constructed with plastic netting to enclose the fiber must be removed and disposed of. Photodegradable netting still takes many years to break down.

Design Criteria

- Prepare the slope before the wattle installation is started.
- The use of fiber rolls constructed with fully biodegradable netting to enclose the straw is recommended because it does not require removal and disposal. Leaving biodegradable product on site adds organic matter to soil and does not add to waste stream.
- Surface irregularities should be smoothed as work progresses.
- Dig small trenches across the slope on contour to place rolls in. Space trenches in accordance with the Table 3-7 Barrier spacing for general application. The trench should be deep enough to accommodate one-third the thickness of the roll.
- Start building trenches and install rolls from the bottom of the slope and work up.
- Install rolls perpendicular to water movement, parallel to the slope contour.
- Lay the roll along the trenches fitting it snugly against the soil. Make sure no gaps exist between the soil and the straw wattle.
- Overlap roll ends 12" to ensure no gaps in protection
- When plant cuttings (live stakes) are used, install during the planting season described in Sections 01040.41 (west of the Cascades – September 1 through May 15) or 01040.42 (east of the Cascades – October 15 through November 30)

- When plant cuttings are specified, do not delay installation of fiber rolls by waiting for planting season. Stake fiber rolls with wooden (dead) stakes then, during the planting season, supplement the wood stake with plant cuttings.
- Use a straight bar to drive holes through the wattle and into the soil for the plant cuttings or wooden stakes.
- Drive the stake through prepared hole into soil. Drive a minimum of 12 in. into undisturbed material. When plant cutting is used, avoid damaging this living plant material to the greatest extent practicable.
- Install stakes not less than every 4 ft. apart through the wattle. Additional stakes may be driven on the downslope side of the trenches on highly erosive or very steep slopes.

Maintenance

- Inspect the fiber rolls and the slopes after significant storms. Make sure the rolls are in contact with the soil.
- Remove accumulated sediment when it is 1/3 the capacity of the fiber roll.
- Repair any rills or gullies promptly.
- Re-seed or replant vegetation if necessary until the slope is stabilized.

Common Failures

- Failures most commonly result from straw rolls not being installed with correct overlapping, allowing water to easily pass between the rolls, resulting in rilling.
- Water can scour beneath the rolls if they are not properly entrenched.
- Fiber rolls with plastic netting that are not removed become plastic litter and eyesores.

3.4.5.4 COMPOST SOCKS – SEDIMENT BARRIER TYPE 8

Compost socks are field fabricated sediment barriers made by blowing coarse compost into a mesh sleeve. The flexible nature of the sleeve combined with the weight of the compost causes the compost sock to conform to surface irregularities of the ground. Embedding compost socks is not necessary. The sock material can be plastic netting or, if the barrier is not intended to be removed, biodegradable netting made of burlap, cotton or other natural fiber. Use plastic netting if compost sock is expected to be relocated. The sock material is available in diameters of 9, 12, 18 and 24 inches. The sock length is determined in the field.

- Refer to detail: [RD 1032](#) Sediment Barrier (Type 8).

Applications

- To capture and retain sediment on slopes.
- To shorten slope length, check runoff velocity on slopes and interrupt sheet and rill erosion (erosion prevention).
- As perimeter control to prevent turbid water from leaving project site.

Advantages

- Difficult to install incorrectly. Does not need to be embedded into soil.
- Compost is waste material repurposed as useful product.
- Sequesters carbon
- Removal of plastic compost sock mesh consists of cutting sock fabric and spilling compost out of fabric and disposing of the fabric only. Fully biodegradable compost socks do not need removal.
- Even as fully biodegradable sock material in contact with soil is decomposing, the BMP will continue to function.
- Compost Socks store moisture for vegetation planted immediately down slope.
- Compost becomes incorporated into the soil with time, adding organic material to the soil and retaining moisture for vegetation.
- Requires minimal ground disturbance to install.
- Rocks rolling down slope usually do not damage compost socks.



Disadvantages

- Requires specialized equipment to install. Not well suited to be specified as emergency material
- The required coarse compost may not always be stocked in material yards.
- Low sediment retaining capacity (depending on compost sock diameter) may require frequent maintenance.
- Removal of plastic netting from compost sock is required and can be difficult due to the weight of wetted compost.
- Biodegradable netting may not be sufficiently robust to be moved without rupturing if phased work required adjusting BMP locations.

Figure 3-23 Compost Sock – Sediment Barrier Type 8

Design Criteria

- Prepare the installation location by removing rocks, roots, branches and surface irregularities larger than 3" before the compost sock installation is started.
- The use of compost socks constructed with fully biodegradable netting is recommended where the BMP will not be moved because it does not require removal or material disposal.
- Install compost socks perpendicular to water movement, parallel to the slope contour.
- Overlap roll ends 12" to ensure no gaps in protection
- Use a straight bar to drive holes through the compost sock and into the soil for plant cuttings here specified.
- Install stakes not less than every 4 ft. apart through the compost sock. Additional stakes may be driven on the downslope side of the trenches on highly erosive or very steep slopes.
- Use 8" diameter compost socks on slopes. Larger diameter (heavier) compost socks are appropriate as perimeter control or on slopes 1V:4H or flatter.

Maintenance

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

Common Failures

- Failures most commonly result from compost socks not being installed with correct overlapping, allowing water to easily pass between the sock sections, resulting in rilling.

3.4.5.5 COMPOST BERMS – SEDIMENT BARRIER TYPE 8

Compost berms are field fabricated linear mounds made by blowing coarse compost through a rolling mold. The weight and unconstrained nature of the compost causes the compost berm to conform to surface irregularities of the ground. Embedding compost berms is not necessary.

- Refer to detail: [RD 1033](#) Sediment Barrier (Type 9).

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.
- As perimeter control to prevent turbid water from leaving project site, entering waterways or paved areas.
- Fully biodegradable compost berms do not need to be removed.

Advantages

- Difficult to install incorrectly. Does not need to be embedded into soil.
- Easy to repair with hand tools if damaged.
- Compost is waste material repurposed as useful product.
- Sequesters carbon
- Compost berm continues to function even as it is being incorporated into the surrounding landscape.
- Compost berms store moisture for vegetation.
- Reduces runoff velocity and shortens slope length (erosion prevention).
- Requires minimal ground disturbance to install.

Disadvantages

- Requires specialized equipment to install.
- The required coarse compost may not always be stocked in material yards (Will be provided by suppliers when they are given adequate lead-time.)
- Compost berms only function for one or two seasons.

- Compost berm is not a robust sediment barrier. It may fail out in big weather events or where water becomes impounded behind berm. Rolling rocks or damage caused by construction equipment can render BMP ineffective.
- Not appropriate for specifying as emergency material

Design Criteria

- Prepare the installation area before the compost berm installation is started.
- Install compost berms perpendicular to water movement, parallel to the slope contour.
- Coarse compost must be used.

Maintenance

- Inspect the compost berms and the slopes after significant storms.
- Repair any rills or gullies promptly.
- Re-seed or replant vegetation if necessary until the slope is stabilized.

Common Failures

- Failures most commonly result from compost berms being installed on too steep a slope with too large a water catchment area.
- Failures can occur if too fine a compost texture is used.

3.4.5.6 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 in. by 12 in. by 6 in. and be filled with firmly packed PCC 3/8"-0 aggregate or round 3/8" – 3/16" pea gravel and weigh at least 75 lb.

- Refer to detail: [RD1030](#) Sediment Barrier, located on the ODOT web page on the Engineering Standards page in the [Roadway Section](#).
- (Type 2 & 4) Biofilter or Sandbags (sand bag and biofilter bag installation similar).

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.
- Can be placed in streams for isolating work areas.
- Appropriate as emergency materials

Advantages

- 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 placed 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 (check dam, Type 4).

Disadvantages

- Generally effective for only a few months.
- Can be easily damaged by construction equipment.
- 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.
- If used on active streets, sand bags on pavement could cause motorcyclists or bicyclist to crash.
- Not effective where water velocities or volumes are high, can get dislodged.

Design Criteria

- On slope applications should be installed on contour.
- Are appropriate for emergency materials
- See Table 3-7 Barrier spacing for general application.
- 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 (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

- Not being tightly abutted together, which allows flow between or under the bags causing rilling.
- Another common failure is caused when the bags are not installed on contour and water flow becomes channeled behind the bags.
- Sandbags are sometimes not removed after site is stabilized.
- Sandbags can also be dislodged when placed in high velocity flows, or when struck by construction equipment or other vehicles.

3.4.5.7 BRUSH BARRIER – SEDIMENT BARRIER TYPE 5

A brush barrier is a rarely used 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. One type of brush barrier detail is provided in Standard drawing [RD1031](#). Other methods of construction and installation are valid.

Applications

- On gently sloped areas.
- Disturbed areas draining less than ¼ acre, where runoff is primarily sheet and rill erosion.
- Residual materials are available onsite for barrier construction.

Advantages

- Saves material costs by utilizing materials onsite, but labor intensive to build.
- Reduces velocity and quantity of runoff.
- Fully biodegradable and can remain in place unless geotextile is used.
- Fresh brush of certain species embedded into moist ground may sprout like live stakes.



Figure 3-24 Novel brush barrier (brush wattles) Installation in Germany

Disadvantages

- Only effective if erosion and sediment are controlled elsewhere onsite.
- Suitable for only a limited drainage area.
- Has limited life span.
- Labor cost to assemble brush barriers is more than with purchased BMPs.

Design Criteria

- The height as shown in Std Drg is shown as being between 3-3/4 – 5 ft. Functional brush barriers can vary in size.
- See Table 3-7 Barrier spacing for general application.
- The width as shown in Std Drg is shown as being between 5 ft. – 15 ft.
- Filter fabric anchored over the barrier can enhance the filtration capacity and effectiveness of the barrier.
- Fill barrier with 6 in. maximum diameter woody debris or topsoil strippings.

Maintenance

- Generally require 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 (if used) should be inspected occasionally for tears and repaired as necessary.
- When the barrier is no longer needed, the fabric must be removed to allow natural establishment of vegetation within the barrier.

Common Failures

Failures most commonly result from loose construction, allowing water to easily pass through the vegetation. Improperly installed filter fabric can also be a problem.

3.4.5.8 AGGREGATE SEDIMENT BARRIER TYPE 6

Aggregate barrier is an infrequently used temporary sediment barrier. The barrier intercepts and retains sediments that are washed from disturbed areas.

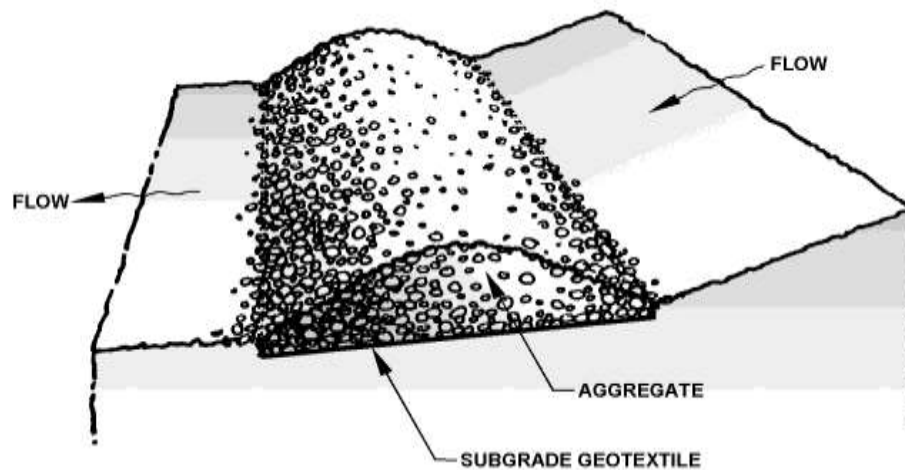


Figure 3-25 Aggregate Barrier Type 6 Retains sediment in aggregate berm.

- Refer to detail: [RD1031](#) Sediment Barrier (Type 6), located on the ODOT web page on the Engineering Standards page in the [Roadway Section](#).

Applications

- In traffic areas on construction sites.
- On gently sloped areas.
- At staging areas, stockpile sites or disposal sites.
- Along roadway edges to dissipate sheet flow.

Advantages

- Very efficient method for sediment removal.
- Reduces runoff velocity.
- Uses common material

Disadvantages

- More expensive than some other measures because it requires clean gravel or crushed rock rather than materials found onsite.
- Clogging from mud and soil may make maintenance difficult.
- Has a limited life span.

Design Criteria

- Use 2 in. maximum washed and well-graded aggregate 4"-1" with less than 5% fines.
 - Height and side slopes: 2 ft. high with 1:3 side slopes.
 - See Table 3-7 Barrier spacing for general application.

Maintenance

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

3.4.5.9 PRE-FABRICATED BARRIER SYSTEM – SEDIMENT BARRIER TYPE 7

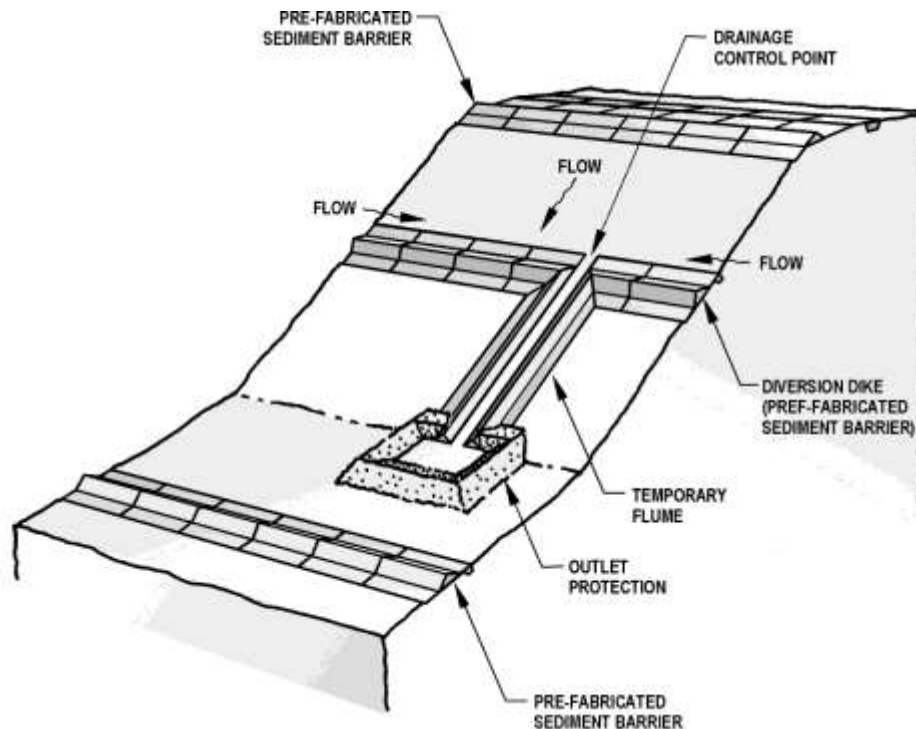


Figure 3-26 Pre-fabricated Barrier System – Sediment Barrier Type 7

Pre-fabricated barrier systems typically consist geotextile fabric surrounding a flexible material usually foam or other flexible, lightweight material. The geotextile extends from the bottom of the barrier to provide flaps or aprons on the upslope and downslope sides of the product. The prefabricated system is anchored by and stapling the aprons, or when used on pavement weighting the aprons down with sand bags. Barrier materials, section lengths and weights vary among manufacturers.

- If using a pre-fabricated barrier system, install in strict compliance with manufacturer's recommendations

Applications

- To capture and retain sediment on slopes.
- To shorten slope length
- To capture runoff from top of slopes or at intermediate locations on slopes and direct water to a suitable conveyance or exit point.
- As sediment barrier on pavement or to direct surface drainage on pavement.
- Diversion dike.
- Check dam.
- Emergency Material

Advantages

- Lightweight.
- Installation is relatively simple.
- Can be used to divert and slow velocities of small flows.
- Conforms to curves and rough terrain.
- Durable and some products are capable of being driven over by light vehicles
- Reusable.

Disadvantages

- Effective for unknown period of time (depends on material properties).
- 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.
- Can be damaged during sediment removal operations.

Design Criteria

- On slope applications should be installed on contour.
- Install in accordance with plans, special provisions and manufacturer's recommendations.
- See Table 3-7 Barrier spacing for general application.

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 (parallel to barrier).
- Remove sediment accumulation behind barrier when sediment reaches one-third the barrier height.
- Replace damaged sections as needed.

Common Failures

- Failures most commonly result from:
- Improper installation (not anchoring the aprons correctly) which allows flow under or around the barrier.
- Physical damage or displacement resulting from being run over by vehicles or equipment

3.4.6 SEDIMENT FENCE



Figure 3-27 Sediment fence is trenched in correctly

Temporary sediment barrier consisting of geotextile fabric stretched across and attached to supporting posts. Sediment fences are adequate to treat flow depths consistent with overland or sheet flow. Sediment fence is generally not the correct material for boundary delineation. Orange colored sediment fence may serve as boundary delineation where a sediment barrier is appropriate, where the boundary is level, and the BMP to be installed on contour as specified for the sediment control BMP. Sediment fence is not the correct BMP to divert surface flow from above disturbed ground.

Sediment fence fabric must comply with Section 02320-3. Refer to Section 00280 for more specific information.

When planning for the use of sediment barriers, consider that many products are effective sediment barriers that do not have the disadvantages of sediment fence.

- Refer to detail: [RD1040](#) Sediment Fence located on the ODOT web page on the Engineering Standards page in the [Roadway Section](#).

APPLICATIONS

- Sediment fences can be used as the sole treatment when the area draining to the fence is less than $\frac{3}{4}$ acre per 300 ft. of sediment fence and the average slope (perpendicular to the fence)

is 1:3 or flatter. Otherwise, use sediment fence in conjunction with other measures such as erosion prevention.

- Sediment fence is viable perimeter control downslope of disturbed ground. Use in conjunction with other BMPs such as erosion prevention and runoff control.
- Sediment fence can be used on slopes flatter than 1V:2H.
- Install downslope of disturbed areas and prior to upslope clearing and grading.
- Do not use sediment fences in v-ditches or streams.
- Sediment fence can be configured as inlet protection around field inlets

ADVANTAGES

- Reduces runoff velocity.
- Generally a robust sediment control measure
- Can retain large volume of sediment
- Relatively inexpensive.
- Familiar BMP that is readily available

DISADVANTAGES

- Applicable to small drainage areas and overland flow; not applicable to concentrated flows.
- Incorrect installation renders BMP ineffective.
- Difficult to embed on compacted or rocky ground.
- Requires frequent maintenance and inspection.
- Easily damaged if struck by rolling rocks during embankment construction
- Must be removed (but often is not) once vegetative stabilization is achieved.
- Removal of sediment fence causes minor soil disturbance that must be addressed.
- Removal of sediment fence can compromise vegetative stabilization.
- Must be disposed of after single use, adding to the waste stream



Figure 3-28 Sediment fence should be removed once vegetation is established

Design CRITERIA

- The height of a sediment fence should not exceed 3 ft. Storage height and ponding height should never exceed 20 in.
- Sediment fence is typically supplied with marks on the fabric to provide guidance on the correct depth of embedment.
- Sediment fence without sewn in sleeves are installed with supporting posts down slope of fabric.
- Sediment fence with sewn in sleeves are correctly installed with sleeves upslope (putting the post on the down slope side of the fabric).
- Design and install sediment fence level and along ground contours.

- When sediment fence approaches a ditch or swale, end the fence on each side of the ditch or swale and install a check dam in the ditch or swale.
- If possible, the filter fabric should be cut from a continuous roll to avoid the use of joints. When joints are necessary, filter cloth should be spliced only at a support post, with a minimum 4 ft. overlap and both ends securely fastened to the post, or join the two end stakes by wrapping the two ends at least one and one-half turns and driving the joined stakes into the ground together.
- Posts should be spaced a maximum of 6 ft. apart and driven securely into the ground (minimum of 10 in.).
- Turn the ends of the sediment fence uphill.
- A trench should be excavated approximately 6 in. deep along the line of the posts and upslope from the barrier in which to embed the fabric.
- To facilitate installation on rocky ground bottom flap can be folded upslope and covered with 12 inches of aggregate or soil to prevent water from piping under fabric
- The filter fabric shall be stapled or wired to the posts if not pre-fitted with sleeves, and the bottom 6 in. of the fabric should extend into the trench.
- The trench should be backfilled and the soil compacted over the bottom flap of the filter fabric. Sediment fences placed at the toe of a slope should be set at least 6 ft. from the grade break in order to increase ponding volume.

MAINTENANCE

- Inspect fences weekly and after each storm event. Immediately repair any damage.
- Remove accumulated sediment once it has reached 1/3 the height of the sediment fence or 1 ft. maximum.
- Inspect for channel formation parallel to the fence, which indicates the sediment fence is not installed on contour or it is acting as a flow barrier.
- Replace deteriorated or clogged geotextile.
- Check for undercutting or piping under fence.
- At base of embankment slope, replace or repair sediment fence that has been damaged by rocks rolling down slope



Figure 3-29 Sediment fence maintenance failure

COMMON FAILURES

Common problems with sediment fence are:

- Inadequate installation such as;
 - Fence posts are not driven deep enough
 - Fabric is not trenched in at least 6 in

- Poor compaction of backfill material in trench
- Sediment fence is installed in areas where concentrated flow occurs
- When not installed along contour.
- When ends of fence runs are not turned upslope.
- When used in flood prone areas sediment fence can become fish trap
- When used at top of slope to divert off-site runoff flow can cut channels against geotextile fabric. (use interceptor dike/swale)
- Wrong material to use as boundary delineation
- When used at bottom of slope, rocks rolling down slope will damage sediment fence.
- When used as an intermediate sediment barrier, mid-slope, low permeability of the geotextile fabric results in impounded water that can over-saturate soil causing a shallow planar slide.
- Commonly not removed as required in Section 00280.70



Figure 3-30 Sediment fence not embedded in ground

3.4.7 INLET PROTECTION

Generally, 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. The marketplace is frequently introducing new inlet protection products to industry to address the multiple configurations of inlets. Designers should be familiar with new products and the best current thinking.

