BEST MANAGEMENT PRACTICES FOR OIL AND GAS WELL SITE CONSTRUCTION

Revised June 2013

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Foreword

Drilling for oil and gas reserves began in Ohio well over a hundred years ago. The petroleum industry today provides employment and business to suppliers and Ohio petroleum to the nation. In many parts of the state the oil and gas drilling activity is an important part of the local economy.

However, with drilling have come disturbances to the land. Due to the rough topography in the eastern half of Ohio where drilling is concentrated, the potential for excessive erosion is significant. Drilling activity may also disturb important drainage patterns or create drainage problems. In addition water quality of surface waters and groundwater aquifers may be affected by sediment and waste brine at wells and storage sites, access roads or from waste disposal activities. In any case, it is clear that to protect water quality and reduce soil loss, it is necessary to properly plan, construct and restore well sites, access roads and other disturbed land.

This handbook has been developed to provide the oil and gas industry and other related contractors with a concise source of site restoration information. The handbook provides general guidelines which will cover most situations. It may be necessary, however, to contact your county soil and water conservation district (SWCD) and/or the Division of Oil and Gas Resources Management for additional assistance. The information within should help reduce soil loss due to oil and gas production activities and limit water quality degradation due to sediment delivery to streams and lakes.

The Importance of Planning Well Sites

It has often been said, "An ounce of prevention is worth a pound of cure." When topsoil is stockpiled, access roads properly located and conservation practices installed as the site is developed, restoration is quicker, simpler and less expensive. Constructing the site according to an erosion control and water management plan can be very cost effective.

Considerations for Planning

Topography:
The relief of the land plays an important role in laying out access roads to prevent erosion. Whenever possible, construct roads along the contour of the hillside. Avoid going directly up the slope or exceeding slopes of 15% (15 feet vertical rise in 100 feet horizontal distance). Any road going across the slope acts as a large diversion ditch. It collects the runoff from above and channels it down the hill. Unless properly spaced and sized waterbars and/or culverts are installed, erosion problems will occur. This means more bulldozer time to repair the road along with increased wear and tear on pumper trucks. When roads are properly planned and constructed many expensive maintenance problems can be eliminated.

Soil Type:
Consider the inherent properties and characteristics of soils in the design of roads and well sites. The first priority is to stockpile the topsoil. When topsoil is saved and spread during restoration, seeding has a much greater chance of becoming established. Slip prone, unstable or wet soils should be avoided due to the many problems they cause. In the event these soils cannot be avoided, special precautions taken before and during site construction will help reduce problems in the future. These soils can be identified prior to site development by obtaining soil maps and soil information from any SWCD office. There is a SWCD office in every county. Many have published soil surveys of their entire county and information concerning every soil type.

Limiting Factors Concerning Vegetation

The stockpiling/ handling and use of topsoil may be the best method of improving your success in reseeding. The topsoil, no matter how thin the layer may be, contains nutrients, organic material and other elements which favor germination and growth of grass and legumes. The sub-soil, which normally remains after site construction, is usually more acid and contains fewer nutrients to help vegetation get established.

Follow these six important steps for successful seeding:

1. stockpile topsoil
2. replace and grade topsoil
3. prepare seedbed
4. spread and incorporate lime and fertilizer
5. seed proper species and
6. apply a mulch.

Remember to follow every step; skipping any step may adversely affect your results.

Erosion and Sedimentation Control Measures

General Information

This following chapter covers commonly used erosion and sediment control measures and their general guidelines for installation.

The erosion and sedimentation control measures described herein offer an effective means of reducing erosion and preventing damage to both the construction area, off site properties, stream and lakes. However, these measures, as well as the site and other involved area, must be well vegetated to operate properly.

The recommendations herein are minimum guidelines and have been prepared for average conditions in