- Refer to detail: [RD1010](#) which shows 6 types of Inlet Protection
 - Type 2 – Geotextile/Wire Mesh & Aggregate
 - Type 3 – Prefabricated filter insert
 - Type 6 – Sod protection
 - Type 7 – Compost filter sock
 - Type 10 – Curb inlet sediment dam
 - Type 11 – Wattle barrier with filter insert.
- Refer to detail: [RD1015](#) Inlet Protection (Type 4) Biofilter bags.

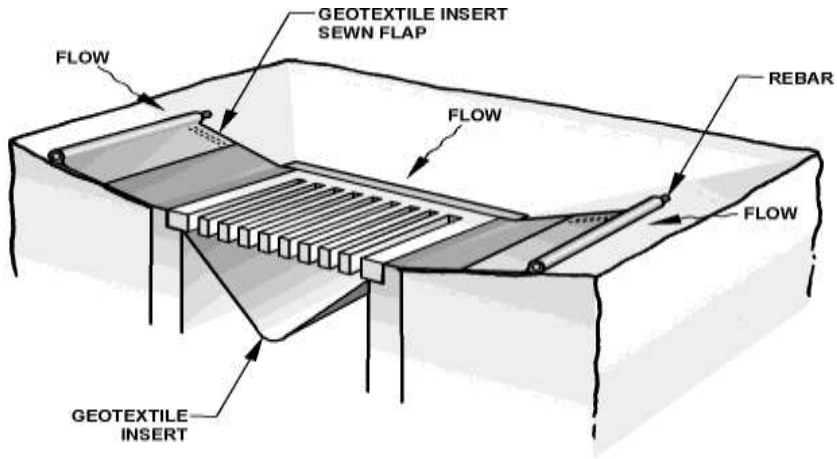


Figure 3-31 Inlet Protection – Geotextile Filter Fabric Insert (Type 3)

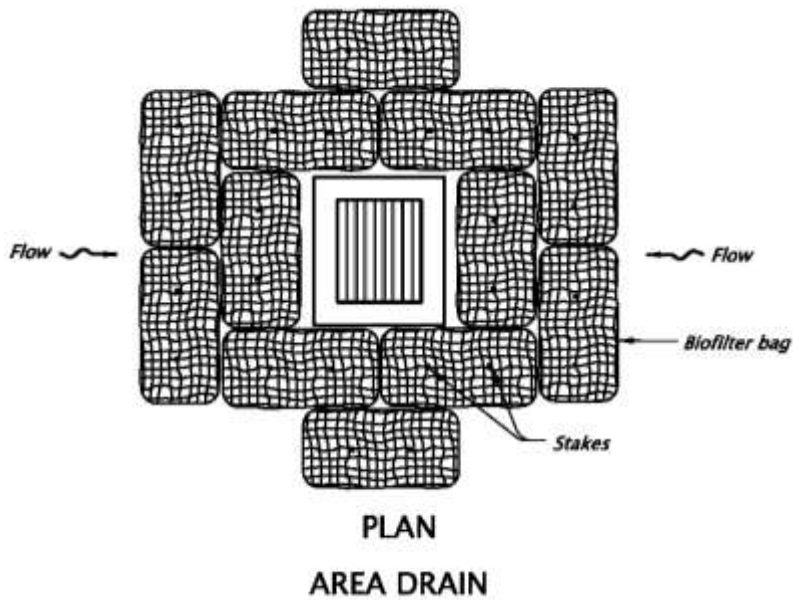


Figure 3-32 Inlet Protection – Biofilter Bags (Type 4)

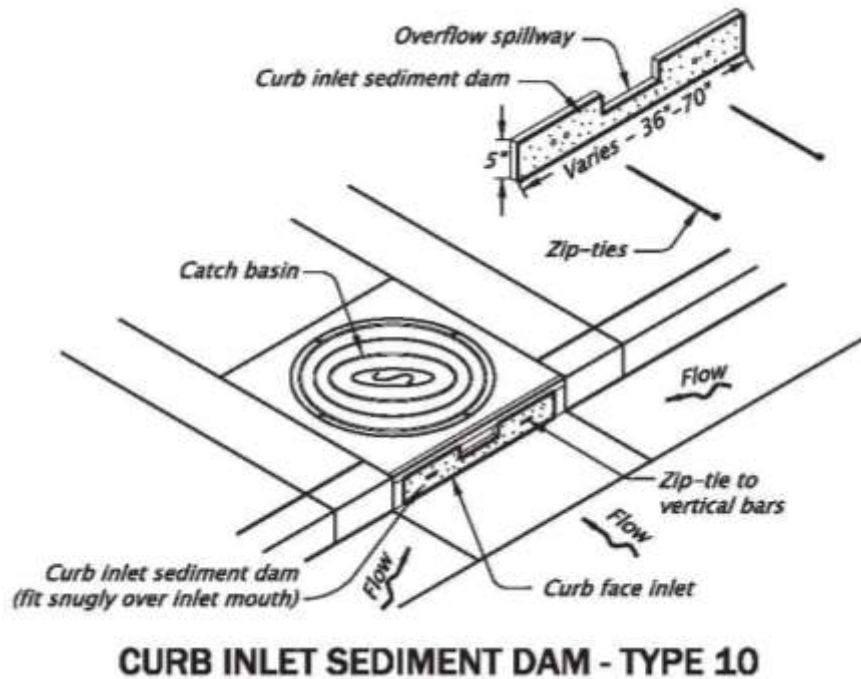


Figure 3-33 Inlet Protection – Curb Inlet Sediment Dam (Type 10)

APPLICATIONS

- All inlets which are capable of receiving stormwater runoff off of exposed soil or areas adjacent to construction sites where potential of sediment-laden water exists.
- At storm drain inlets downslope and within 500 ft. of a disturbed area or construction entrance.
- As a secondary measure downstream from erosion prevention and sediment trapping measures.

ADVANTAGES

- Prevents sediment from entering the storm drain system.
- Reduces amount of sediment leaving the site.

DISADVANTAGES

- May result in ponding of water above the catch basin. Ponding that extends to active roadways must not be allowed to occur.
- Sediment removal may be difficult under high-flow conditions. Perform maintenance as ongoing procedure and before anticipated rain events.
- If struck by vehicle compost socks (Type 7) or biofilter bags (Type 4) are easily dislodged or damaged, rendering them ineffective and requiring maintenance. Surface mounted inlet protections, such as compost socks (Type 7) or biofilter bags (Type 4) can be a traffic hazard that can cause injury if struck by bicyclist or motorcyclist.
- Short-circuiting of flow may occur if not properly installed.
- Improper installation, maintenance or removal may introduce sediment into the storm drain system.

DESIGN CRITERIA

- When protecting area drains, place inlet protection in areas where water can pond, and where ponding will not have adverse impacts.
- Inlet protection must allow for overflow in a severe storm event.
- Inlet protection types include:
 - Type 2 Geotextile with Aggregate Filter – Functional but rarely used
 - Type 3 Catch Basin Insert – easy to install & remove. No impediment to traffic. Usually constructed with high flow overflow. This BMP is installed under inlet grates and is easily overlooked during inspections, maintenance and when they are supposed to be removed.
 - Type 4 Biofilter Bags – This BMP is appropriate for use around field inlets and area drains. When installed on pavement per the standard drawing, there is a likelihood that biofilter bags will be struck by vehicle and dislodged and/or broken, spilling contents. An accident can result if a bicyclist or motorcyclist strikes a biofilter bag used as inlet protection on active pavement.
 - Type 6 Sod – This BMP slows velocity and filters sediment out of runoff.
 - Type 7 – Compost Filter Sock or Wattle – This type of inlet protection is most appropriate for field inlet or area drain applications surrounded by soil. Compost sock has significant mass and will conform to ground with no embedment. When used on inlets in active pavement there is a high likelihood they may be struck by vehicles and dislodged or broken. An accident can result if a bicyclist or motorcyclist strikes a compost sock or a straw wattle used as inlet protection on active pavement.
 - Type 10 – Curb Inlet Sediment Dam – This inlet protection consists of filter material that is fixed to the opening of inlets with the opening in the curb face. By themselves, these are not effective for inlets that combine horizontal grates with the curb face inlets and may need Type 3 inlet protection as well (similar to standard drawing for Type 11).
 - Type 11 – Wattle Barrier combined with Type 3 Filter Insert. – Inlets that combine curb face inlets with horizontal grated inlets require hybrid or combination inlet protection.
- Inlet protection types have recently been introduced that consist of different types of prefabricated filters suitable for different types of inlets. These are made to protect configurations including area drains, trench drains and curb face inlets. These newer products can be less labor intensive than more familiar BMPs and they may be approved for use by Construction PM or technical expert.
- Sediment Fence – Using field fabrication, sediment fence can be used to protect area drains surrounded by soil. Note that sediment fence fabric has low permeability and will impound water. This type of inlet protection is not supported by a standard drawing
- Masonry & Aggregate – This inlet protection BMP is labor intensive to install, difficult to maintain and is not supported by standard drawings and not recommended for use.
- * Where inlets combine curb face and grate inlets, these inlet protections are used in combination

The industries that make products for erosion and sediment control are constantly coming up with new products. These products might be improvements on existing designs or designs that address inlet types that are not otherwise addressed. ODOT is generous in granting conditional approval on a project-by-project basis for products that are not on the Qualified Products List (QPL). It is desirable for ODOT to use the most appropriate BMPs on its projects, so designers should stay informed and be aware of products that best address a project's need.

INLET TYPE & SITE CONDITIONS			Area drain - soil	Area drain - Pavement	Ditch Inlet - soil	Ditch Inlet - Pavement	Grate Inlet Along Curb - Soil	Grate Inlet along Curb - Pavement	Curb Opening Inlet - Pavement	Curb Opening & Grate Inlet - Pavement
	2		Y	Y	N	N	Y	Y	N	N
	3		Y	Y	N	N	Y	Y	N	Y*
	4		Y	Y	Y	Y	Y	Y	Y	Y
	6		Y	N	Y	N	Y	N	N	N
	7		Y	Y	Y	Y	Y	Y	Y	Y*
	10		N	N	N	N	N	N	Y	Y*
	11		N	N	N	N	N	N	N	Y

*Where inlets combine curb face and grate inlets, these inlet protections are used in combination

Table 3-8 Inlet protection selection based on site conditions

MAINTENANCE

- Inspect each inlet protection during routine monitoring and after each rain event of 1/2 inch or more.
- Replacement of Type 3 inlet inserts may be more efficient than removing captured sediment
- If the Type 2 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 (not acceptable on active roadways) and provide an overflow weir or some other type of relief.
- If Type 4 or Type 7 inlet protection is damaged or displaced (by vehicles or equipment), repair or replace that inlet protection.
- Consider the effect of placing obstructions at inlets on grade may have on their hydraulic efficiency. Refer to the ODOT Hydraulics Manual or contact the Geo- Environmental Unit when placing protection at several inlets on grade along a roadway section.
- Do not use water to clean inlet and do not flush sediment into inlet.
- Remove sediment from inlet protection when it has reached 50% of its capacity.
- Repair or replace materials as needed to ensure proper functioning.

COMMON FAILURES

- The most common problems with this BMP include:
- Torn geotextile material

- Improperly sealed gaps between inlet protection and the inlet structure
- Maintenance not conducted.
- Vehicle strikes on biofilter bags, wattles or compost socks that displace the BMP or break open the BMP spilling contents
- On active roadways, motorcycle or bicycle strikes on biofilter bags, wattles or compost socks that may cause rider to fall.
- Inlet protection not removed after site is stabilized.

3.4.8 SEDIMENT TRAP

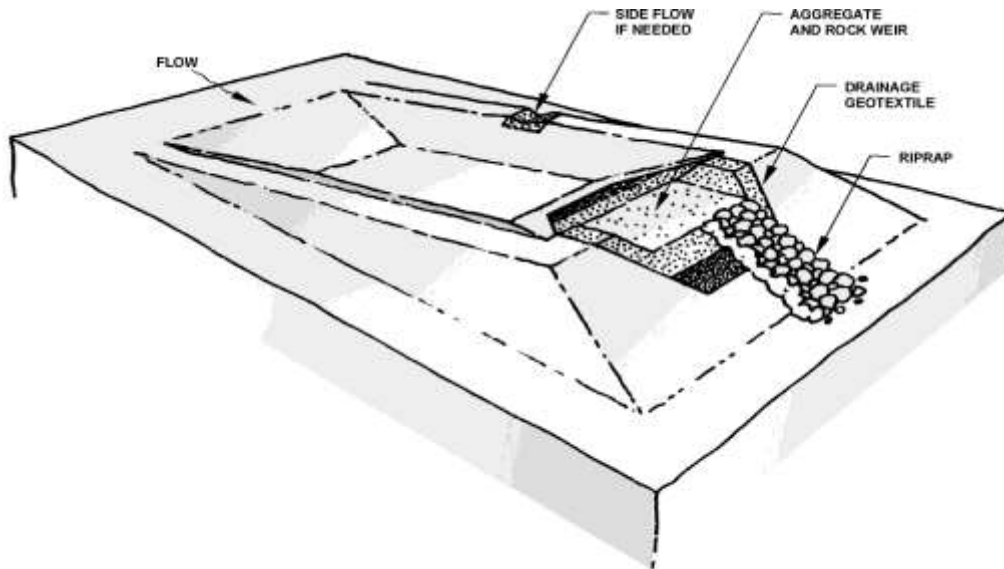


Figure 3-34 Sediment Trap

A sediment trap consists of a small, temporary ponding area, any appropriately sized basin with stabilized outlet can function as a sediment trap. The sediment trap serves drainage areas 5 acres and smaller and has a design life of approximately six months.

- Refer to the Standard Detail: [RD1065](#) Sediment Trap, located at the end of this section. Also, refer to Sediment Trap Sizing.

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.

COMBINING WITH PERMANENT DRAINAGE FACILITIES

- If a project includes a permanent storm water retention/detention pond, the rough- graded or final-graded facility could function as a trap during construction. Design features of the

permanent structure, such as surface area, retention time and outlet control, should meet the design requirements of the temporary facility. Completion of the permanent facility should occur only when all upstream control structures are in place and stabilization of contributing drainage areas is complete.

- If a project includes an infiltration facility, the roughly excavated facility could be used as a trap or basin providing the facility provides the surface area and retention time required by the trap or basin. Excavate the sides and bottom of the facility to a minimum of 2 ft. below final grade with a backhoe working at "arm's length" to minimize disturbance and compaction of the infiltration surface.
- Additionally, any required pretreatment facilities should be fully constructed prior to any release of sediment-laden water to the facility. Pretreatment and shallow excavations are intended to prevent the clogging of soil with fines.

ADVANTAGES

- 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 (0.02 mm).
- 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.

DISADVANTAGES

- 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 flocculent treatment. Erosion prevention such as seeding and mulching reduces the turbidity of water entering the trap.

DESIGN CRITERIA

- See Sediment Trap Sizing.
- Construct prior to any upslope clearing and grading.
- Locate in a low area where the trap will intercept all or most of the runoff from the disturbed area before it enters a waterway, considering safety in case structure fails.
- Locate the trap so that it is readily accessible for maintenance.
- Provide for diversion dikes and ditches, as needed, to collect and divert water toward the trap.
- Design the trap with a level bottom, 1:3 or flatter side slopes and a L:W ratio of 3. Because sediment traps are temporary, the sizing is less important to proper functioning than is constant maintenance.
- Construct the trap as the first step in the clearing and grading of the site.
- Form the trap by excavation or by construction of compacted embankment. If the trap is formed by embankment, the designer should note that dam safety regulation may apply to heights

exceeding 5 ft. The embankment should be stabilized using a cover method such as seeding, mulching, plastic sheeting or erosion control matting.

- Use floating skimmer drain inlets to remove least turbid water from surface water of sediment trap.
- Do not drain traps directly into a stream, lake or other waterway. Water temperature in the trap may be too high for direct release. Always moderate the water temperature before it drains into a lake, stream, wetland or waterway. Whenever possible, release the trap discharge onsite onto a relatively level, densely grassed area at least 60 ft. from a waterway or wetland.
- Evaluate the release areas on a site-by-site basis in order to determine appropriate locations for and methods of releasing runoff. Do not use vegetated wetlands for this purpose. Refer to the ODOT Hydraulics Manual for design guidance on culverts and channels.

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, the embankments or the slopes.

COMMON FAILURES

Most sediment trap failures are related to poor location, incorrect sizing, and poor maintenance. If sediment is not removed from the trap on a regular basis, the sediment trap may become a source of sediment pollution during large rain events.

3.4.9 FLOCCULENT TREATMENT

**Passive Water Quality Treatment Swale:**

Chitosan sleeve is installed in upstream cell of chambered treatment swale. Flocculent binds suspended sediments into larger aggregates that can be filtered or fall out of suspension in the still-water chambers.

Figure 3-35 Passive Water Quality Treatment Swale

When used in sediment control a flocculent is a clarifying agent. Flocculants as approved for use on ODOT projects is naturally occurring long chain polymers that consist of crushed crab and shrimp shells called chitosan. The flocculent is enclosed in a pervious sleeve and when turbid water is processed through the sleeve the sediments in liquid suspension aggregate together and gain size and mass so that they can fall out of suspension or be filtered. Flocculants can be used in passive treatment facilities that depend on gravity to settle out sediment, such as the treatment swales shown in photos. After turbid water flows over/through the flocculent sock the water must be provided with settling pools, check dam arrays or filters to address the aggregated sediment. Flocculants can also be used in active treatment facilities, like Baker Tanks, where pumps are used to move the water and filters capture the aggregated sediments. Again, settlement or filtration must be provided for the flocculent treatment to function. When treatment systems using tanks, pumps and filters, comply with system manufacturer's recommendations for operation and monitoring of system. Operators of flocculent treatment systems are required to be qualified in their use and operation.

3.4.10 TEMPORARY SETTLING TANKS

Temporary settling tanks are commonly known as Baker tanks or Rain For Rent tanks. These are active treatment facilities that detain, treat and release treated water.



Figure 3-36 Array of Baker Tanks

APPLICATIONS

- Projects with little available land on which to provide other treatments.
- In Temporary Settling Tanks where treatment is accelerated with the use of pumps and filters.
- Sites in proximity to salmonid streams, wetlands,
- Sites where major clearing and grading is likely to occur during the wet season.
- Sites with downstream sedimentation problems.

ADVANTAGES

- Because pumps are used, tanks do not need to be located at project low points.
- Protect downstream riparian properties from sediment deposits.
- Prevents clogging of downstream facilities.
- Remove particles up to medium silt size (0.02 mm).
- Surface water conveyances can be connected to the facility as site development proceeds.
- Proven and predictable results.

DISADVANTAGES

- Require power source to operate pumps.
- A relatively expensive BMP
- Maintenance and sediment removal are essential for adequate performance.
- Must be operated by experienced technician.
- Treatment media gets used up over time and must be replaced.

DESIGN CRITERIA

- Active system is assembled at project site. Tanks, pumps and plumbing are sized as project criteria require.

- Active systems using pumps, tanks and filters are calibrated to meter the flocculent accurately. Use all components in the system per manufacturer's recommendations
- Active systems must be operated by qualified personnel.
- Outfall must discharge into a scour hole or energy dissipater.

MAINTENANCE

- Inspect weekly and after each rain.
- Replace treatment media as necessary.
- Remove sediment when the sediment storage capacity is half-full.

COMMON FAILURES

Most failures with flocculent treatment are:

- Electricity outage
- Inadequate maintenance
- Depleted filter media are not replaced.

CHAPTER 4 POLLUTION CONTROL MEASURES AND BMP'S

4.1 MANAGEMENT OF OTHER CONSTRUCTION SITE POLLUTANTS

There are numerous potential pollutants other than sediment associated with construction activities. Potential pollutants include those associated with the use of concrete and other cement-related mortars. Standard Drawing RD1070 in the catalog of erosion and sediment control BMPs includes a simple concrete washout. Other concerns and pollutants are the handling, application, and disposal of construction products and chemicals such as paints, adhesives, and solvents. The improper use and handling of construction materials can result in wash water, spills or wastes being left on the ground. These chemicals can infiltrate into soils causing groundwater contamination or wash off to surface waters during storms. Proper handling of these materials is included in the permit requirements making violations punishable by law.

The contractor is required to develop a Pollution Control Plan (PCP) on all projects as required by Standard Specification Section 00290.30. Although this manual is not intended to address all aspects of construction site pollution control, some issues overlap with erosion and sediment control and must be taken into account in the overall planning process. At a minimum, the contractor should provide pollution prevention for 1) off-site tracking of soils, 2) material management, 3) waste management, and 4) vehicle and equipment management. Also, [Technical Advisory GE12-01\(A\)](#) provides guidance allowing diminished reliance on the 00280 Section of the Specifications for small projects.

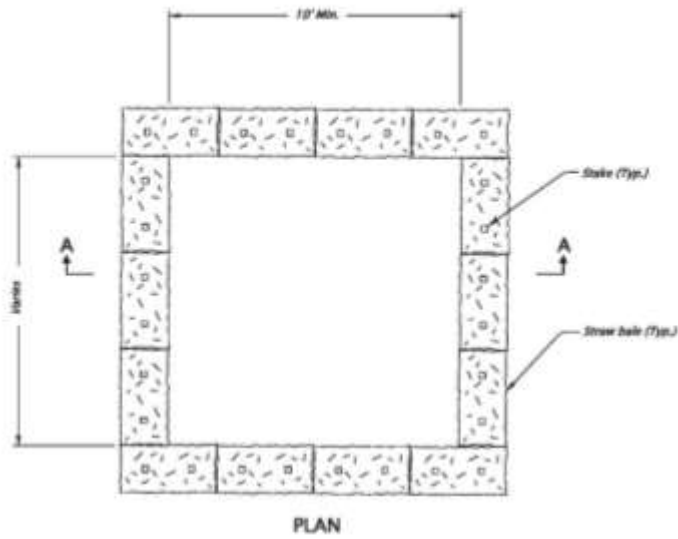
For those projects that qualify for the simplified (or eliminated) Erosion and Sediment Control Section, 00280, the Environmental Protection required in the 00290 Section becomes more important. The PCP should also include erosion and sediment control for contractor activities that are not addressed in the ESCP, including in-water work activities and on-site or off-site activities related to the project.

Each construction project is unique, and understanding the pollution risks for each construction activity is essential to successfully selecting and implementing pollution control BMP's. Defining these risks requires careful review of the site characteristics and the nature of the construction project. Once risks are defined, BMP objectives can be developed and pollution control BMP's selected. In general, the pollution control BMP objectives for construction projects are as follows:

- Practice Good Housekeeping – Perform activities in a manner which keeps potential pollutants from either draining or being transported off-site by managing pollutant sources and modifying construction activities.
- Contain Waste – Dispose of all construction waste in designated areas and keep storm water from flowing on or off of these areas.



Figure 4-1 Petroleum products are a common pollutant



See Standard Specifications Section 00290 for more information

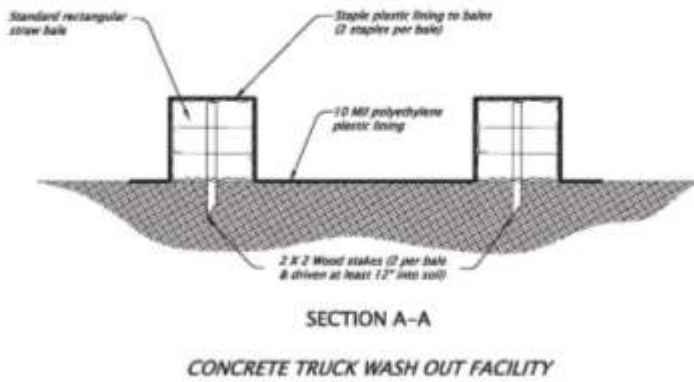


Figure 4-2 Concrete Washout - Standard Drawing RD01070

CHAPTER 5 EROSION AND SEDIMENT CONTROL PLANNING

The purpose of erosion and sediment control planning is to predict areas that are at risk of erosion, to predict where stormwater runoff will flow and to predict locations where erosion and sediment control can be most effective. This planning should establish clearly which control measures are likely to be most successful to prevent erosion and off-site sedimentation during construction. The Erosion and Sediment Control Plan (ESCP) serves as a blueprint for the location, installation, and maintenance of practices to control erosion and prevent sediment from leaving the site during construction.

Sections 1 and 2 of this chapter discuss planning issues relevant to designers, contractors and inspectors, including:

- Site information
- Data collection
- Types of construction
- Erosion prevention vs. sediment control
- Assessing the project site
- 5 basic rules
- Project scheduling
- Site characteristics

Chapter 6 discusses the ODOT ESCP design process. Chapter 6 will be of interest primarily to designers, however, much of the information included is useful to persons involved in ESCP implementation.

5.1 SITE INFORMATION

An erosion and sediment control plan must contain sufficient information to describe the site development and the system of multiple BMPs intended to control erosion and prevent permit violations and off-site damage from sedimentation. The [1200-CA permit](#) (provided in Appendix A) lists information that is required to be on the ESCP. That information is categorized under the following headings:

- Site Description
- Site Map
- Required Control Practices
- Additional Control Practices

5.2 DATA COLLECTION

The base map for the Agency ESCP is prepared from a detailed topographic map, usually developed by Agency surveyors and included in the directory of project files. A soils map should be obtained from the local office at the USDA [Natural Resource Conservation Service](#). Transferring soil survey information to the topographic map is helpful for site evaluation.

The design engineer, landscape architect or erosion and sediment control specialist responsible for the plan should inspect the site to verify the base map with respect to natural drainage patterns, drainage areas, general soil characteristics, and off-site factors. The base map should reflect such characteristics as:

- Soil types.
- Existing drainage patterns.

- Proposed drainage patterns.
- Water bodies with Ordinary High Water Elevations (OHWE).
- Watershed areas.
- Existing vegetation, noting special vegetative considerations such as high value habitats.
- Regulated areas such as wetlands or riparian corridors.
- Areas that are critical habitat for regulated or listed plant or animal species. Areas directly adjacent to critical habitat for regulated or listed plant or animal species.
- Critical areas such as steep slopes, eroding areas, rock outcroppings, and seepage zones.
- Critical or highly erodible soils that should be left undisturbed.
- In the analysis of these data, identify:
 - Buffer zones.
 - Suitable stream crossing areas.
 - Borrow and waste disposal areas.
 - Stockpile and staging areas.
 - Access routes for construction and maintenance of erosion and sediment control devices.
 - The most practicable sites for control practices.

5.3 TYPES OF CONSTRUCTION

ODOT construction projects may include new roadway alignments, shoulders, lanes, drainage improvements, bridges, culverts, retaining walls and soundwalls, structure widening, paving and pavement replacement. Other activities may include the reconstruction of interchanges, retrofitting of bridges, culverts, channel improvements, landslide stabilization, and the protection of environmentally sensitive areas. ODOT also constructs wetlands, uplands, grasslands, stream channels, riparian corridors and other landscapes as replacement or mitigation for impacts of transportation related construction. Typical activities that result in soil disturbance include clearing and grubbing existing vegetation, construction of staging areas, excavation and embankment work, construction of drainage facilities, grading of slopes, and preparation for final seeding, planting and soil stabilization. Other related construction activities generate wastewater directly, such as wet sawing of concrete or directional boring. The type of construction activities greatly affects the amount and type of BMP's which may be required.

5.4 EROSION PREVENTION VS. SEDIMENT CONTROL

It is more effective to provide erosion prevention measures rather than sediment control. Although every ESCP must have elements of both, it is more cost effective and practical to emphasize erosion prevention. Erosion prevention measures are designed to prevent exposed soil particles from becoming dislodged by rain or wind. Erosion control measures are described in Chapter 3 .

Sediment control involves the capture and retention of dislodged sediment from runoff. Sediment control measures are described in chapter 3. The benefit of erosion prevention is that it seeks to prevent the problem before it starts. It is also impractical to clarify large amounts of sediment-laden water. One half inch of rain on one acre is 67 cubic yards, so the volumes become unwieldy quickly. On projects where the predominant soil particle size is very small (fine silts and clays), the amount of time required to allow for settling of solids can reach days or even weeks. It is also generally true that erosion control measures are more reliable, whereas sediment control measures require frequent maintenance that becomes expensive. Because successful erosion control requires minimizing disturbed areas, the ESCP should emphasize scheduling and phasing. Project scheduling and phasing is often driven by factors other than erosion control. Because of this, contingency planning is essential.

After the Pre-Construction meeting, the ESCP is the responsibility of the Contractor who knows best the scheduling and the construction means and methods. During the course of construction, the ESCP is expected to be a dynamic plan that is adapted to address changes in the project.

5.5 ASSESSING THE PROJECT SITE

The erosion and sediment control plan should seek to protect the soil surface from erosion, control the volume and velocity of runoff, and 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:

5.5.1 REGULATORY REQUIREMENTS

1. Conditions and requirements of the NPDES 1200-CA permit, including potential penalties for violations or non-compliance.
2. Conditions and requirements associated with the Army Corps of Engineers 404 permit and associated 401 certification.
3. Particular requirements from local permitting agency, municipality or county.
4. Special requirements by the Oregon Department of Fish and Wildlife, Department of Environmental Quality or other agencies.
5. Recommendations and considerations, including endangered species, mentioned in the E.A., EIS, Environmental Technical Report and any other project related documents.

5.5.2 EXISTING CONDITIONS

1. Type and condition of existing vegetation.
2. Soil types expected.
3. Runoff flowing onto the construction site.
4. Swales or streams which run through the site and their watershed areas.
5. Runoff which concentrates in drainage swales or ditches.
6. Streams that could rise during high water flow.
7. Storm drain system with inlets, which might receive sediment-laden water.
8. Outlets at culverts and other storm water conveyances.
9. Permanent landscaping.

5.5.3 CONSTRUCTION CONDITIONS

1. Contract requirements as defined in erosion and sediment control plans, 00280 specifications and 00280 special provisions.
2. Construction traffic crossing a drainage swale or stream. (Do not allow driving through water. Temporary culverts and crossings are simple BMPs)
3. Runoff flowing onto the construction site.
4. Runoff that will flow onto disturbed areas having slopes 1:4 or steeper.
5. Cut or fill slopes 1:3 or steeper and higher than 6 ft.
6. Runoff leaving the disturbed areas as sheet flow.
7. Runoff leaving disturbed areas as concentrated flow.
8. Runoff from paved or other impervious areas, especially prior to completion of storm drainage system.

9. Exposed soils within 100 ft. of a waterway or wetland.
10. Disturbed areas of more than 5 acres that drain to a common location.
11. Disturbed areas of less than 5 acres that drain to a common location.
12. Staging and stockpile areas
13. Temporary alignments for traffic bypass of work area
14. On-site haul routes
15. Storm drain system with inlets that might receive sediment-laden water.
16. Outlets at culverts and other storm water conveyances.
17. Permanent landscaping

5.6 FIVE BASIC RULES

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

1. **Timing** – Schedule work to minimize overall impacts.
2. **Stage Work** – Identify and process critical areas first, look at new drainage patterns created through phases of construction. Provide erosion and sediment control fitted to conditions during each phase of construction.
3. **Minimize Disturbances** – Create buffers and reduce mass grading.
4. **Pre-construction Planning** – Identify construction sequences and lay out erosion control measures.
5. **Documentation** – Photograph/video/record existing conditions and throughout construction. Use the monitoring form [734-2361](#). Monitoring of ESCP and documentation of that monitoring is required during construction by both the 1200-CA permit and in the Specifications.

As the ownership of the ESCP moves from design to the contractor, it 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.

5.7 PROJECT SCHEDULING

Following a specified work schedule that coordinates the timing of land disturbing activities and the installation of control measures is perhaps the most cost-effective way of controlling erosion during construction. The removal of ground cover leaves a site vulnerable to accelerated erosion. Construction procedures that limit land clearing, provide the timely installation of erosion control and sedimentation 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. The Contractor's ESCP uses the construction schedule to list all major land disturbing activities that will be used to identify the erosion and sedimentation control

measures needed for a project. This type of schedule guides the contractor on work sequencing so that serious erosion and sedimentation problems can be avoided.

The Contractor's ESCP should indicate in each phase of the scheduled work, how the proposed erosion/sediment control measures will divert flows, store flows, limit runoff from exposed areas, stabilize exposed soil and filter sediment. 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 on or 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 specified linear sequence, and schedules will vary due to weather and other unpredictable factors.

Schedules for temporary and permanent erosion control work and the multiple components of the contracted work, must 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. It is uncommon that the ESCP in the project's plans will have the details of the Contractor's schedule or means and methods. The contractor may submit the ESCP from the project plans if it is correct for the proposed stage of construction. It is usually necessary for the Contractor to prepare a modified version of the Agency's ESCP, proposing using their insight regarding construction methods and site conditions at the time of construction to create a more accurate ESCP.

5.8 SITE CHARACTERISTICS

Projects should be designed to integrate existing land contours. This practice diminishes the area of exposed soil. 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 1V:2H or flatter to reduce erosion potential and increase slope stability. Steeper slopes are unstable and may increase maintenance issues.

5.9 GRADING PLAN

The grading plan should be utilized to establish drainage areas, drainage patterns, and runoff velocities. The plan should identify disturbed areas, cuts, fills, and finished project elevations. The proposed grades define the proposed flow of water and the locations where erosion risks will be introduced. The Contractor's ESCP must provide means for controlling erosion on the graded site and

minimizing sedimentation downstream for all phases of construction. These BMPs may be temporary or permanent; depending upon the need after construction is completed

CHAPTER 6 EROSION AND SEDIMENT CONTROL PLAN (ESCP) DESIGN

6.1 BACKGROUND

The purpose of erosion and sediment control planning is to clearly establish which control measures are appropriate to prevent erosion and control sedimentation during construction. The Erosion and Sediment Control Plan (ESCP) provided in the Project Plans (Agency ESCP) should serve as a guide for the location and installation of measures to control erosion and prevent sediment from leaving the site during construction. An example an Agency ESCP with explanatory notes is included in Appendix C.

The planning and design for the Agency ESCP is included in Contract Plans. Once the contract is awarded, the ESCP is “owned” by the contractor who dictates the details of the project construction. Even though the contractor is the lead on erosion and sediment control during construction, ODOT is the permittee and ultimately responsible for effective functioning of the ESCP.

The Agency ESCP also identifies measures to control volume, velocity and peak flow rates of storm water runoff so to keep the quantity and velocity of runoff leaving the site similar to conditions that existed prior to construction. Permanent storm water management facilities such as curbs, inlets, gutters, etc. may be incorporated as elements of the Contractor’s ESCP for use during construction. It is worth noting that plans must also address the stormwater runoff before these facilities are built.

In order to prevent pollution related to its construction, ODOT requires a Pollution Control Plan (PCP) as well as an Erosion and Sediment Control Plan (ESCP) for each project. For projects with minimal soil disturbance ODOT may specify that the contractor develop both the PCP and the ESCP. Otherwise, ODOT develops the ESCP and the contractor modifies it to fit the construction scenario. The contractor develops the PCP.

An approved ESCP is the primary document addressing erosion and sedimentation. The ESCP is reviewed and approved by ODOT prior to beginning construction. ODOT has 1200-CA permits for each Region and local jurisdiction permits are required if regulations for a local agency are more stringent than that described in the 1200-CA. The Agency ESCP consists of plans, details, and Specifications 00280, 00290, and 01030 in the contract documents. The Contractor’s ESCP must be available on the construction site for review.

Typically, internal review of the Agency ESCP occur at the preliminary, advanced and final stages of the project along with other sections of the contract plans. The Agency ESCP should be developed and included in the distribution of the preliminary plans. A more complete Agency ESCP, including details, specifications bid list and cost estimate, should be developed for inclusion in the advanced plans. Once the plan is developed and before the plan goes to final approval, the designer should request review of the plan, special provisions and details by an erosion control designer in the Geo-Environmental Section.

6.1.1 DESIGNER RESPONSIBILITIES

A designer puts the Agency ESCP together in the office based upon information provided from the surveyors, the roadway plans and field site visits. A variety of BMP’s should be included on the plan order to provide a variety of tools in sufficient quantity to address erosion, control runoff, sedimentation and protect the project site through all phases of construction. The Agency ESCP provides enforceable contract requirements to hold contractors accountable.

The contractor bids on the work outlined in the Agency plans, not more and not less. After the Agency ESCP is created in the office, the reality of construction and Mother Nature will change site conditions. Changes to

the Contractor's ESCP are inevitable, and mandatory. It is important that the designer anticipate wet season work, emergency materials, schedule delays and provide sufficient erosion and sediment control measures that the contractor's scope of work is adequately defined.

Once a project is in construction, it is the responsibility of the project inspector to see that the contractor keeps the project in compliance with the NPDES Permit and the contract. If the plan does not provide adequate "enforcement pieces" (BMPs, and requirements) in the Agency Plans, Specs and Estimate, the inspector might find that compliance can be difficult to enforce. The designer must anticipate erosion and sedimentation issues that could occur during construction and provide BMPs that provide final stabilization. When potential issues are addressed with a variety of BMPs and with sufficient quantity, expensive change orders can be minimized. Change orders are common, but are costly, burdensome and best avoided. Provide a good plan and keep open lines of communication with the construction team.

6.2 PLAN PREPARATION

Chapter 5 discusses the ODOT ESCP planning process. Chapter 6 will be of interest primarily to designers; however, much of the information included is useful to persons involved in ESCP implementation.

6.2.1 ASSESSING THE PROJECT SITE

To develop the ESCP, a designer must, (1) identify potential erosion and sediment problems, (2) develop design objectives, (3) formulate and evaluate alternatives, (4) select best erosion control measures to combat potential concerns and (5) develop a plan.

The following site and project information are required to be evaluated for project design:

- Surface soil types and erodability.
- Extent and location of soil disturbance (total area).
- What kind of runoff and how much is coming onto the construction site? Clean rainwater from a stabilized site, bare ground runoff, sheet flows, channel flows, etc.?
- Where is the total runoff volume going to exit and how?
- In a major rain event, what are the worst-case scenarios upstream and downstream?
- What is the overall construction environment? Urban, rural, open fields, industrial, pristine forestland?
- When will construction take place in relation to wet season? What is the construction schedule? Will construction be phased?

The designer should note the following conditions that exist:

- Requirements of permitting and local agencies. Requirements of the 1200-CA permit are plainly written in the document.
- Special requirements by Oregon Department of Fish and Wildlife, Department of Forestry, NOAA-Fisheries, or the Department of Environmental Quality. This information is gathered at project team meetings or with the assistance of the Region Environmental Coordinator (REC) or the ODOT Environmental Section.
- Type and condition of existing vegetation. Note whether the existing vegetation has root mass that is capable of holding the soil in place and a leaf canopy that can break the velocity of overland flow. If sediment is suspended in the runoff, can it settle out before it reaches surface water? Does the topography of the site trap sediment that has been entrained? These questions will help the designer to determine whether clearing limits are required.

The designer should insist on contour maps of existing and proposed conditions be provided to fully understand the nature of the topography and drainage patterns. Agency developed Drainage and Utility Plans, Roadway Plans and staging plans all provide vital information during design. Cross sections and profiles can be instrumental in helping designers understand how grading varies along a projects length.

6.2.1.1 SOIL TYPES

Knowing the type of soil found on the project site will help the designer decide upon the degree of erosion protection required. This will ensure that the ESCP is adequate to control soil movement without being overly conservative. Soil information is found in the Natural Resource Conservation Service Soil Survey, a mapped inventory by county with physical properties and characteristics described for each soil type.

One can roughly determine soil type by feeling the soil. Visit the project site and pick up a handful of soil. Rub it between your fingers. Does it feel gritty like sand or is it smooth like powder? Gritty soils may indicate a high content of sand. Clays and silts feel powdery when dry. Clay is sticky when wet. Soils that contain mostly sand will drain freely and resist erosion, but once sandy soils become saturated they are very erodible. Silts and clays absorb water slowly before becoming saturated and cause runoff of rainwater on the soil's surface. In addition, clays and silts have smaller particles that are easily detached and carried in runoff.

The soils found on a construction site are often highly disturbed and do not resemble the native soil. Consider the depth of cut on the project and what soils are there. Consider the fill material. Will these soils be erodible? Will they sustain vegetation or be covered with rock? Will they become highly compacted? Soil particle properties, such as size, shape, and density have a direct effect on soil detachment, dispersion, transport, and eventual deposition. For example, a fine textured soil having large amounts of silt is quite susceptible to erosion from rain splash and runoff. The smaller, lighter particles (fine sand and clays) are transported by water more easily than the coarser particles: as soil particle size increases the soil's erodibility decreases.

Table 6-1 USDA Particle size classes

USDA Particle Size Classes

<u>Particle name</u>	<u>Size, inches</u>	
Gravel	Greater than 0.0787	<i>Larger = Less Erodible</i>
Sand	0.0787-0.00394	
Very fine sand	0.00394-0.00197	
Silt	0.00197-0.0000787	
Clay	Less than 0.0000787	<i>Smaller = More Erodible</i>

6.2.1.2 TOPOGRAPHY

From the site visit, determine the drainage patterns from the topography. Does runoff flow from offsite through the construction site? If so, measures should be taken to re-route this clean water around (under) areas that will have ground disturbance.

Will areas of soil disturbance occur on long slopes that are greater than a 2% grade? If so, the lengths of these uninterrupted flows should be broken up so that the rainfall runoff will only flow short distances thereby decreasing flow velocity and the erosive force. In flat areas, runoff is slow and soil particles are not moved far from the point of raindrop impact. If the slopes are steep and short, surface cover may be needed to decrease runoff and promote rainfall infiltration into the soil. On steep slopes, soil movement increases dramatically. For example, on a 100 ft. long slope, doubling the gradient from 1:3 to 1:1.5 triples the soil loss. Constructing

long slopes and especially, long, steep slopes, should be avoided, however on road project that is not always possible. Steep slopes that already exist should not be disturbed.

6.2.1.3 *ESCP – DETERMINE APPLICABLE DESIGN ELEMENTS*

Once the project site has been assessed, the catch points for cuts and fills, drainage areas and drainage patterns, sensitive areas, size and location of drainage structures, and of disturbance should be located on the base map. Approximate final slope (grades) and any known problems such as highly erodible soils or unstable slopes should also be noted.

The following eight elements should be evaluated for every project. Erosion control measures should be chosen based on the elements which apply to the project and on the Best Management Practices design criteria in Chapter 4, Erosion and Sediment Control Measures and Best Management Practices.

6.2.1.4 *CLEARING LIMIT*

Limiting site disturbance is an effective method for reducing erosion. Clearing limits prevent disturbance of areas not designated for clearing or grading, protect the natural environment, provide a buffer between disturbed areas and sensitive areas and reduces the need for other erosion control measures. Clearing limits shown on the plan should be clearly marked in the field. This is not necessary outside of the project right of way.

Since clearing limits should be marked before ground disturbance occurs, the designer should show the regulated areas and sensitive areas as “no work” areas on the ESCP, even when the “no work” areas are shown elsewhere in the plans. Regulated areas, sensitive areas and their buffers may require more substantial protection such as plastic or metal safety fences or stake and wire fences. Orange type sediment fence, when used correctly as a sediment barrier can double as a boundary delineator, marking sensitive areas and their buffers. However, sediment fences should only be used for this purpose if it is also needed for sediment control.

6.2.1.5 *SENSITIVE AREA RESTRICTIONS*

Any project, regardless of size, that disturbs areas near or within a stream or associated buffer, a wetland or its associated buffer, or within 100 ft. of a lake has the potential to seriously damage water resources. Projects along or near waterways may have special requirements that should be incorporated into the Agency ESCP. Contact ODOT Environmental Section for specific requirements.

When dealing with sensitive areas, the following recommendations should be incorporated into the plan where appropriate:

- Before the rainy season, a sediment barrier should be constructed between the disturbed areas and the surface water in order to isolate the construction area from the water resource.
- Additional perimeter protection should be installed to reduce the likelihood of sediment entering the surface waters. This might include redundant sediment barriers; sediment fences in combination with sediment barriers, a berm, or application of a thick layer of mulch upslope of a sediment fence.
- Turbid runoff generated by dewatering operations should be directed through a sediment trap, a filter bag or the water released uniformly over a well-vegetated, relatively flat area. A well-vegetated area with dense grass or similar vegetation is a filter for the runoff to pass through. Since pumps are used for dewatering, it may be possible to pump the sediment-laden water away from the surface water so that vegetation can be more effectively utilized for filtration.

6.2.1.6 SURFACE WATER CONTROL (RUNOFF CONTROL)

Runoff Control collects and conveys surface water to minimize erosion and may:

- Intercept runoff on and above disturbed slopes.
- Divert offsite runoff around project.
- Convey the runoff to a sediment trap, basin or stabilized outlet.
- Release the runoff downslope of any disturbed areas.

Runoff control measures include dikes, swales, ditches, pipe slope drains and level spreaders. Interceptor dikes/swales intercept runoff and take it away from disturbed ground. Ditches and pipe slope drains convey runoff through a site. Riprap or level spreaders dissipate the velocity of runoff and release it in a non-erosive manner. Vegetation-lined channels are often preferable to pipe slope drains whenever the channel gradient does not exceed 5%. Vegetation must be adequately established prior to runoff being diverted into it. Channel liner matting is a proven BMP to stabilize channels and check dams perform well to remove sediment from turbid runoff. The channel must be accessible for maintenance.

The initial grading of an area should be conducted in coordination with stormwater runoff controls. Grading should direct flows to the runoff control BMPs. If the soils and topography are such that no offsite discharge of surface water is anticipated based on the 10-year design storm, surface water controls may not be needed. When using vegetation-lined channels, they should be established early in the project. Irrigation may be required to establish a thick, dense stand of vegetation. Grass may require mowing and removal of the dead plant material to maintain hydraulic function. If vegetation cannot be adequately established, the channel should be protected with matting or rock.

Of especial concern is the runoff control for newly constructed water quality swales. These are required features that usually rely on vegetation for the permanent stabilization. These swales are built with lightweight and very erodible soils and vegetation will not be established immediately upon completion of the feature. It is unfortunate but common that stormwater will be directed through the features prior to establishment of vegetation. Runoff control for water quality (biofiltration) swales should include an appropriate channel liner matting to cover the special soil and removable check dams that will reduce flow velocity during plant establishment.

6.2.1.7 PERIMETER PROTECTION

Perimeter protection measures are so named because they are installed at the perimeter of disturbed areas. Perimeter control must be installed prior to any ground disturbing activity and installed down gradient from ground disturbing activity. These measures both reduce runoff velocity and retain sediment while allowing water to pass. Perimeter control could also collect runoff and direct it to a sediment trap or basin for treatment. Perimeter protection can be used as the primary means of sediment removal when the catchment area is very small. It may be a secondary means of sediment removal, for instance, following a sediment trap or basin. Perimeter protection measures include sediment fence, sediment barriers. Perimeter protection is a common BMP used on linear projects such as roadway work. Perimeter protection should be used in combination with other measures.

Design and construction of perimeter control must account for concentrated runoff for the work area. Conveyance of runoff from a construction site can more safely be achieved by:

- Utilizing and supplementing existing stable ditches.
- Installing storm drains with stable outlets.
- Designing and constructing stable open channels.

The plan should indicate locations for these design facilities. Perimeter protection measures should be installed prior to clearing and grubbing. Outlets for channels, diversions, slope drains, or other structures should be completed and stabilized before water is diverted to them. Impacts to existing facilities, if they are to be used for erosion control during construction, should be evaluated.

6.2.1.8 REVISED UNIVERSAL SOIL LOSS EQUATION (RUSLE)

In order to properly design retention and conveyance structures, a designer must be able to calculate the quantities of water and sediment that will be managed by the structure. For smaller structures such as sediment traps, lined swales or check dams, design details can be developed using simple guidelines based on general assumptions about soil type and tributary area. This is generally acceptable because the failure of one of these BMP's would not generally be a catastrophic event. Moreover, maintenance of these BMP's is relatively simple and if sediment loads are higher than expected, they can be easily modified and maintained more frequently without loss of effectiveness. The design and construction of a sediment basin or large conveyance is more rigorous, however, because failure of these types of structures could seriously endanger natural resources or human life. In addition, they cannot be easily maintained when in use during the rainy season. For this reason, the designer needs to be able to calculate the quantity of sediment that will be transported or retained in a structure. The design method for calculating soil loss from disturbed land presented in this manual is the Revised Universal Soil Loss Equation (RUSLE). RUSLE estimates soil loss from a slope caused by raindrop impact and overland flow (collectively referred to as "inter-rill" erosion), plus rill erosion. It does not estimate gully or stream-channel erosion. RUSLE is a tool to estimate the rate of soil loss based on site-specific environmental conditions and a guide for the selection and design of sediment and erosion-control systems for the site. RUSLE does not determine when soil loss is excessive at a site, or when erosion-control systems have failed. The RUSLE user makes such decisions based upon numerous criteria, of which soil-loss and sediment-yield estimates are one important component.

Portions of the following paragraphs describing RUSLE were excerpted from Chapter 1 of the Guidelines for the use of RUSLE – Version 1.06, with permission of Publishing Editor Joe Galetovic of the Office of Surface Mining in Denver, Colorado. For a copy of the complete guidelines and RUSLE software, please contact:

The Office of Technology Transfer Western Regional
Coordinating Center Office of Surface Mining
1999 Broadway, Suite 3320
Denver, CO 80202-5733

The Revised Universal Soil Loss Equation (RUSLE, Renard et al., 1997) is a technology for estimating soil loss from most undisturbed lands experiencing overland flow, from lands undergoing disturbance, and from newly or established reclaimed lands. RUSLE also may be used as a part of the procedures to prepare permit applications and to assess reclamation success in support of bond release.

Erosion Terminology

Several terms are used in association with the removal of soil from the land surface. Although there is not complete agreement in the connotations attributed to these terms, the following definitions are employed in this report.

- Erosion includes a group of processes by which earth materials are detached, entrained and transported across a given surface.
- Soil loss is that material actually removed from the particular hillslope or hillslope segment. The soil loss may be less than erosion due to onsite deposition in micro-topographic depressions on the hillslope.
- Sediment yield from a surface is the sum of the soil losses minus deposition in macro-topographic depressions, at the toe of the hillslope, along field boundaries, or in terraces and channels sculpted into the hillslope.

RUSLE estimates soil loss from a hillslope caused by raindrop impact and overland flow (collectively referred to as "interrill" erosion), plus rill erosion. It does not estimate gully or stream-channel erosion.

The RUSLE Model

RUSLE is a set of mathematical equations that estimate average annual soil loss and sediment yield resulting from interrill and rill erosion. It is derived from the theory of erosion processes, more than 10,000 plot-years of data from natural rainfall plots, and numerous rainfall-simulation plots. RUSLE is an exceptionally well-validated and documented equation. A strength of RUSLE is that it was developed by a group of nationally recognized scientists and soil conservationists who had considerable experience with erosional processes (Soil and Water Conservation Society, 1993).

RUSLE retains the structure of its predecessor, the Universal Soil Loss Equation (USLE, Wischmeier and Smith, 1978), namely:

$$A = R K L S C P \quad (1)$$

Where: A = Average annual soil loss in tons per acre per year
R = Rainfall/runoff erosivity

K = Soil erodibility

LS = Hillslope length and steepness
C = Cover-management

P = Support practice

In overview, the R, K and LS values are integers that when factored in the equation increase soil loss values and the C and P values are decimal fractions that when factored in the equation decrease soil loss values.

The R factor is an expression of the erosivity of rainfall and runoff at a particular location. The value of "R" increases as the amount and intensity of rainfall increase. For user convenience, these data are contained in the CITY database file provided within the computer program. The basic program includes the files for numerous cities throughout the United States, but many more site-specific files are available within each state from the offices of the United States Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS); formerly the Soil Conservation Service, (SCS).

The K factor is an expression of the inherent erodibility of the soil or surface material at a particular site under standard experimental conditions. The value of "K" is a function of the particle-size distribution, organic-matter content, structure, and permeability of the soil or surface material. For undisturbed soils, the nomograph equations embedded within the RUSLE program are used to compute appropriate erodibility values.

The LS factor is an expression of the effect of topography, specifically hillslope length and steepness, on rates of soil loss at a particular site. The value of "LS" increases as hillslope length and steepness increase, under the assumption that runoff accumulates and accelerates in the downslope direction. This assumption is usually valid for lands experiencing overland flow but may not be valid for forest and other densely vegetated areas.

The C factor is an expression of the effects of surface covers and roughness on rates of soil loss at a particular site. The value of "C" decreases as surface cover increases, thus protecting the soil from rain splash and runoff. For user convenience in determining the "C" factor, a VEGETATION database file is contained within the computer program that characterizes numerous plant types. Likewise, the files include other types of surface treatments used as temporary covers for erosion control.

RUSLE also contains an OPERATIONS database file that characterizes the effects of various soil-disturbing activities on soil-loss rates. These operations alter the roughness, infiltration, distribution of biomass, and runoff properties of the surface. The operations usually are common tillage activities that may be used in the development of a seedbed at reclaimed sites. The files include activities specific to erosion control and disturbed-land reclamation. The effectiveness of cover-management sub-factors varies with local conditions.

Therefore, the user is strongly encouraged to calculate C values through the RUSLE equations rather than selecting values from generalized tables.

The P factor is an expression of the effects of supporting conservation practices, such as contouring, buffer strips of close-growing vegetation, and terracing, on soil loss at a particular site. The value of "P" decreases with the installation of these practices because they reduce runoff volume and velocity and encourage the deposition of sediment on the hillslope surface. The effectiveness of certain erosion-control practices varies substantially due to local conditions. For example, contouring is far more effective in low-rainfall areas than in high-rainfall areas.

Therefore, the user is strongly encouraged to calculate P values through the RUSLE equations rather than selecting values from generalized tables.

Care must be exercised to insure that all data inputs are accurate because they may affect several components of soil-loss estimation. It is often prudent to consult with qualified earth and environmental scientists to affirm the accuracy of the data inputs. Further, the soil-loss estimates produced by RUSLE rest upon the assumption that factor inputs accurately reflect field conditions. Factor adjustments are required whenever actual conditions depart from specification.

The recommendations provided herein for the use of RUSLE on mining, construction, and reclaimed land applications represent the best judgment of the Working Group. It is the user's responsibility to determine whether or not RUSLE is applicable to a particular field situation.

These guidelines provide direction for maximizing the accuracy of RUSLE soil-loss estimates on construction sites, and reclaimed lands.

RUSLE is a tool to estimate the rate of soil loss based on site-specific environmental conditions and a guide for the selection and design of sediment and erosion-control systems for the site.

RUSLE does not determine when soil loss is excessive at a site, or when erosion control systems have failed. According to 1200-CA permit which regulates ODOT construction, the determining factor for the success or failure of erosion control systems is if sediment or sediment-laden water has left the project site.

6.2.1.9 SEDIMENT RETENTION

Sediment retention measures remove sediment from runoff by holding a volume of water for a length of time, allowing soil particles to settle out of liquid suspension. Sediment retention is used as a last line of defense when included in an ESCP. Other design elements must also be included in the plan to assure sediment from erosion is under control.

When sediment retention is used by itself, the potential for catastrophic failures is high. Sediment traps are a common facility used for sediment retention. When a sediment trap is required, it should be shown on the ESCP with the dimensions of each trap described on the sediment trap detail or plan sheets.

Sediment Trap Sizing

Sediment traps must be sized to handle the area contributing sediment-laden runoff. The following design criteria are based on a variation of the Rational Formula, allowing a relatively simple set of calculations to be used to size the traps, while accounting for rainfall patterns that occur in different hydrologic zones across the state. Facilities designed to collect contributing areas up to 5 acres can use these design criteria. Facilities designed to collect contributing areas larger than 5 acres must use more thorough design criteria and would then be considered a Sediment Basin. Refer to the Volume 1 of the ODOT Hydraulics Manual for more detailed designed guidance.

STEP 1: Calculate the Storage Volume (V), using a variation of the Rational Formula.

Determine the volume of rainfall generated by the 10-year, 6-hour rainfall event over the contributing area to the trap.

$$V = (C) \times (I) \times (A) \times (\text{Duration})$$

Constants (assumed)

C = 0.5 = runoff Coefficient assumed to represent smooth graded area with no vegetation.

Duration = T_C = Time of Concentration = 6 hrs. = **21,600 sec**

STEP 1-A: Determine area contributing sediment laden runoff to the sediment trap. Areas with existing vegetation or paved surfaces need not be included when determining this area.

A = Contributing Area (acre)

STEP 1-B: Determine hydrologic zone within which the project site is located. Refer to I-D- R Curve Zone Map in Appendix D.

Zone = Hydrologic Zone

STEP 1-C: Determine rainfall intensity generated by the 10-year, 6-hour rainfall event. Use the following table to select the appropriate intensity.

I_{10} = Intensity (in/hr)

Zone	1	2	3	4	5	6	7	8	9	10	11	12	13
I_{10} (in/hr)	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1
	5	2	7	7	7		7	8	5	9	8	9	5

STEP 1-D: Determine the volume of required storage.

By using the formula described in STEP 1 and applying the assumed constants, the formula can be simplified to:

$$V \text{ (ft.}^3\text{)} = I A (10,800)$$

Divide the storage volume evenly between dry and wet storage. The wet storage normally occupies the bottom two-thirds of the trap depth. **Example**

Required: Determine required volume for a temporary sediment trap. Given: A = 1.2 acre;

Site Location = Alsea, Oregon

Solution: Alsea is located in Zone 4; I_{10} for 6-hr storm in Zone 4 = 0.37 in/hr.

$$V = (0.37 \text{ in/hr}) \times (1.2 \text{ acre}) \times (10,800) = \underline{\underline{4,795 \text{ ft.}^3}}$$

STEP 2: Calculate the dimensions of the sediment trap by satisfying the volume requirements.

The trap dimensions must be assumed and then the volume of the trap based on the initial assumptions can be calculated using the following:

$$V = [LWD] + [(L+W)ZD^2] + [4/3Z^2D^3]$$

Where:

V = Storage Volume

W = Width of Trap on Bottom

L	=	Length of Trap on Bottom
D	=	Depth of Trap
Z	=	Side slope (1:Z; vertical to horizontal)

Example

Required: Determine volume of proposed temporary sediment trap. Given:

$$W = 10 \text{ ft.}, L = 30 \text{ ft.}, D = 4.5 \text{ ft.}, Z = 3$$

Solution: $V = [30 \times 10 \times 4.5] + [(30+10) \times 3 \times 4.5^2] + [(4/3) \times 3^2 \times 4.5^3] = \underline{\underline{4,874 \text{ ft.}^3}}$

STEP 3: Outlet Structure Design: The outlet structure for a temporary sediment trap should be sized to handle expected flows. For most sediment traps a rock weir (spillway) will be sufficient. For larger flows or areas with heavy sediment loading a perforated riser pipe may need to be used as outlet to the trap.

ROCK WIER The crest of the weir should be 1 ft. below the top of the embankment. The weir should be constructed of two layers of different size rock. The top 12 in. must be 3-6 in. riprap. The bottom layer should be of a smaller size. If large flows are expected, the size of the rock should be designed for stability in accordance with Volume 1 of the ODOT Hydraulics Manual.

Rock Weir Sizing: The weir length (X) can be estimated using the broad crested weir equation and assuming a 1 in. flow depth over the weir (H). The amount of flow going over the weir can be estimated using the information developed for sizing the trap. Assume a weir coefficient (C_w) of 0.4.

$$Q = C I^{10} A \quad (\text{Rational Formula})$$

$$X = \{(3/16) Q/C - [0.8(\tan \Theta) H^{2.5}]\} / H^{1.5} \quad (\text{Broad Crested Weir Formula})$$

$X \text{ (ft.)} = 6 I^{10} A$

Example

Required: Determine length of rock weir.

Given: $A = 1.2$ acre; Site Location = Alsea, Oregon

Solution: Alsea is located in Zone 4; I_{10} for 6-hr storm in Zone 4 = 0.37 in/hr.

$$X = (6) \times (0.37 \text{ in/hr}) \times (1.2 \text{ acre}) = 2.7 \text{ ft. } \underline{\underline{\text{use 3 ft. min}}}$$

RISER PIPE An alternate to the rock weir outlet is a riser pipe. A typical detail for the riser pipe should show the following:

- Pipe slit perforations, which are .6 in. wide by 6 in. long, or 1 in. diameter holes spaced 6 in. vertically and horizontally from the outside edges above the wet storage elevation.

- The riser pipe should be wrapped with .3 to .6 in. wire hardware cloth and covered with geotextile overlapped, folded and fastened at the seam. The geotextile should extend 6 in. above and below the highest and lowest slits and should be secured top and bottom with straps or connecting bands.
- Anchor the riser using a concrete or steel base. The concrete base should be 20 in. deep with the riser embedded 10 in. The steel base should be .3 in. thick, welded watertight to the riser and covered with 2 ft. of stone or gravel.
- Table 6-3 gives riser pipe diameters for different size drainage areas.

Table 6-2 Outlet riser pipe diameters.

Maximum Area	Drainage	Minimum Diameter	Barrel	Minimum Diameter	Riser
1 acre		24 in.		15 in.	
2 acres		15 in.		18 in.	
3 acres		18 in.		21 in.	
4 acres		21 in.		24 in.	
5 acres		21 in.		27 in.	

Recommended Limits

A list of recommended size limits must be checked prior to completing the trap sizing calculations. These limits include:

Table 6-3 List of recommended outlet riser pipe diameters

Recommended Limits		
Variable	Min	Max
V	890	17,658
D	1.1	1.5
L	3	N/A
W	1	N/A
L/W	2	N/A
Z	2	N/A
X	1	N/A

- V Acceptable volumes using this design criteria are 890 ft.³ to 17,658 ft.³.
Sediment traps smaller than 33 yd.³ are equivalent to a check dam. Sediment traps larger than 654 yd.³ are considered a sediment basin and designed using more thorough methods.

D	Sediment traps shallower than 3 ft. will not provide adequate settling depth or wet vs. dry storage volume separation. Sediment traps deeper than 5 ft. are considered a sediment basin and designed using more thorough methods.
L	Any sediment trap shorter than 10 ft. is equivalent to a check dam.
L/W	Calculate the trap length (L) using: $L = 3W$ If site conditions disallow a 1:3 L/W ratio, a 1:2 may be used if the traps are small in size.
W	Any sediment trap narrower than 3 ft. is equivalent to a check dam.
Z	Optimum side slopes are 1:3. Side slopes as steep as 1:2 can be used if site conditions cannot sustain flatter slopes. Slopes may be steeper than 1:2 if ground consists of stable rock.
X	Rock weirs (spillway) narrower than 3 ft. provide less effective flow spreading and may contribute to erosion downstream.

Design Options

Site conditions often dictate sediment trap sizes and locations. When required sediment trap volumes exceed feasible site location conditions the following options can be considered:

- Design smaller sediment traps and place them in series instead of providing one large sediment trap.
- Limiting areas of disturbance (which reduces the area the sediment trap must serve).

Spreadsheet Analysis

A spreadsheet has been developed to assist designing temporary sediment traps. The spreadsheet calculates STEP 1, STEP 2, STEP 3 (rock weir only) and checks the recommended limits. The location of the spreadsheet is discussed in section 6.3.

6.2.2 COVER MEASURES

Temporary and permanent cover measures protect disturbed areas. Covering exposed soils prevents erosion, thus reducing reliance on less effective sediment removal. Ideally, all disturbed ground not being worked should be covered to prevent wind and water erosion.

Temporary cover protects disturbed areas not at finished grade or areas that will be redisturbed at a later date. Temporary cover methods include mulch, erosion control matting, plastic sheeting, seeding, sodding, and others as discussed in Chapter 3. Mulch and plastic sheeting protect disturbed areas from days to a few months. Plastic sheeting is most applicable to short-term stockpile protection and on certain slopes steeper than 1:1.5. Seeding and sodding can protect uncovered areas for months. Soil stockpiles should always be protected with plastic sheeting, tarpaulins, sediment barriers, diversion dikes, or combinations thereof.

Permanent cover methods include seeding and mulching, erosion control matting with seed, riprap, gravel, mulch with tree and shrub planting and sodding.

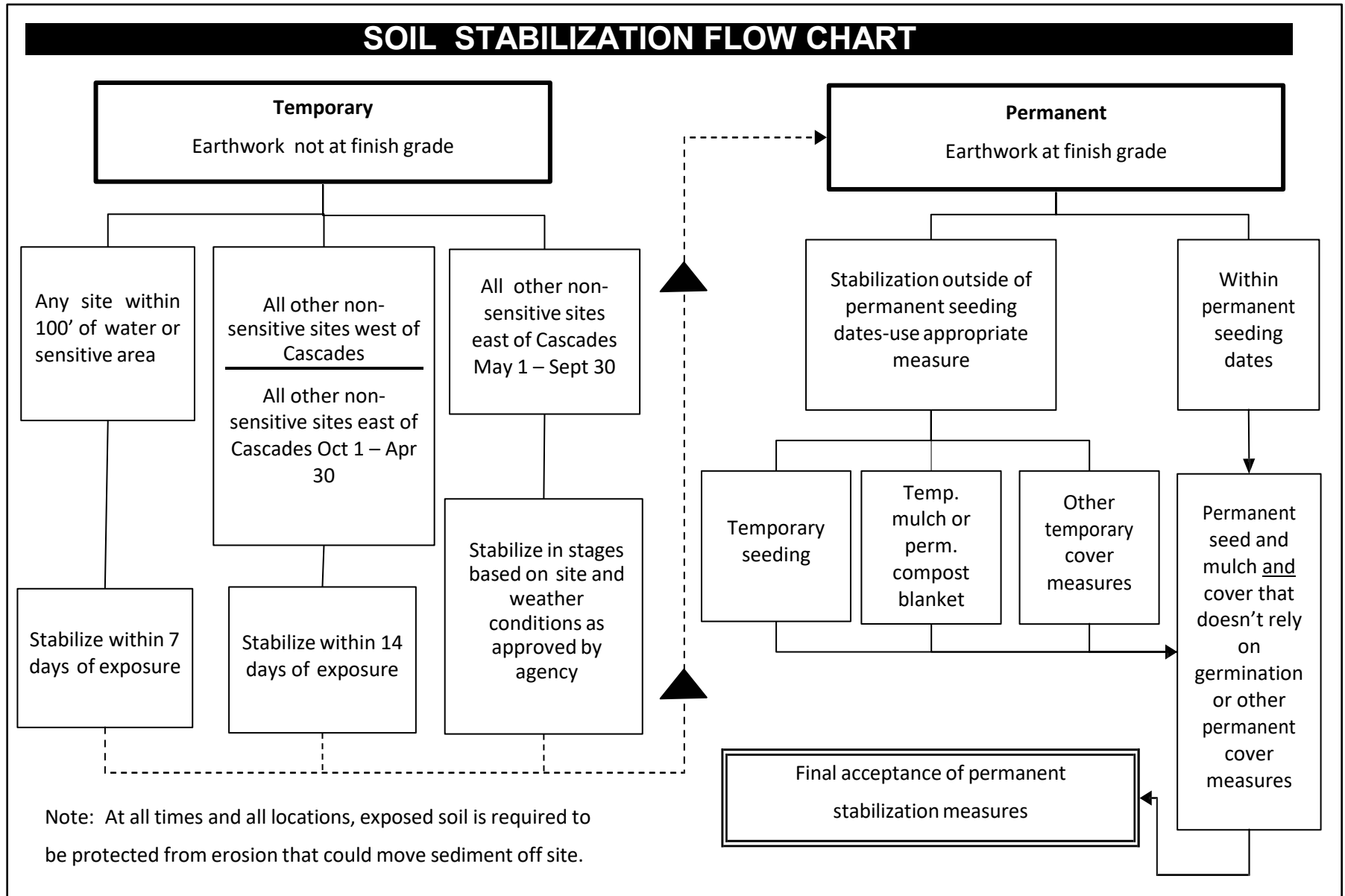


Figure 6-1 Flow diagram of the stabilization requirements found in specifications

Cover measures are described in Section 00280 of the Standard Specifications and seeding dates are described in Section 01030.

6.2.3 MATTING

Matting that is appropriate for use on ODOT construction projects and included in ODOTS Qualified Products List (QPL) it must be tested and approved by the Texas Department of Transportation (TXDOT). For roll-type and spray-on erosion control products used to stabilize and revegetate slopes or drainage channels, TXDOT test for two critical performance standards:

1. How well the product protects the surface of the slope or the geometry of the channel from loss of sediment.
2. How well the product promoted the establishment of warm-season perennial vegetation over time.

TXDOT engineers believe that in order for a product to be placed on its Approved Product List (APL), it must meet or exceed the adopted standards for both the sediment loss and the vegetation density factors. A failure within either one prevents a product from being included on the APL.

By analyzing how products actually performed, TXDOT has established both a maximum allowable sediment loss standard and a minimum vegetation density standard for each of four possible slope/soil combinations on an embankment.

To determine the type of matting that will be appropriate for slope protection, the designer must know the soil type and the slope steepness, i.e. 1:2 or 1:3 (V:H). To determine the type of matting appropriate for channel lining, the designer must know the shear stress on the channel bottom. The procedure for determining shear stress is described in Volume 1 of the ODOT Hydraulics Manual.

The latest performance information and the [APL](#) are available on the Web.

The ODOT Specifications list eight-performance grades of slope and channel liner matting that are categorized by letter. Types A, B, C, D and E, the five lightest grades of matting, are required to be fully biodegradable (photodegradable components are not acceptable). Matting types F, G and H are Turf Reinforcement Mattings (TRMs) or channel liner mattings that are robust and usually permanent erosion prevention mattings.

Areas of the ESCP that require erosion control matting should be shown using a patterning that is reflected in the legend.

6.2.4 TRAFFIC AREA STABILIZATION

The stabilization of unpaved roads in the work area, staging areas and construction entrance are required by the 1200-CA permit (Schedule A (3) (c) i and ii). This reduces the amount of sediment that can end up in the drainage system by minimizing the amount of sediment tracked offsite. Construction road and parking area stabilization also reduces safety hazards and nuisance complaints caused by sediment tracking onto public right-of-way. Stabilization of haul routes is also an excellent form of dust control in the summer months. Traffic area stabilization methods covered in this manual include construction entrance stabilization and construction road/parking area stabilization. Construction entrances are needed to prevent sediment from being tracked offsite or onto paved surfaces and required by the 1200-CA permit. They should be included on the plans, legend, and in the cost estimate. Equipment servicing areas and other areas that require stabilization are included in the Pollution Control Plan and need not be shown in the ESCP or paid for separately.

6.2.5 DUST CONTROL

Dust control measures minimize the transport of soil by wind, thereby reducing traffic hazards and sediment deposition in water resources. Watering is the most common dust control (palliative) used. Other methods include mulching, seeding, gravel, or spraying exposed areas with an approved dust palliative – see Qualified Products List. Oil, waste, and wastewater are prohibited for use as dust control. Using covered haul equipment reduces dust from materials transported offsite. Measures strictly for dust control are included in the Pollution Control Plan however if chemical soil binder or other pay items are specified in plans or special provisions for dust control they must be included in the cost estimate. Dirt that has been tracked onto pavement is a conspicuous source of dust and it is a permit violation and must be removed. A vacuum sweeper is the appropriate tool for dirt removal from pavement. It is never acceptable to allow the flushing of dirt from pavement into waterways or storm sewer systems.

6.2.6 ADDITIONAL DESIGN FEATURES

In addition to the addressing the issues noted above, the 1200-CA outlines items that are required to be included in an Agency ESCP.

- Site Description: A description of the following:
 - Nature of the construction activity, including a proposed timetable for major activities.
 - Estimates of the total area of the permitted site and the area of the site that is expected to undergo clearing, grading and/or excavation.
 - Nature of the fill material to be used, the insitu soils, and the erosion potential for such soils.
 - Names of the receiving water(s) for storm water runoff
- Site Map indicating the following: (A general location map in addition to a site map is required)
 - Area of total development
- Show clearing limits, drainage courses, easements, right-of-way boundary, setbacks, and sensitive areas and their buffers, no work areas and areas of preserved vegetation.
- Provide controls such as check dams at features such as cuts and fills; cut and fill transitions and use storm drain inlet protection.
- Provide erosion prevention measures such as matting and intermediate sediment barriers on slopes.
- Provide permanent stabilization measures such as seeding on all disturbed soils.
- Provide energy dissipation at culvert outlets when needed such as scour basins.
- Provide velocity control structures such as check dams or temporary slope drains along steep slopes and grades.

Once the applicable design elements are determined, plan sheets can be developed using the base map. The plan sheets should include enough information at a scale large enough to clearly communicate the ESCP to contractors, inspectors and permitting jurisdictions.

The erosion and sediment control products industry is constantly providing new products and specialized products for unique applications. The industry is developing filtering sediment barriers, new types of inlet protections for trench drains and other unique inlets. Specialized fully biodegradable products are available to provide temporary strengthening for stream channels while vegetative stabilization gets established. Keep apprised of industry advances their use can reduce risk and save the Agency time and money.

6.3 DEVELOP BASE MAP

The base map for erosion and sediment control plans can easily be developed from the roadway construction base map. Erosion and sediment control plans should be plotted at the same scale as that of the rest of the roadway plans. Topographic features for both existing and proposed conditions are important because erosion and sediment control plans must address the transition between those conditions. Contours and sensitive areas are important because the length of slope and steepness of slope is used to determine the level of erosion protection. Sensitive areas, Regulated areas and no-work zones must be shown. Grading limits and their proximity to water features or other sensitive areas will tell the designer when to use perimeter protection or another method that will trap sediments before they reach the water. Cut and fill lines are necessary to determine whether perimeter erosion protection is required such as sediment barriers or if check dams are needed when determining how the project grading will change the existing topography at the site.

The existing and proposed storm drainage features are required so the designer can evaluate where inlet or outlet protection measures will be needed. Drainage ditches may need check dams to slow the runoff from the project site in order to settle out sediments. Water quality features need to be fitted with robust erosion and runoff controls to protect and stabilize the special treatment soils during the time that vegetation is being established. Erosion features should be selected with the foreknowledge o.

The base map should be plotted at a scale large enough to easily distinguish important features such as drainage swales and topography. The base map should include the following information:

- Alignment and stations.
- Names of roads and waterways.
- Right of Way and easements.
- Storm water drainage (culverts, pipes, etc.).
- Natural drainage features (lakes, swales, rivers, streams, wetlands, etc.).
- Cut and fill lines and expected slopes.
- Topography outside cuts and fills.
- Roadway grades.
- Extent of surrounding development.
- Detours and detour structures.

6.4 DEVELOP PLAN SHEETS

The [ODOT Contract Plans Development Guide](#), has been supplanted by the [Contract Plans Manual](#). The ESCP Plan Sheets will follow the templates outlined in the Contract Plans Manual. The following is a list of items that should be included in the Agency ESCP:

Plan Sheet Checklist

- Sheet title, sheet number and “V” number
- Plan sheet (DEK.DGN and PLANS.DGN)
- ODOT flying tee logo
- Notes in the lower right corner (as sheet layout allows)
- Reference to standard drawings (if necessary)
- Signature block
- Engineer or landscape architect’s stamp (all ESCP sheets)
- Location of Best Management Practices (BMP) using standard symbols
- Erosion control construction notes and reference bubbles
- Existing ground contour lines in 1 or 2 foot increments (screening optional) with major elevations labeled
- Proposed grading contours (optional)
- Cut and fill lines and topography outside cuts and fills
- Erosion control BMP’s, relative to construction staging (optional)
- Alignment showing line labels and stationing ahead on line
- Place names including roads and all waterways
- Right of Way and easements
- Storm water drainage system (culverts, pipes, inlets)
- Natural drainage features (lakes, swales, rivers, streams, etc.)
- Arrows indicating drainage patterns and flow directions
- Show boundaries of environmentally sensitive areas such as wetlands, burial grounds, etc.
- Location and names of Best Management Practices (BMP) including aggregate construction entrances
- Delineation of clearing limits
- Construction notes for each plan sheet giving construction directions
- North Arrow on each plan sheet
- Legend of ODOT standard symbols actually used per plan sheet
- Existing structures

6.4.1 EROSION CONTROL CONSTRUCTION NOTES

The boilerplate language for the construction notes is found in the cache of erosion control cells that provides typically used symbols accessed in Microstation. The cache can be accessed through the tab “element” and then “cells”. (See Chapter 8 of the Contract Plans Manual). The Construction Notes should be put on the first ESCP plan sheet. Use only the paragraphs that are pertinent to the plan. For example,

when aggregate construction entrances are not used in the plan, the final paragraph must be deleted from the construction notes. Also, if sediment fences are not used on the project, delete the paragraph that pertains to sediment fence. The designer may add language in the construction notes to direct the contractor or to further explain the ESCP.

GENERAL NOTES:

The construction, adjustment, maintenance, and upgrade of these Erosion and Sediment Control measures is the responsibility of the contractor for the duration of the project to comply with Section 00280 of the Oregon Standard Specifications for construction and the NPDES 1200-CA permit

Erosion and Sediment Control measures shown on this plan are for anticipated site conditions. Adjust or upgrade these measures for unexpected storm events to ensure that sediment and sediment-laden water does not leave the site.

Develop a revised plan for the Erosion and Sediment Control measures shown as required by Section 00280, Oregon Standard Specifications for Construction. Implement this plan for all clearing and grading activities and in segments applicable to each staging phase. Construct in such a manner so as to ensure that sediment and sediment-laden water does not enter the roadway or drainage system, or violate applicable water standards.

Install measures within the right-of-way unless directed otherwise.

6.4.2 EROSION CONTROL LEGEND

The ESCP and construction legend should meet the same standards as given for the roadway portion of the plans. Show in the legend only the items that are included in the ESCP design.

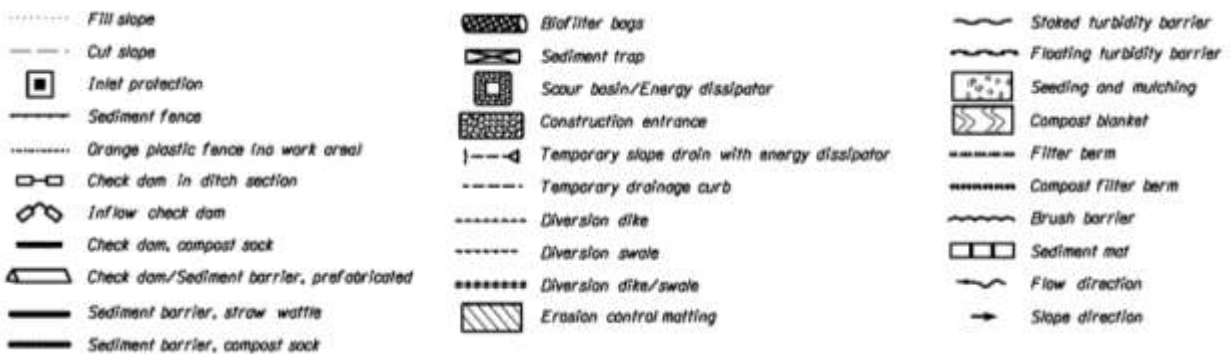


Figure 6-2 EROSION CONTROL LEGEND

6.4.3 PLAN SHEET FORMAT

In the project plan set the Agency ESCP is usually its own section numbered in the convention of the Contract Plans Manual. Erosion and Sediment Control Plans are the FB series, being numbered: FB01, FB02 etc. On small projects with little ground disturbance the erosion and sediment control BMPs may be included in the roadway construction plans.

The ESCP is normally a separate section of the contract plans and is 11" X 17" sheet size as is most common for contract plans developed in the ODOT Roadway Section. The detail sheets follow the plan

sheets in the erosion and sediment control section. Each plan and detail sheet will all have a professional of record's stamp. The sheets in the ESCP set will also include the name of the drafter, designer and the reviewer.

The ESCP can have the following formats:

- 11 X 17 sheets with a separate ESCP section in the plans.
- 11 X 17 sheets with the ESCP incorporated into the Roadway plans
- Table of Locations

In the event that the ESCP is not too complicated and the roadway plans can accommodate additional items without appearing confusing, the erosion control items can be placed on the roadway construction plans. It is important to include a legend that reflects the erosion control items. In this case, the construction notes should be on the first erosion control page of the first standard detail sheet.

6.4.4 TABLE OF LOCATION PLAN SHEET FORMAT

Although this ESCP format is rarely used, when the project is long and the need for erosion control best management practices is limited to sporadic locations this format is effective. At a minimum, the ESCP must include the table of location, the erosion control construction notes, and the details for each best management practice called for on the table of locations. The table of locations must include the location where the erosion control method is needed. The locations should be noted using English stationing as provided on the Roadway General Construction sheets. The erosion control item is listed by station as well as which side of the road that it should be installed. An *L* is used for left or *R* for right by increasing station. The page number reference for the corresponding plan sheet displaying the detail or the Standard Drawing reference should also be included. Below is an example of an ESCP table of locations.

Table 6-4 EROSION SEDIMENT CONTROL PLAN TABLE OF LOCATION

Station	(L/R)	Erosion Control BMP	Quantity	Plan Sheet
"L" 1+61 – 1+75	Lt.	Sediment Fence		FB02
"NB" 1+65	Lt.	Inlet Protection, Type 3	2	FB02
"L" 1+79 -	Rt.	Inlet Protection, Type 3	2	FB03
"L" 0+98 to "L" 1+99	Lt.	Sediment Barrier, Type 8	101'	FB04
"L" 1+14 to "L" 1+18	Lt.	Sediment Fence	4'	FB06
"NB" 1+32	Rt.	Inlet Protection (Type 3)	1	FB06
"L" 1+94 to "L" 1+96	Rt.	Sediment Fence	2'	FB07

6.5 DESIGNER TOOLS

6.5.1 SOIL SURVEY INFORMATION

The [USDA's Natural Resource Conservation Service \(NRCS\)](#) has soil surveys available on line. The NRCS has the soil surveys organized by county. The county soil survey contains a lot of information useful for any land-planning program. Of prime importance are the predictions of soil behavior for selected land uses. Great differences in soil properties can occur even within short distances. Soils may be seasonally wet or subject to flooding. They may be shallow to bedrock.

These and many other soil properties that affect land use are described in the soil survey. Broad areas of soils are shown on a general soil map. The location of each kind of soil is shown on detailed soil maps. Each kind of soil in the survey area is described, and much information is given about each soil for specific uses. Additional information or assistance in using this publication can be obtained from the local office of the Natural Resource Conservation Service. The [NRCS county offices](#) are listed on their web page.

6.5.2 CONTRACT PLANS DEVELOPMENT GUIDE/CONTRACT PLANS MANUAL

The [Contract Plans Development Guide](#) (CPDG) is currently being phased out. It is being replaced with the [Contract Plans Manual](#). At the time of this writing, the Contract Plans Manual is under development. There are conflicts between the two manuals. The changes are driven, in part because ODOT continues to embrace technology and it needs to shape its processes to work with that model. An example of the changes is that the sheet order and sheet numbering protocol is revised. ODOT now provides final plans electronically as PDFs with digital signatures. When conflicts between the two manuals are found, follow directions provided in the Contract Plans Manual. For the production of plan sheets much of the method for putting together the contract plans remains the unchanged. One significant change is that the file management for our graphic files (plans) is now centralized in the ProjectWise file management system. As noted in the CPDG, drafting is done in Microstation™.

When the Contract Plans Manual is completed, the Manual will outline the organization and structure of Contract Plans and provide comprehensive guidance for the organization of drawings and drafting standards.

6.5.3 HYDRAULICS MANUAL

The [ODOT Hydraulics Manual](#) is available from the Geo-Environmental Unit's Practices & Standards Unit. This manual provides practices and procedures used by ODOT for the hydraulic design of highway facilities. Within this manual there is a wealth of resources that can be valuable in planning erosion and sediment control plans. Among the resources are topographic data, 24-hour precipitation maps and information about stormwater treatment. It is worthwhile for Erosion and Sediment Control Designers to be familiar with its contents.

6.5.4 PRECIPITATION DATA

The occurrence and amounts of rainfall is important for the designer when deciding to what extent the erosion control measures must be used. During construction, the contractor must monitor the rainfall onsite using a rain gauge. Precipitation data may be found by contacting the [National Weather Service](#). This web site provide multiple tabs and a search engine to provide information on temperatures, wind

direction, relative humidity, and precipitation all over the United States including the Oregon Coast and Pacific Northwest.

6.5.5 INTERNET SITES

[Oregon Seed Certification Service](#)

[Natural Resource Conservation Service](#)

[International Erosion Control Association](#)

[Qualified Products List:](#)

[TXDOT Erosion Control](#)

[ODOT FTP Site](#)

[ODOT Standard Drawings](#) Erosion & Sediment Control 1000 Series

[ODOT Standard Details](#) Erosion & Sediment Control 6100 Series

[Roadside Development Manual](#)

6.6 COST ESTIMATE

The ESCP designer prepares a quantity and cost estimate for specific erosion control best management practices included in the ESCP. The designer must compile a list of all erosion control bid items and estimate a cost for each of the bid items.

A project cost estimate normally includes a lump sum bid item called “Erosion Control”. This item is for developing and updating the Erosion and Sediment Control Plan (ESCP) required in section 00280, and also covers any additional work required but not included in the Bid Schedule, including monitoring and reporting on BMP’s and providing an Erosion and Sediment Control Manager (ESCM). When developing the cost estimate follow the format provided in the ODOT [Bid Item List](#). The bid item list provides the ODOT item number, the exact language to be used in naming the item and the unit of measure associated with each item. Following the example provided in the bid item list simplifies work for specifications technician and design engineer who compiles cost estimates from all disciplines. An example of the (current) estimate format is provided on the following page. Get a copy of the roadway engineer’s spreadsheet to use in developing the erosion and sediment control estimate.

It is important that every item the designer specifies, be it a work item or a product, is included in the cost estimate. The cost estimate is a component of the contract that is used as a list of the tasks for the contractor. If work is not listed, it may need to be added to the project by a change order. ODOT wants to minimize the use of change orders.

Roberts Hill Climbing Lanes		http://touchmap.com/latlong.html		How to select U		
Bid Item Number	ITEM	Latitude	Longitude	UNIT	AMOUNT	UNIT COST
		4D^ MM'	12D^ MM' SS^			
Erosion and Sediment Control						
0210-0100000A	MOBILIZATION			LS	All	2.00%
0280-0100000A	EROSION CONTROL			LS	All	10000.00
0280-0104029R	TEMPORARY MULCHING, STRAW			ACRE	10	\$1,400.00
0280-0105040J	MATTING, TYPE D			SQYD	1251	\$3.50
0280-0105050J	MATTING, TYPE G			SQYD	81835	\$3.50
0280-0106010E	CHECK DAM, TYPE 1			EACH	194.0	\$175
0280-0106050E	CHECK DAM, TYPE 5			EACH	10.0	\$175
0280-0108000E	TEMPORARY SLOPE DRAIN			EACH	3	\$250.00
0280-0109000F	FLOW SPREADER			FOOT	0	\$12.00
0280-0110010E	CONSTRUCTION ENTRANCE, TYPE 1			EACH	3	\$2,000.00
0280-0113000F	SEDIMENT FENCE			FOOT	700	\$2.80
0280-0114030E	INLET PROTECTION, TYPE 3			EACH	72	\$80.00
0280-0114030E	INLET PROTECTION, TYPE 4			EACH	15	\$80.00
0280-0115030F	SEDIMENT BARRIER, TYPE 3			FOOT	200	\$5.00
0280-0115080F	SEDIMENT BARRIER, TYPE 8			FOOT	6154	\$5.00
0280-0117000E	FLOCCULANT			EACH	4	\$500.00
0280-0117000E	TEMPORARY ENERGY DISSIPATER			EACH	4	\$500.00
0290-0200000A	TURBIDITY MONITORING			LS	1	\$1,500.00
0280-0107000F	TEMPORARY INTERCEPTOR DIKE/SWALE			FOOT	861	\$5.00
1030-0109000R	PERMANENT SEEDING, MIX NO. 1			ACRE	6.7	\$4,500
1030-0110000R	PERMANENT SEEDING, MIX NO. 2			ACRE	41.6	\$6,000
1030-0111000R	PERMANENT SEEDING, MIX NO. 3			ACRE	0.0	\$3,500
1050-0105000F	TYPE 2 MODIFIED FENCE			FOOT	2100	\$5
EROSION CONTROL SUBTOTAL						

Figure 6-3 Bid Item List

6.7 SPECIFICATIONS

The Specifications are the [Oregon Standard Specifications for Construction 2018](#). These are contract documents that provide baseline direction to contractors and provide project manager enforcement tools to keep the contractors compliant with project requirements. When designs deviate from the Standard Specifications those changes are provided in Special Provisions. The Specifications and Special Provisions are tightly organized. For erosion and sediment control special provisions the system of order is as follows:

- Scope or description of work is in 00280.00 to 00280.09
- Specified materials are described in 00280.10 to 00280.19
- Specialized equipment requirements are in 00280.20 to 00280.29
- Labor or skills certifications are in 00280.30 to 00280.39
- Construction is in 00280.40 to 00280.59
- Maintenance requirements are in 00280.60 to 00280.69
- Scope or description of work is in 00280.00 to 00280.09
- Finishing, cleanup and warranties are in 00280.70 to 00280.79
- Measurement is provided in 00280.80 to 00280.89
- Payment is described in 00280.90 to 00280.99

The Special Provisions add, delete or revise information provided in the Specifications. Special Provisions have a higher order of precedence than the Specifications, meaning they have greater authority than the Specifications. Special Provisions begin as [Boilerplate Special Provisions](#) which are the word document templates for editing. Always begin with a new Boilerplate because they are regularly updated. The

Boilerplate Special Provisions are structured with instructions for editing. Edits to these are conducted in track changes mode and the writing style is conducted in the “imperative mood”. The imperative mood directs the subject (contractor) to do things with clear, simple language. The Specifications do not expressly direct the contractor. It is implied the contractor is the subject of directives. The writing style is easy to adopt and important to follow. For guidance in following this writing style review the short and simple [Specifications and Writing Style Manual](#). It provides good advice for all writing.

The designer develops and is responsible for the Special Provisions for the Agency ESCP. The Specifications or Special Provisions must reflect each best management practice found in the ESCP and some items that are not shown on plans but may be needed as emergency materials. Special Provisions may contain additional information about materials, construction, maintenance, and payment. Special provisions are used to make changes to the standard specifications on a job-by-job basis.

The designer and the construction staff should be familiar with each portion of sections 00290, 00280, and 01030 of the specifications (Standard and Special Provisions).

6.7.1 EROSION CONTROL – SECTION 00280

Erosion control measures are a part of work required on all construction projects which disturb soil (greater than 1 acre). Section 00280 of the specifications describes the contractor’s responsibilities related to the erosion control for the project. The work for installation, maintenance, inspection, and removal of each BMP is included in payment for the pay item for the specific BMP. Some BMP’s are included in the lump sum pay item “Erosion Control.” Unit measure pay items are preferred over lump sum because it reduces the risk to the contractor, generally yields more reasonable costs, and makes quantity adjustments in the field easier to negotiate.

6.7.2 POLLUTION CONTROL – SECTION 00290

Pollution Prevention Measures are a part of work required on all construction projects. Section 00290 of the specifications describes the contractor’s responsibilities related to the prevention of pollution of water and land. The Pollution Control Plan requirements are described in the 00290 Section. Also included in the 00290 Section are protections of wildlife, historic and archeological and cultural resources.

6.7.2.1 SPECIFIC BMP’S

In the ODOT Specifications many best management practices are listed by what they do, not what they are made of. For example, Sediment Barrier, Type 2 is constructed from biofilter bags, Inlet Protection, Type 4 is biofilter bags and Check Dam, Type 3 is also made from biofilter bags. These BMPs are all made from biofilter bags, but are listed by the function they perform. Other pay items may be listed by the product, for example Plastic Sheeting or Matting. The Bid Item List provides unit of measure and the Special Provisions includes units of measure for (at least) one emergency material, Straw Bale. The pay items as listed in the 00280.90 section of the Standard Specifications include:

<u>Pay Item</u>	<u>Unit of Measurement</u>
Erosion Control	Lump Sum
Plastic Sheeting	Square Yard
Chemical Soil Binder	Acre
Chemical Dust Control	Acre
Temporary Mulching (Hydromulch, Straw and Compost)	Acre
Matting (Types A through H)	Square Yard
Compost Erosion Blanket	Square Yard

Check Dam (Types 1 through 6)	Each
Temporary Interceptor Dike/Swale	Foot
Temporary Slope Drain	Each or Foot
Flow Spreader	Foot
Compost Filter Berm	Foot
Construction Entrance (Types 1 through 3)	Each
Tire Wash Facility (Types 1 and 2)	Each
Concrete Washout Facility	Each
Sediment Fence	Foot
Inlet Protection (Types 2, 3, 4, 6, and 7)	Each
Sediment Barrier (Types 2 through 9)	Each or Foot
Sediment Mat	Square Yard
Temporary Energy Dissipater	Each
Temporary Sediment Trap	Each

If required products or work items are needed for the project but not listed, they must be added. Each relevant aspect of the added feature must be described within the subsection number described [above](#) regarding specification organization. For example: if a sediment filter bag (Dirt Bag) is required, it would be described in the dot-teen subsection, the placement and use would be described in the dot-thirty subsection, removal would be described in the dot-seventy subsection and of critical importance the units of measure and payment would be described in the dot-eighty and dot-ninety subsections.

6.7.2.2 EROSION CONTROL

Erosion Control is a lump sum pay item that is required on all jobs. Many important tasks are paid for by this pay item and it should not be ignored or minimized when preparing an engineer's estimate or bid for a construction contract. If this pay item is not included in the contract, all work described below is considered incidental and no separate payment is made. The major tasks include:

- Providing a qualified individual as an Erosion and Sediment Control Manager (ESCM).
- Developing, revising and documenting the Erosion Control Plan (ESCP).
- Mobilization of crews to address ESC needs.
- Monitoring activities to maintain effective functioning.
- Furnishing, stockpiling, protecting, restocking and removing emergency materials.
- Preparing Project for a period of extended non-activity.
- Inspecting, maintaining and removing erosion control devices.
- Turbidity monitoring
- Restoring, mulching, tacking and seeding all disturbed ground, Work and storage areas not otherwise covered.

6.7.3 SEEDING – SECTION 01030

[Seeding](#) is a part of work required on all construction projects where disturbed soil is anticipated. Section 01030 of the specifications describes the contractor's responsibilities related to seeding, fertilizing, mulching, and any specified soil testing operations that are necessary for vegetation establishment. An

important part of seeding is the selection of the appropriate seed mixtures and rate of application. Each job may have unique soil, climatic, or other environmental conditions, so it is recommended to contact a qualified Landscape Architect, agronomist, horticulturist, or erosion control specialist for recommendations. ODOT specifications require the designer to specify seed mixtures and rates of application. The final performance criteria such as vegetative coverage requirements and time allowed to achieve that coverage is provided in the Standard Specifications.

The pay items, which are available for specific seeding applications, include:

<u>Pay Item</u>	<u>Unit of Measurement</u>
Weed Control	acre
Seeding Mobilization	each
Temporary Seeding	acre
Permanent Seeding	acre
Wetland Seeding	acre
Water Quality Seeding	acre
Plant Seeding	acre
Native Plant Seeding	acre
Wildflower Seeding	acre
Lawns Seeding	acre or ft. ²
Fertilizing	acre
Mulching	acre

Seeding, fertilizing, and mulching are often combined into one operation. In these cases a single “Seeding” pay item may be used that is explained in the special provisions as including other materials as part of the operation.

6.8 NARRATIVE

For more complex projects, a narrative is included in the project file and may also become part of the plan when necessary to explain the ESCP in greater detail. The narrative should be brief, clear and concise while stating pertinent information. A detailed narrative should include design dates, expected rainfall, expected runoff velocities, expected peak flows, soil types, total project area and total disturbed area. It should discuss any particular concerns related to the project ESCP including special environmental and jurisdictional requirements, steep slopes, highly erodible soils, etc. and how the concerns are addressed. Less detailed narratives are usually acceptable that describe erosion and sediment control in more sweeping terms.

The Erosion and Sediment Control designer will be providing the narrative only for the information in their scope of work. General information, such as project area may already be provided elsewhere in the narrative document.

Narrative Checklist

- Estimated total project area (acre)
- Estimated total disturbed (acre)
- Surficial soil types and erodibility (Soil Conservation Service K value)
- Runoff coefficients for disturbed areas
- Estimated peak flows for the design storm runoff

- Receiving waters
- Jurisdictions within the project limits
- State and local requirements incorporated into the plan
- Special environmental considerations related to storm water runoff
- Anticipated concerns, or possible problems
- Information sources and/or contacts

6.9 PROJECT DESIGN PHASES

In ODOT, Regions are responsible for the development of projects. The following are the major project development phases used by ODOT and a brief summary of typical erosion control-related tasks for each phase (for projects with significant ground disturbance):

6.9.1 PROJECT PLANNING AND SCOPING

- Estimate erosion control needs based on the type of project, type and amount of disturbance impacts anticipated, and project environmental setting.
- From above, estimate level of effort required for erosion control preliminary engineering (design and associated).
- Using budgeting guidelines, estimate a dollar figure for cost of constructed items.
- Plan for the time, labor, and budget resources needed to perform the work.
- Incorporate scoping results into general project planning.

6.9.2 DESIGN ACCEPTANCE PACKAGE (DAP)

- Establishes geometric boundaries and project footprint
- Roadway design strategy is established
- Access management and Traffic design are strategized.
- Environmental studies and Geo/Hydro site analysis.
- Right of Way development.
- Permits and clearances tasks
- Design acceptance review.
- Draft DAP.

6.9.3 PRELIMINARY PLANS

- Confirm that a designer has been assigned for erosion control.
- Monitor general project design decisions with any potential for affecting erosion- related impacts. The goal is to eliminate or minimize impacts where feasible. Attend Project Delivery Team (PDT) meetings.
- Adapt copies of Roadway base sheets for erosion control plans.
- Incorporate into base sheets all critical information such as topography.
- Begin development of Erosion and Sediment Control plans.
- Coordinate ESC plans with Preliminary Roadway, Drainage and Utility plans and other general construction plans including any structures, staging, or other areas of work.
- Perform on-site analysis of risks and opportunities.
- Get peer review from qualified erosion control designer.

6.9.4 ADVANCE PLANS

- Respond to comments made during Preliminary Plans distribution.
- Begin erosion control design (if not begun in previous phase) and coordinate ESC plans with other design and engineering disciplines.
- Ensure that all relevant information has been collected for design including relevant environmental documents such as the Biological Assessment or unique permit requirements.
- Analyze project for erosion-related, runoff-related or sediment control-related impacts from all areas of design.
- Visit site to confirm data and review site conditions.
- Select initial BMPs to mitigate for disturbance impacts.
- Finalize BMPs and complete plans, specifications, and estimate.
- Get peer review from qualified erosion control designer.

6.9.5 FINAL PLANS

- Respond to comments made during Advance Plans distribution.
- Update base sheets and revise design and plans as required.
- Prepare final set of contract documents, submit for final review.
- Affix electronic Stamp to Contract Documents in compliance with state requirements and provide digital signature as approved by State Landscape Architect's Board.
- Ensure that designer is available to respond to questions throughout bidding period.

CHAPTER 7 CONSTRUCTION

Erosion and sediment control measures are necessary on construction sites because they are required as conditions of permits, because they protect natural resources and because they are contract requirements that diminish risk to the Agency. The compliance with the permits is enforceable by law. Inspection of erosion and sediment control measures is necessary to ensure proper installation, continued maintenance and effective functioning.

7.1 EROSION AND SEDIMENT CONTROL MANAGER

The way ODOT's erosion and Sediment Control Plan is put to use on projects is that the contractor is the primary agent in dealing with erosion and sediment control issues during construction. The contractor provides an Erosion and Sediment Control Manager (ESCM) as their lead person for erosion and sediment control. That person must be experienced in all aspects of construction and qualified to design and inspect erosion control plans and facilities. At a minimum, the ESCM must have certification verifying completion of a class on erosion control that covered all the items included in this manual. Acceptable courses for ESCM certifications are as follows:

- [ODOT ESCM training](#)
- Certified Professional in Erosion and Sediment Control ([CPESC](#))
- Certified Professional in Storm Water Quality ([CPSWQ](#))
- Washington Department of Ecology's Certified Erosion and Sediment Control Lead ([CESCL](#)) Certification
- [Rogue Valley Sewer Services Erosion and Sediment Control Certification](#),

The ESCM is responsible for assuring the implementation of the ESCP and have the authority to immediately mobilize necessary personnel to correct and modify erosion prevention and sediment controls if required. ODOT remains the permit holder and is ultimately responsible for compliance with the conditions of the NPDES 1200-CA permit, so ODOT inspectors verify the ESCM's performance.

Duties of the EPCM include:

- Manage and insure proper implementation of the ESCP.
- Accompanying the Agency inspector in a field review of the ESCP prior to the beginning of work.
- Monitor rainfall on the project site.
- Monitor turbidity in receiving waters downstream of the Project site.
- During periods of active construction maintain the ESCP documentation at the project site, available for review upon request.
- Inspecting erosion and sediment controls on active construction sites weekly for effective functioning.
- Inspecting erosion and sediment controls on inactive sites at least every two weeks for effective functioning.
- Inspecting erosion and sediment controls on both inactive and active sites at least daily during rainy periods where a minimum ½ inch of rain has fallen in a 24-hour period for effective functioning.
- Ensure that erosion and sediment controls are regularly cleaned and maintained.
- Mobilizing crews to make immediate repairs to erosion and sediment controls or install additional erosion and sediment controls during working and non-working hours when erosion and sediment controls are not effectively functioning.

- Recording actions taken to clean up significant amounts of sediment on [form #734-2361](#).
- Report potential permit violations to the Agency in a timely manner.
- Completing erosion control monitoring forms ([form #734-2361](#)) after each inspection, erosion control facility modification, or maintenance action. Submit forms to the Agency weekly for active sites and bi-weekly for inactive sites.
- Update the ESCP monthly and within 24 hours after changes or major ESC modifications are implemented.
- Prepare a contingency plan in preparation for emergencies and the wet season (October 1 through May 31).
- Accompany the Agency on inspections and, if requested, on inspections made by other regulating agencies.
- Update the ESCP and schedule for work proposed during the wet season.

7.1.1 INEFFECTIVE CONTROLS

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

- Immediately repair the control.
- Replace the control.
- Provide additional controls.
- Document the sediment discharge, the clean up and modifications to the ESC facilities.
- Report sediment discharge to Project Engineer.

7.1.2 RAINFALL MONITORING

The ESCM shall furnish and install a rain gauge at the project site. Rainfall should be monitored and the Agency will be notified if one half inch or more, of rainfall occurs within 24 hours. The entire project should be inspected to evaluate the condition of the control measures as soon as is practicable, but no later than 24 hours, including weekends and holidays.

7.2 PRE-CONSTRUCTION MEETING

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 should be 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 or regulated areas and their buffers.

The pre-construction meeting provides an opportunity for the contractor to discuss the plan with the inspector and learn which elements of the ESCP deserve 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. Additional key points to consider in the pre-construction meeting are:

- Pollution Control Plan for contractor operations.
- Qualifications of individual designated as the ESCM.
- Method to be used to document the up-to-date ESCP.
- Adjacent areas that need special protection from sedimentation, particularly environmentally sensitive areas such as wetlands, stream crossings, channel, and water disposal outlets. Steep slopes are areas that need special protection from erosion.
- Location of erosion and sediment control practices and their implementation.
- Sequence of installation with respect to the construction schedule.
- Surface stabilization plans, temporary and permanent seeding.
- Construction schedule and any anticipated shutdown periods such as work suspension during wet season.
- Maintenance plans and the contractor's procedure for monitoring performance.
- Location of all borrow and disposal areas.
- Emergency or contingency plans.
- Any special requirements identified in permits.
- Monitoring Form submittal requirements, provide a copy of the monitoring form to the contractor and provide location of form on ODOT's web page.
- Biological Opinion – this is furnished by ODOT and covers special needs and concerns for threatened and endangered species on the project. The contractor should be made aware of its contents.

7.2.1 CONTRACTOR-MODIFIED ESCP

Most Contract Plans will include the Agency ESCP prepared by designers. Erosion and sediment control designers cannot know a contractor's means and methods or their schedule so the Agency ESCP unlikely to have addressed all erosion concerns for the project adequately. The Agency ESCP should be used as the basis for the Project ESCP and not be followed blindly. It is the contractor's responsibility to propose modifications to the plan. The modifications can be marked on the ESCP included in the plan set and submitted to the Agency. The Project Manager or Agency 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 plan should include a brief narrative describing any unique site characteristics or special considerations. Sufficient detail should be provided to implement the plan properly and control erosion and sedimentation 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 properties and protect downstream properties and waterways from erosion by control velocity and volume of runoff as it leaves the site?
 - Prevent upslope runoff from flowing over disturbed areas?
 - Provide measures which trap sediment onsite?
 - Route dewatering devices through a sediment-trapping device before leaving site?
 - Protect inlets and the storm drain system?
 - 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?

7.2.2 UP-TO-DATE ESCP

Effective erosion control is closely tied to a contractor's staging, operation methods, and construction timing. When ODOT develops the erosion control plan, the contractor's staging and operation methods are unknown. Therefore, ODOT 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 ESCM. Contractor's ESCM submits changes to the ESCP 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 become a master up-to-date ESCP. It is required that the ESCP be updated at least monthly. When site conditions require that BMP be installed that were not anticipated, revisions to the ESCP must be made within 24 hours of the BMP implementation. An example of an updated 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).

7.2.3 CONSTRUCTION SCHEDULE REVIEW

Refer to Sections 00290.30(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 (October 1 – May 31) and temporary work shutdown.
- Timing of activities to meet "in-water" work restrictions.
- Install erosion prevention and sediment controls shown on the plans before ground-disturbing activities begin (00280.40)
- Permanent facilities, such as sediment traps and basins, which will be used during construction as temporary measures should be installed.
- Temporary stabilization / erosion prevention
- Retention of temporary perimeter controls until all upstream areas are finally stabilized.
- Timing of seeding operations.

7.2.4 MONITORING FORM

All inspections are to be recorded on the ODOT [Erosion Control Monitoring form \(734-2361\)](#) which is included in Appendix E. The form is an interactive PDF with expandable fields that enlarge as content is added. The ODOT form also uses DocuSign for digital signatures that verify the identity of the signer and the date of the signature. The digital form allows for the attachment of digital photographs. The inclusion of digital photographs is an excellent practice and is recommended. Contractor's ESCMs must provide honest evaluation of BMPs on monitoring forms. Falsification of monitoring forms is a Class C felony, punishable by up to \$100,000 in fines. ESCMs found to falsify a monitoring form will have their ESCM certification revoked.

The effectiveness of each BMP at every location on site should be documented on the form, and general observations on site conditions should also be recorded. 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.

7.3 MATERIALS

The following sections present information on erosion and sediment control products and materials approved for use on ODOT projects. Information necessary to verify proper Quality Control /Quality Assurance in accordance with the specifications is also provided.

7.3.1 ODOT QUALIFIED PRODUCTS LIST (QPL)

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 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 the New Products Coordinator, Construction Section, ODOT materials Laboratory or the [Technical Expert](#) for Erosion and Sediment Control.

7.3.2 SUSTAINABILITY

Products made with plastic unless specified as permanent features must be removed from the landscape once stabilization is achieved and properly disposed of. This removal of materials may itself cause soil disturbance. Many types of erosion and sediment control products are fully biodegradable. ODOT requires that the 5 lightest grades of rolled erosion control products (matting) be fully biodegradable. Some matting types stitch random fiber, such as straw, between monofilament plastic netting. This netting persists in the landscape and has been shown to trap and eventually kill small animals. Enclosing mesh for straw wattles and for compost socks is not required to be fully biodegradable, but biodegradable mesh for these products are available and listed on the QPL. Fully biodegradable sediment barrier products function as well products that contain plastic but they do not leave plastic in the landscape, they do not add to the waste stream, they do not require the time and labor to remove them from a project site and they do not incur the cost of disposal. However, biodegradable products such as compost socks or wattles are often not sufficiently robust to hold together if they need to be relocated, or removed intact. Biodegradable wattles and compost socks will continue to function even as they break down and where removal is not going to be necessary, such as long slopes, they are an attractive alternative to plastic enclosed products. ODOT encourages the use of fully biodegradable erosion and sediment control products where their use is appropriate.

7.3.3 SEED TAGS

Seed furnished for a project must meet or exceed the requirements of the Standard Specifications in Section 01030. An important requirement is meeting state and federal seed law which, among other things, spells out exact seed labeling requirements. (See [Oregon Revised Statute 633.520](#)). The following are typical requirements:

- The kind and variety of the seed or each seed constituting 5% percent or more in a mixture – ensure that seed mix labels bear the word “mixture” or words “mixed seed”.
- The country or state where the seed is grown
- 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
- Statement of “No Noxious (weed) Found”
- For each named seed:
 - a) Percentage of germination
 - b) Percentage of hard seed, if more than 1% (Hard seed is seed with a shell or coating that may delay germination)
- Month and year of (seed) test
- Name and address of seed labeler or seller
- If seed inoculant is used, the claimed date that inoculant effectiveness ends
- For treated seed (if any present):
 - a) Statement that the seeds have been treated
 - b) Name of any chemical used in the treatment
 - c) Descriptive statement of any process used in the treatment
 - d) Warning statement for any residual chemicals used
- Net weight of each container

The label must be correct and the purity, germination and other information on the tag must be backed by a dated seed lab analysis report. High quality seed germinates well, has a high purity percentage, and is free of noxious weeds or unintended species. The identity, purity and uniformity of the seed must be maintained at all times by continuing to monitor seed delivered to the project for proper labeling.

Seed suppliers may perform calculations using the germination and purity percentages of the seed to determine the Pure Live Seed (PLS) and blend the seed mixes with the PLS already determined. Seed container labels will provide this information if that step is already taken.

See Section 01030 for special labeling requirements for Certified Seed. Native seed may also have unique labeling requirements that will be shown in 01030.13 and the project Special Provisions.

All seed must be tested. Lots containing weed seeds as listed by State or Federal law are not allowed. If there is reason to be suspicious of the quality of the seed, it is advisable to have samples of the seed tested at the state seed laboratory. Wet, moldy, or otherwise damaged seed should not be accepted. If a specified seed variety is not available, the contractor needs to consult with the Agency and receive approval of any proposed substitutions prior to any substitutions. Seed must be used with 18 months of testing. Seed should be used soon after purchase and should be stored for any length of time in a cool and dry space. Seed should not be subject to extreme heat or cold temperatures prior to application.

7.3.4 PURE LIVE SEED CALCULATION

This is a method of calculating an amount of seed to be planted which takes into account the variation of seed germination and purity of the seed source. Before calculating the Pure Live Seed (PLS) verify that the seed has not already gone through this exercise and been packaged as PLS.

$$\text{Pure Live Seed (PLS)} = \% \text{ Germination} \times \% \text{ Purity}$$

Example:

A recommended seed mixture requires that 26 lb (PLS) of intermediate wheatgrass be planted.

Intermediate wheatgrass germination = 80% (0.80)

Intermediate wheatgrass purity = 90% (0.90)

$0.80 \times 0.90 = 0.72$ or 72% PLS

26 lb (PLS) to be planted = Approximately 37 lb. of bagged seed should be
 0.72 (PLS factor) used so that 26 lb. of PLS will be planted.

7.3.5 WEED FREE STRAW/STRAW BALES

Grass seed crops in Oregon become certified through the Oregon State University Extension Service. This program was created to ensure that the seed that is produced will be the correct species and variety and have genetic purity. The certification program includes an inspection of the field by OSU Extension where they look at whether 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 seed certification program when specifying straw and grass seed for temporary erosion control in an effort to control the spread of noxious and other invasive weeds.

Straw from the certified fields in Oregon and straw bales are entitled to bind the bales with a unique purple and yellow twine. Straw bales are not approved BMPs sediment barriers or check dams, but loose straw is approved (and provides good protection) as temporary mulch for erosion prevention. (Straw bales are also used to form a basin structure to be lined with plastic sheeting for use as an approved concrete washout basin.) Documentation must be provided that demonstrates the straw is certified weed free. Straw will contain viable seeds from the parent crop. A common crop for weed free straw is perennial rye grass. Rye grass is not a native species and although it is pervasive in many landscapes, it may be unwanted on projects where native permanent seeding is specified. Removal of temporary mulch may be required in Project Special Provisions.

Straw can originate from cereal grain as well, however, the grain crop must be from a certified field. Plants from grain crops may themselves be weeds. Cereal rye (*Secale cereale*) for example is a listed weed in Washington State (but not in Oregon). Designers must know the characteristics of the plants used in vegetative stabilization so as not to release unwanted plant pests into Oregon's environment. 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.

7.4 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 any additional installations should also be made throughout the life of the project as needed.

The inspector should be familiar with installation details for each BMP used on the project. Details for the correct installation of all specified BMP's are provided in the ESCP. Installation details for BMP's are also provided in [Chapter 3](#) of this manual, and in the Standard Drawings (Appendix C). Installation descriptions are provided in Section 00280 (Appendix B).

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 areas of similar area preparation and material specifications.

7.5 MEASURES DURING CONSTRUCTION

The approved ESCP should be viewed as an open-ended document, subject to approved adjustments and modifications. Contingencies such as changes in the construction schedule or unexpectedly severe weather frequently call for changes or adjustments to the plan.

In addition the contractor is required 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 they are implemented.

The contractor's responsibility does not end with installation and maintenance of designated measures, the plan must also work effectively. Excessive erosion on the site or sediment leaving the project site is not acceptable. If performance of the ESCP is not adequate the plan must be revised and changes implemented to provide effective functioning as quickly as possible. Directing work to improve erosion and sediment control is the role of the ESCM, however if ESCM is not providing effective erosion and sediment control the Project Engineer or even the regulatory agency (Oregon DEQ) can require changes. Major revisions may be made in the field if they are well documented and work effectively. The Project Manager or Engineer should discuss revisions that are ineffective with the engineer of record to bring expertise into the discussion and to improve future projects. All graded areas and the supporting erosion and sediment control measures should be monitored as required. All captured sediment from diversions and other water-treatment practices should be promptly removed. If washouts or breaks occur, they should be repaired immediately. Prompt maintenance of small eroded areas before they become significant permit violations is an essential part of an effective ESCP.

Inspections, changes, problems, and solutions should be documented on the Updated ESCP as described in Section 7.2.2. Weekly construction meetings should have erosion and sediment control as a standing agenda item. Meetings to review and update the ESCP before wet season work and before temporary work suspension should be conducted. Submittals for materials and alternative measures should be reviewed and approved.

7.5.1 WORK RESTRICTIONS

All ODOT construction projects are required to restrict certain types of work, which may contribute to sediment-laden water leaving the project boundaries or entering waterways. The following work restricts may apply:

1. **Flag Clearing Limits:** Construction site clearing limits will be clearly flagged or otherwise delineated in accordance with the approved plans by the contractor. No ground disturbance is permitted beyond the flagged boundary. Flagging should be maintained for the duration of construction. Sensitive and restricted areas should be delineated with orange plastic mesh fence.

2. **Perimeter Controls Before Grubbing:** All appropriate perimeter controls should be installed prior to any major site grubbing operation. Perimeter controls usually consist of sediment barriers or sediment fences but also include interceptor ditches, berms in fill areas, along the banks of existing streams and toes of slopes. Redundant perimeter controls are recommended where risk is high or where debris from upslope might damage the controls.
3. **Wet Season Plan and Schedule:** Prior to wet season work and before temporary work suspension for winter, the Agency should review the contractor's ESCP to verify that appropriate controls are implemented and maintained during the wet season work and suspended periods.
4. **Limit Disturbed Areas:** If soil erosion and sediment resulting from construction activities is not effectively controlled, the Agency will limit the amount of disturbed areas that can be effectively controlled.
5. **Install BMP's Early:** Erosion and sediment control features are required to be incorporated into the project at the earliest practicable time. (see Section 00280.40) All erosion and sediment control measures should be installed according to the approved implementation schedule and in compliance with specifications and the 1200-CA permit.
6. **Stop Work:** Failure to control erosion and or pollution shall be cause for the Agency to stop all construction work until measures have been taken to bring all construction into compliance with these specifications. ODOT must self-regulate to ensure contractors comply with contract and permit requirements.

7.5.2 STABILIZATION REQUIREMENTS

This is the definition of stabilization from the 1200-CA Permit:

Stabilization The completion of all soil disturbance activities at the site and the establishment of a permanent vegetative cover, or equivalent permanent stabilization measures (such as riprap, gabions, geotextiles, or bioengineering methods) that will prevent erosion.

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

- Statewide (Entire Year) – Stabilize within 7 days of exposure all areas within 100' 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's Representative.

Satisfying the time frames for stabilization requires that measures that do not rely on seed germination may be needed.

7.5.3 EROSION CONTROL EMERGENCY 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 BMP's installed as part of the ESCP. A thorough Agency ESCP will have a list of required emergency materials provided in the 00280 Section of the Special Provisions. These items would be kept on-site and available for use in the event of heavy rainfall that creates runoff beyond the capabilities of the site's installed erosion control facilities. Materials that require mobilization or delivery are poorly suited for emergency use. Appropriate emergency materials would include replacements for

products that are specified in the ESCP, such as inlet insert filter sacks. The quantity and type of emergency materials would vary depending on the project type and size, but items that have multiple uses and can be quickly deployed are good choices. Examples of good BMPs for emergency materials to be kept on the project site for use in emergencies are:

- Straw wattles w/ stakes (Sediment barrier- type 3, check dams-type 2, inlet protection-type 7)
- 6 ml plastic sheeting
- Bags for sand bags (these are only empty bags, so they do not take up much space)
- straw bales for use as mulch
- biofilter bags w/ stakes (check dam-type 3, inlet protection-type 4, sediment barrier-type 2)

The emergency items may also be used at the discretion of the project 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 stock- pile of soil at the project 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 would be used to secure the plastic from blowing around in the wind. Contingency materials on-hand which are not installed are paid for in the Lump Sum Bid Item under Section 00280 – Erosion Control. If the contingency erosion control items are not used during the project, the restocking costs are covered by the lump sum bid item “Erosion Control”.

7.6 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 maintained and retained in place until the Agency issue notification of acceptance of permanent stabilization. All maintenance and repairs are included in the bid price submitted by the contractor and are contracted expenses.

Typical maintenance activities, guidelines, and failure modes for BMP’s are discussed in [Chapter 3](#) of this manual, and in 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 BMP’s, and will depend largely on weather and other site conditions. In general, effective erosion prevention will diminish the need for maintenance on sediment controls.

7.6.1 SEDIMENT REMOVAL

Sediment shall 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 shall be hand-carried and installed in accordance with best management practices and as approved by the Agency. Catch basins insert filter sacks shall be maintained when they reach 1/2 the capacity in sediment depth. Sediment shall be removed from sediment barriers (all types), check dams, and sediment traps once the sediment buildup has reached 1/3 the exposed height of the control or storage depth. Rock filters and filter berm material shall be replaced with new aggregate material when sediment substantially reduces the effective filtering capacity by 50 percent.

7.6.2 CONSTRUCTION ENTRANCES AND PAVED AREAS

Aggregate or other material specified shall be added, removed or “stirred” with bladed equipment to open pore space as needed to maintain proper function of the entrance areas. All paved areas shall be kept clean for the duration of the project. Sweeping and removal of material or using a vacuum sweeper is the correct method to remove sediment from pavement.

7.6.3 SEDIMENT DISPOSAL

Removed sediment shall be regraded into slopes or removed and disposed of off-site in accordance with Section 00290.20, all federal, state and local laws and ordinances. Sediment-laden water shall not be flushed into the storm drain system or waterways of any type.

7.7 FINISHING AND CLEANUP

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

Removed sediment should be regraded 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.

7.8 INSPECTOR'S TOOLS

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

7.8.1 INSPECTOR CHECKLIST

The Inspector Checklist included in Appendix E 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
- Erosion and Sediment Control Plan
- Erosion and Pollution Control Manager
- Sensitive Areas
- Contingency Plans
- Materials On-Hand
- Maintenance
- Monitoring Forms
- Slope Protection and Stabilization
- Plan Revisions and Modifications
- BMP Evaluation
- Technical Resources
- Additional Items

7.8.2 WINTERIZATION

The wet season, as defined in the Standard Specifications, in Oregon is October 1 through May 31. Prior to wet season work and before temporary work suspension for winter, the contractor shall meet with the Agency to review and update the ESCP and to develop a schedule to assure that appropriate controls are implemented and maintained during wet season and work suspension periods. When sites are inactive, the contractor's ESCM remains responsible for periodic inspections every two weeks and within 24 hours of rain events of 1/2 inch or more.

Winter preparations should begin in August. Winterization planning should address the items listed above, and in the "Inspector Checklist" and "Buttoning Up Construction for the Rainy Season" list in Appendix E.

7.8.3 RULES OF THUMB

Several Rules of Thumb worksheets are provided in Appendix D 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. Appendix D includes the following:

- Example Seed Tags
- Slope Inclination Conversions
- Slope computation factors
- Sediment Trap Sizing Spreadsheet
- I-D-R Curve Zone Map
- Straw Mulch Application Worksheet
- Hydraulic Application Equations
- Wood Fiber Mulch Hydraulic Application Worksheet
- Seed / Fertilizer Hydraulic Application Worksheet
- Hydraulic Application Example Problems

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APPENDIX C: TYPICAL EROSION & SEDIMENT CONTROL PLAN AND STANDARD
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APPENDIX C: TYPICAL EROSION & SEDIMENT CONTROL PLAN AND STANDARD
DRAWINGS & DETAILS

APPENDIX C: TYPICAL EROSION & SEDIMENT CONTROL PLAN AND STANDARD
DRAWINGS & DETAILS

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APPENDIX D: RULES OF THUMB

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APPENDIX E: MONITORING FORM AND CHECKLIST

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APPENDIX F:

ACRONYMS & GLOSSARY OF TERMS

ACRONYMS

#:1	Slope Ratio Horizontal: Vertical
AASHTO	American Association of State Highway and Transportation Officials
ATB	Asphalt-Treated Base
BA	Biological Assessment
BMP	Best Management Practice
BOD	Biological Oxygen Demand
CNCP	Coastal Nonpoint Pollution Control Program
COD	Chemical Oxygen Demand
CWA	Clean Water Act
CZARA	Coastal Zone Act Reauthorization Amendments of 1990
CZMA	Coastal Zone Management Act of 1972
DEQ	Department of Environmental Quality
DFW	Department of Fish and Wildlife
DSL	Division of State Lands
EA	Environmental Assessment
ECRM	Erosion Control and Revegetation Mats
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
EPCM	Erosion and Pollution Control Manager
ESCP	Erosion and Sediment Control Plan
FHWA	Federal Highway Administration
HDPE	High Density Polyethylene
IDR	Intensity-Duration-Recurrence
m	Meter
m ²	Square Meters
m ³	Cubic Meters
mg/l	Milligram per Liter
mm	Millimeter
NMFS	National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resource Conservation Service

OAR	Oregon Administrative Rules
ODL	Oregon Drainage Law
ODOT	Oregon Department of Transportation
ORS	Oregon Revised Statutes
OSU	Oregon State University
QA/QC	Quality Assurance/Quality Control
QPL	Qualified Products List
PCB	Polychlorinated Biphenyl
PCP	Pollution Control Plan
PLS	Pure Live Seed
POTW	Publicly Owned Treatment Works
ppm	Parts per Million
RUSLE	Revised Universal Soil Loss Equation
TRM	Turf Reinforcement Mats
US	United States
USACE	United States Army Corps of Engineers
USC	United States Code
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
USLE	Universal Soil Loss Equation

GLOSSARY OF TERMS

AASHTO Classification

The official classification of soil materials and soil aggregate mixtures for highway construction used by the American Association of State Highway and Transportation Officials.

Acid Soil

A soil with a preponderance of hydrogen ions (and probably aluminum) in proportion to hydroxyl ions. Specifically, soil with a pH value less than 7.0. For most practical purposes, a soil with a pH value of less than 6.6.

Adsorption

The adhesion of a substance to the surface of a solid or liquid. Heavy metals, such as zinc and lead, often adsorb onto particles.

Alluvial Soils

Soils developed from transported and relatively recently deposited material (alluvium) characterized by a weak modification (or none) of the original material by soil-forming processes.

Alluvium

A general term for all detrital material deposited or in transit by streams, including gravel, sand, silt, clay, and all variations and mixtures of these. Unless otherwise noted, alluvium is unconsolidated.

Anadromous

Fishes that ascend rivers from the sea for breeding.

Annual Storm

The highest peak storm discharge that is expected in any given year.

Apron

A pad of non-erosive material designed to prevent scouring from developing at the outlet ends of culverts, outlet pipes, grade stabilization structures, and other water-control devices.

Aquifer

An underground porous, water-bearing geological formation. The term is generally restricted to materials capable of yielding an appreciable supply of water.

Barrel

A conduit placed through a dam, levee, or a dike to control the release of water.

Bearing Capacity

The maximum load that a material can support before failing.

Bedrock

The relatively solid rock in place either on or beneath the surface of the earth. It may be soft, medium, or hard and have a smooth or irregular surface.

Berm

A constructed barrier of compacted earth.

Best Management Practices (BMPs)

Physical, structural, or managerial practices employed to avoid or mitigate damage or potential damage from the contamination or pollution of surface waters or wetlands. Structural BMPs are actual physical installations rather than procedural or managerial BMPs, such as good housekeeping and employee training.

Capillary Action

The tendency of drier soil particles to attract moisture from wetter portions of soil.

Catch Basin

A grated inlet, curb opening, or combination inlet with or without a sump that admits storm water to a sewer or subdrain.

CD

Cross-machine direction; direction perpendicular to the machine or manufacture direction.

Channel

A natural stream or excavated ditch that conveys water.

Channel Stabilization

Protecting the sides and bed of a channel from erosion by controlling flow velocities and flow directions using jetties, drops, or other structures, or by lining the channel with a suitable liner such as vegetation, riprap, concrete, or other similar material.

Channelization

Alteration of a stream channel by widening, deepening, straightening, or paving certain areas to improve flow characteristics.

Check Dam

A small dam constructed in a gully or other small watercourse to decrease flow velocity, minimize channel scour, and promote sediment deposition.

Chute

A high-velocity, open channel for conveying water down a steep slope without erosion, usually paved.

Clay

(a) Soil fraction consisting of particles less than 0.002 mm in diameter. (b) A soil texture class that is dominated by clay or at least has a larger proportion of clay than either silt or sand.

Cohesion

The capacity of a soil to resist shearing stress, exclusive of functional resistance.

Cohesive Soil

A soil that, when unconfined, has considerable strength when air-dried and significant strength when saturated.

Coir

Fiber made from coconut husks.

Compost

Organic residue or a mixture of organic residues and soil that has undergone biological decomposition until it has become relatively stable humus.

Conventional Pollutants

Contaminants (other than nutrients) such as sediment, oil, and vehicle fluids.

Contour

An imaginary line on the surface of the earth connecting points of the same elevation.

Cut

Portion of land surface or area from which earth has been removed or will be removed by excavating; the depth below the original ground surface to the excavated surface.

Cut-and-Fill

Process of earth grading by excavating part of a higher area and using the excavated material for fill to raise the surface of an adjacent lower area.

Cutoff Trench

A long, narrow excavation (keyway) constructed along the centerline of a dam, dike, levee, or embankment and filled with relatively impervious material intended to reduce seepage of water through porous strata.

Cutting

A leaf, stem, or branch cut from a plant to establish a new plant.

Dam

A barrier to confine or impound water for storage or diversion, to prevent gully erosion, or for retention of soil, sediment, or other debris.

Debris Dam

A barrier built across a stream channel to retain logs, tree limbs, sand, gravel, silt or other material.

Design Highwater

The elevation of the water surface at peak flow conditions of the design flood.

Design Life

The period of time for which a facility is expected to perform its intended function.

Design Storm

Selected storm of a given frequency used for designing a design storm system. Hypothetical storm derived from intensity-duration-frequency curves. A prescribed hyetograph and total precipitation amount (for a specific duration recurrence frequency) used to estimate runoff in order to analyze existing drainage, design new drainage facilities, or assess impacts of a proposed project on surface water flow.

Desilting Area

An area of grass, shrubs, or other vegetation used for including deposition of silt and other debris from flowing water; located above a stock tank, pond, field, or other area needing protection from sediment accumulation.

Detention

Storage and subsequent release of excess storm water runoff.

Detention Facility

An above or below ground facility, such as a pond or tank, that temporarily stores storm water runoff and releases it at a controlled rate. There is little or no infiltration of the stored storm water.

Detention Time

The theoretical time required to displace the contents of a tank or unit at a given rate of discharge (volume divided by rate of discharge).

Dewatering

The removal of water temporarily impounded in a holding basin.

Dike

An embankment to confine or control water, often built along the banks of a river to prevent overflow of lowlands; a levee.

Discharge

Usually the rate of water flow; a volume of fluid passing a point per unit time commonly expressed as cubic feet per second, cubic meters per second, gallons per minute, or millions of gallons per day.

Dispersion, Soil

The breaking down of fine soil aggregates into individual particles, resulting in single-grain structure. Ease of dispersion influences the erodibility of soils. Generally speaking, the more easily dispersed the soil, the more erodible it is.

Diversion

A channel with a supporting ridge on the lower side constructed at the top, across, or at the bottom of a slope for the purpose of controlling surface runoff.

Diversion Dike

A barrier built to divert surface runoff.

Drain

A buried slotted or perforated pipe, or other conduit (subsurface drain), or a ditch (open drain) for carrying off surplus groundwater or surface water.

Drainage

The removal of excess surface water or groundwater from land by means of ditches or subsurface drains.

Drainageway

A natural or artificial depression that carries surface water to a larger water course or outlet such as a river, lake, or bay.

Drop Inlet

Overall structure in which the water drops through a vertical riser connected a discharge conduit or storm sewer.

Drop Spillway

Overall structure in which the water drops over a vertical wall onto an apron at a lower elevation.

Dry Pond

A facility that provides storm water quantity control by detaining runoff in a detention basin, then releasing the runoff at allowable rates.

Earth Dam

Dam constructed of compacted suitable soil materials.

Elongation

The increase in length produced in the gauge length produced by a tensile load.

Embankment

A man-made deposit of soil, rock, or other material often used to form an impoundment.

Emergency Spillway

Usually a vegetated earth channel used to safely convey flood discharges around an impoundment structure.

Energy Dissipater

A device used to reduce the energy of flowing water to prevent erosion.

Environment

The sum total of all the external conditions that may act upon a living organism or community to influence its development or existence.

Erodibility

Susceptibility to erosion.

Erosion

The wearing away of the land surface by water, wind, ice, gravity, or other geological agents. The following terms are used to describe different types of water erosion:

- Accelerated erosion – Erosion much more rapid than normal or geologic erosion, primarily as a result of the activities of man.
- Channel erosion – The erosion process whereby the volume and velocity of flow wears away the bed or banks of a well-defined channel.
- Gully erosion – The erosion process whereby runoff water accumulates in narrow channels and, over relatively short periods, removes the soil to considerable depths, ranging from 1 to 2 feet to as much as 75 to 100 feet.
- Rill erosion – An erosion process in which numerous small channels only several inches deep are formed; occurs mainly on recently disturbed and exposed soils. See Rill.
- Splash erosion – The spattering of small soil particles caused by the impact of raindrops on wet soils. The loosened and spattered particles may or may not be subsequently removed by surface runoff.
- Sheet erosion – The gradual removal of a fairly uniform layer of soil from the land surface by runoff water.

Erosion and Sediment Control

Any temporary or permanent measures taken to reduce erosion, control siltation and sedimentation, and ensure that sediment-laden water does not leave a site.

Erosion and Sediment Control Plan (ESCP)

Plans, specification, and BMP details intended to prevent and control erosion and sediment related to the project construction activities.

Estuary

Area where fresh water meets salt water, (e.g., bays, mouths of rivers, salt marshes and lagoons). Estuaries serve as spawning and feeding grounds for large numbers of marine organisms and provide shelter and food for birds and wildlife.

Evapotranspiration

The combined loss of water from an area by evaporation from the soil surface and by transpiration of plants.

Excess Rainfall

The amount of rainfall that runs directly off an area.

Filter Blanket

A layer of sand or gravel designed to prevent the movement of fine-grained soils.

Filter Fabric

A woven or non-woven, water permeable material generally made of synthetic products, such as polypropylene, and used in erosion and sediment control applications to trap sediment or prevent the movement of fine soil particles. Often used instead of a filter blanket.

Flood Peak

The highest stage or greatest discharge attained by a flood event. Thus, peak stage or peak discharge.

Floodplain

The lowland that borders a stream and is subject to flooding when the stream overflows its banks.

Flood Stage

The stage at which overflow of the natural banks of a stream begins.

Floodway

A channel, either natural, excavated, or bounded by dikes and levees, used to carry flood flows.

Flume

A constructed channel lined with erosion-resistant materials used to convey water on steep grades without erosion.

Fluvial Sediment

Those deposits produced by stream or river action.

Foundation Drain

A pipe, or series of pipes, that collects groundwater from the foundation or footing of structures to improve stability.

Freeboard

Vertical clearance between the normal operating level and the top of an open conduit or channel. Vertical distance between the design water surface elevation and the elevation of the barrier retaining the water.

Frequency of Storm (design storm frequency)

The anticipated period in years that will elapse before another storm of equal intensity and/or total volume will recur: a 10-year storm can be expected to occur on the average once every 10 years.

Gabion

A wire-mesh cage, usually rectangular, filled with rock and used to protect channel banks and other sloping areas from erosion.

Gauge

Device for measuring precipitation, water level, discharge, velocity, pressure, temperature, etc. (e.g., a rain gauge). A measure of the thickness of metal (e.g., diameter of wire or wall thickness of steel pipe).

Geotextile

Any permeable textile used with foundation, rock, earth, or any other geotechnical engineering-related material as an integral part of a man-made project, structure or system.

Grade

(a) The slope of a road, a channel, or natural ground. (b) The finished surface of canal bed, roadbed, top of embankment, or bottom of excavation; any surface prepared to a design elevation for the support of construction such as paving or the laying of a conduit. (c) To finish the surface of a canal bed, roadbed, top of embankment, or bottom of excavation, or other land area to a smooth, even condition.

Grade Stabilization Structure

A structure for the purpose of stabilizing the grade of a gully or other watercourse, thereby preventing further head-cutting or lowering of the channel bottom.

Gradient

Change of elevation, velocity, pressure, or other characteristics per unit length; slope.

Grading

The cutting or filling of the land surface to a desired slope or elevation.

Grass

A member of the botanical family Gramineae, characterized by blade-like leaves that originate as a sheath wrapped around the stem.

Grassed Waterway

A natural or constructed waterway, usually broad and shallow, covered with erosion-resistant grasses and used to safely conduct surface water from an area.

Ground Cover

(Horticulture) Low-growing, spreading plants useful for low-maintenance landscape areas.

Habitat

The environment in which the life needs of a plant or animal are supplied.

Harmful Pollutant

A substance that has adverse effects on an organism. Adverse effects include immediate death, chronic poisoning, impaired reproduction, and other conditions.

Head

The height of water above any plain of reference. The energy, either kinetic or potential, possessed by each unit weight of a liquid, expressed as the vertical height through which a unit weight would have to fall to release the average energy possessed. Used in various compound terms such as pressure head or velocity head.

Head loss

Energy loss due to friction, eddies, changes in velocity, elevation or direction of flow.

Headwater

The source of a stream. The water upstream from a structure or point a stream.

Heavy Metals

Metals having a high specific gravity, present in municipal and industrial wastes, that pose long-term environmental hazards. Such metals include cadmium, chromium, cobalt, copper, lead, mercury, nickel, and zinc.

Hydrologic cycle

The circuit of water movement from the atmosphere to the earth and back to the atmosphere through various stages or processes such as precipitation, interception, runoff, infiltration, percolation, storage, evaporation, and transpiration.

Hydrology

The science of the behavior of water in the atmosphere, on the surface of the earth, and underground.

Hyetograph

A graph of runoff rate, inflow rate or discharge rate past a specific point in time. A graph of flow versus time.

Impact basin

A device used to dissipate the energy of flowing water to reduce erosion. Generally constructed of concrete partially submerged with baffles to dissipate velocities.

Impervious

A surface that water can not easily penetrate. Can include graveled surface as well as paved surfaces.

Infiltration

The downward movement of water from the surface to the subsoil.

Inoculum

A culture of microorganisms intentionally introduced into a medium such as seed, soil, or compost.

Invert

The inside bottom of a culvert or other conduit.

Keyway

A cutoff trench dug beneath the entire length of a dam to cut through soil layers that may cause seepage and possible dam failure.

Laminar Flow

Flow at relatively slow velocity in which fluid particles slide smoothly along straight lines everywhere parallel to the axis of a channel or pipe.

Land Capability

The suitability of land for use. Land capability classification involves consideration of: the risks of land damage from erosion and other causes; and, the difficulties in land use owing to physical land characteristics, including climate.

Land Use Controls

Methods for regulating the uses to which a given land area may be put, including such things as zoning, subdivision regulation, and floodplain regulation.

Legume

Any member of the pea or pulse family, which includes peas, beans, peanuts, clovers, alfalfas, sweet clovers, lespedezas, vetches, black locust, and kudzu. Practically all legumes are nitrogen-fixing plants.

Liquid Limit

The moisture content at which the soil passes from a plastic to a liquid state.

Loam

A soil textural classification in which the proportions of sand, silt, and clay are well balanced. Loams have the best properties for cultivation of plants.

Material Safety Data Sheets (MSDS)

Data sheets which come with materials. The sheets contain information such as pH, flashpoint, reactivity, first aid recommendations and indicate material classification and handling requirements.

MD

Machine direction; in textiles, the direction in a machine-made fabric parallel to the direction the fabric followed in the manufacturing machine.

Mean Depth

Average depth; cross-sectional area of stream or channel divided by its surface or top width.

Mean Velocity

The average velocity of a stream flowing in a channel or conduit at a given cross-section or in a given reach. It is equal to the discharge divided by the cross-section area of the reach.

Microclimate

The climate specifically associated with a very small area such as a crevice in a rock outcropping.

Mitigation

Means, in the following order of importance:

1. Avoiding the impact altogether by not taking a certain action or part of an action
2. Minimizing impacts by limiting the degree or magnitude of the action and its implementation, by using appropriate technology, or by taking affirmative steps to avoid or reduce impacts.
3. Rectifying the impact by repairing, rehabilitating or restoring the affected environment.
4. Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.
5. Compensation for the impact by replacing, enhancing, or providing substitute resources or environments.

Mulch

A natural or artificial layer of plant residue or other materials covering the land surface that conserves moisture, holds soil in place, aids in establishing plant cover, and minimizes temperature fluctuations.

National Pollutant Discharge Elimination System (NPDES)

The part of the Federal Clean Water Act that requires permits (NPDES permits) for point and nonpoint source discharges.

Natural Drainage

The flow patterns of storm water runoff over the land in its pre-development state.

Nitrogen Fixation

The conversion of atmospheric nitrogen into stable compounds usable by plants. Carried out by bacteria that colonize the roots of most legumes.

Nonpoint Source Pollution

Pollution that enters a water body from diffuse origins on the watershed and does not result from discernible, confined, or discrete conveyances.

Normal Depth

Depth of flow in an open conduit during uniform flow for the given conditions.

Nutrients

Essential chemicals for plant and animal growth. Excessive amounts can lead to water quality degradation and algae blooms. Some nutrients are toxic at high concentrations.

Open Drain

Natural watercourse or constructed open channel that conveys drainage water.

Orifice

An opening with closed perimeter, usually of regular form, through which water may flow, generally to control outlet flow.

Outfall

The point, location, or structure where wastewater or drainage discharge from a sewer to a receiving body of water.

Outlet

Point of water disposal from a stream, river, lake, tidewater, or artificial drain.

Outlet channel

A waterway constructed or altered primarily to carry water from man-made structures, such as smaller channels, tiles, lines, and diversions.

Peak Discharge

The maximum, instantaneous flowrate during a storm, usually in reference to a specific design storm event.

Permeability

A generic term for the ability of a material to conduct a fluid.

Permeable Soils

Soil materials with filtration rate of 10 minutes per inch or better. Such soils allow infiltration and reduce or eliminate surface and storm water runoff. Classified as SCS (Soil Conservation Services) Type A.

Permeability Rate

The rate at which water will move through a saturated soil. Permeability rates are classified as follows:

- Very slow – Less than 0.06 inches per hour.
- Slow – 0.06 to 0.20 inches per hour.
- Moderately slow – 0.20 to 0.63 inches per hour.
- Moderate – 0.63 to 2.0 inches per hour.
- Rapid – 6.3 to 20.0 inches per hour.
- Very rapid – More than 20.0 inches per hour.

Permittivity

For a geotextile, the volumetric flow rate of water per unit cross-section area, per unit head, under laminar flow conditions, in the normal direction through the fabric.

Plasticity Index

The numerical difference between the liquid limit and the plastic limit of soil; the range of moisture content within which the soil remains plastic.

Plastic Limit

The moisture content at which a soil changes from a semi-solid to a plastic state.

Point Source

Any discernible, confined and discrete conveyance, including but not limited to any pipe ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged.

Point Source Pollutants

Pollution that enters a water body resulting from discernible confined or discrete conveyances.

Pollution Control Plan (PCP)

Consists of PCP form, narrative, site map, and details describing measures to prevent pollution related to contractor activities. Special Provision 00170.30(c) spells out the contractor's responsibilities related to pollution control.

Pervious

Allowing movement of water.

Porosity

The volume of pore space in soil or rock.

pH

A numerical measure of hydrogen ion activity. The neutral point is pH 7.0. All pH values below 7.0 are acid and all above 7.0 are alkaline.

Rainfall Intensity

The rate at which rain is falling at any given instant, usually expressed in inches per hour.

Rational Method

A means of computing storm drainage flow rates, Q , by use of the formula $Q=CIA$, where C is a coefficient describing the physical drainage area, I is the rainfall intensity, and A is the area.

Receiving Stream

The body of water into which runoff or effluent is discharged.

Recharge Basin

A basin provided to increase infiltration for the purpose of replenishing groundwater supply.

Retention

The process of collecting and holding surface and storm water runoff with no surface overflow.

Retention/Detention Facility

A type of drainage facility designed either to hold water for a considerable length of time and then release it by evaporation, plant transpiration, or infiltration into the ground; or to hold surface and storm water runoff for a short period of time, and then release it to the surface and storm water management system.

Retention Structure

A natural or artificial basin that functions similar to a detention structure except that it maintains a permanent water supply.

Riparian

Pertaining to banks of streams, wetlands, lakes or tide waters.

Riparian Rights

A principle of common law that requires any user of waters adjoining or flowing through his lands must so use and protect them that he will enable his neighbor to utilize the same waters undiminished in quantity and undefiled in quality.

Riser

The inlet portions of a drop inlet spillway that extends vertically from the pipe conduit barrel to the water surface.

Runoff

That portion of precipitation that flows from a drainage area on the land surface, in open channels, or in storm water conveyance systems.

Salmonid

A member of the fish family salmonidae. Includes Chinook, coho, chum, sockeye and pink salmon, cutthroat, steelhead, rainbow, Dolly varden, brook, kokanee and whitefish.

Sand

(a) Soil particles between 0.05 and 2.0 mm in diameter. (b) A soil textural class inclusive of all soils which are at least 70% sand and 15% or less clay.

Saturation

In soils, the point at which a soil or an aquifer will no longer absorb any amount of water without losing an equal amount.

Scour

The clearing and digging action of flowing water, especially the downward erosion caused by stream water in sweeping away mud and silt from the stream bed and outside bank of a curved channel.

Sediment

Fragmented material originated from weathering and erosion of rocks and unconsolidated deposits. The material is transported by, suspended in, or deposited by water.

Sedimentation

Deposition or formation of sediment.

Sediment Delivery Ratio

The fraction of the soil eroded from upland sources that actually reaches a stream channel or storage reservoir.

Sediment Discharge

The quality of sediment, measured in dry weight or by volume, transported through a stream cross-section in a given time. Sediment discharge consists of both suspended load and bedload.

Sediment Pool

The reservoir space allotted to the accumulation of sediment during the life of the structure.

Seedbed

The soil prepared by natural or artificial means to promote the germination of seed and the growth of seedlings.

Seedling

A young plant grown from seed.

Settling Basin

An enlargement in the channel of a stream to permit the settling of debris carried in suspension.

Sheet Erosion

Relatively uniform removal of soil from an area without the development of conspicuous water channels.

Sheetflow

Relatively uniform flow over a plane surface without concentration of water into conspicuous channels.

Shoot

The above ground portion of a plant.

Silt

(a) Soil fraction consisting of particles between 0.002 and 0.05 mm in diameter. (b) A soil textural class indicating more than 80% silt.

Siltation

Process by which a river, lake, or other water body becomes clogged with sediment. Siltation can clog gravel beds and prevent successful salmon spawning.

Slope

Degree of deviation of a surface from the horizontal; measured as a numerical ratio or percent. Expressed as a ratio, the first number is the horizontal distance (run) and the second is the vertical distance (rise), e.g., 2:1. Slope can also be expressed as the rise over the run. For instance, a 2:1 slope is a 50 percent slope.

Soil

The unconsolidated mineral and organic material on the immediate surface of the earth that serves as a natural medium for the growth of land plants.

Soil Horizon

A horizontal layer of soil that, through processes of soil formation, has developed characteristics distinct from the layers above and below.

Soil Profile

A vertical section of the soil from the surface through all horizons.

Soil Stabilization

Use of rock lining, vegetation, or other methods to prevent soil movement when loads are applied to the soil.

Soil Structure

The relation of particles or groups of particles that impart to the whole soil a characteristic manner of breaking; some types are crumb structure, block structure, platy structure, and columnar structure.

Soil Texture

The physical structure or character of soil determined by the relative proportions of the soil separates (sand, silt and clay) of which it is composed.

Spillway

A passage, such as a paved apron or channel, for surplus water over or around or through a dam or similar structure. An open or closed channel, or both, used to convey excess water from a reservoir. It may contain gates, whether manually or automatically controlled, to regulate the discharge of excess water.

Storm Frequency

The statistical time interval between major storms of predetermined intensity and runoff volumes for which storm sewers and other structures are designed and constructed to handle hydraulically without surcharge or backflow.

Storm Sewer

A sewer that carries storm water, surface drainage, street wash, and other wash waters, but excludes sewage and industrial wastes. Also called a storm drain.

Stormwater

That portion of precipitation that does not percolate into the ground or evaporate, but flows via overland flow, interflow, channels, or pipes into a defined surface water channel, or a constructed infiltration facility.

Stormwater Facility

A constructed component of a storm water drainage system, designed or constructed to perform a particular function, or multiple functions. Storm water facilities include pipes, swales, ditches, culverts, street gutters, detention basins, retention basins, constructed wetlands, and other facilities.

Streambanks

The usual boundaries, not the flood boundaries, of a stream channel. Right and left banks are named facing downstream.

Stream Gauging

The quantitative determination of stream flow using gauges, current meters, weirs, or other measuring instruments at selected locations. See Gauging station.

Subcritical Flow

Flow at relatively low velocity where the wave from a disturbance can move upstream. Froude No. less than 1.

Subsoil

The B horizons of soils with distinct profiles. In soils with weak profile development, the subsoil can be defined as the soil below which roots do not normally grow.

Subsurface Drain

A pervious backfilled trench usually containing stone and perforated pipe for intercepting groundwater or seepage.

Sub-Watershed

A watershed subdivision of unspecified size that forms a convenient natural unit.

Surface Runoff

Precipitation that falls onto the surfaces of roofs, streets, the ground, etc., and is not absorbed or retained by that surface, but collects and runs off.

Suspended Solids

Organic or inorganic particles suspended in and carried by water: sand, mud, clay, as well as other solids.

Swale

An elongated depression in the land surface that is at least seasonally wet, is usually heavily vegetated, and is normally without flowing water. Swales conduct storm water into primary drainage channels and may provide some groundwater recharge.

Tile Drain

Pipe made of perforated plastic, burned clay, concrete, or similar material, laid to a designed grade and depth, to collect and carry excess water from the soil.

Tile Drainage

Land drainage by means of a series of tile lines laid at a specified depth, grade and spacing.

Time of Concentration

The time period necessary for surface water runoff to reach the outlet of a sub-basin from the hydraulically most remote point in the tributary drainage area.

Toe of Dam

The base, or bottom, of the sloping faces of a constructed dam at the point of intersection with the natural ground surface - normally a much flatter slope. A dam has an inside toe (the impoundment or upstream side) and an outside toe (the downstream side).

Toe of Slope

The base or bottom of a slope at the point where the ground surface abruptly changes to a significantly flatter grade.

Topography

General term to include characteristics of the ground surface, such as plains, hills, mountains, degree of relief, steepness of slopes, and other physiographic features.

Topsoil

The dark-colored surface layer of the A horizon of a soil. When present it ranges in depth from a fraction of an inch to 2 or 3 feet; equivalent to the plow layer of cultivated soils. Commonly used to refer to the surface soil layer(s), enriched in organic matter and having textural and structural characteristics favorable for plant growth.

Total Solids

Solids in water, sewage, or other liquids including dissolved, filterable and nonfilterable solids. The residue left when moisture evaporates and the remainder is dried at a specified temperature.

Total Suspended Solids (TSS)

The entire amount of organic and inorganic particles dispersed in water. TSS are the larger particles in the water that are more easily removed by sedimentation than smaller particles that cause turbidity.

Toxicity

The characteristic of being poisonous or harmful to plant animal life. The relative degree or severity of this characteristic.

Trash Rack

A structural device used to prevent debris from entering a pipe spillway or other hydraulic structure.

Transmissivity

The volumetric flow rate per unit thickness under laminar flow conditions, in the in-plane direction of the fabric.

Turbidity

Is caused by silt and clay particles, particles smaller than 0.02 mm, suspended in water. Measurement of turbidity can be done by turbidimeter, which measures light-beam scatter caused by small, suspended particles and converts it to NTU (national turbidity units).

Turf

Surface soil supporting a dense growth of grass and associated root mat.

Unified Soil Classification System

A classification system based on the identification of soils according to their particle size, gradation, plasticity index, and liquid limit.

Vactor Waste

The waste material in the bottom of a catch basin.

Vegetative Stabilization

Protection of erodible or sediment-producing areas with:

- Permanent seeding, producing long-term vegetative cover.
- Short-term seeding, producing temporary vegetative cover.
- Sodding, producing areas covered with a turf of perennial sod-forming grass.

Watercourse

A definite channel with bed and banks within which concentrated water flows, either continuously or intermittently.

Water Quality

A term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose.

Water Resources

The supply of groundwater and surface water in a given area.

Watershed Area

All land and water within the confines of a drainage divide.

Water Table

The free surface of the groundwater. That surface subject to atmospheric pressure under the ground, generally rising and falling with the season, or from other conditions such as water withdrawal.

Weir

Device for measure or regulating the flow of water.

Weir Notch

The opening in a weir for the passage of water.

Wet Pond

A facility treating storm water by utilizing a permanent pool of water to remove conventional pollutants from runoff. Treatment mechanisms include sedimentation, biological uptake and plant filtration.

Wet Season

October 1 to May 31.

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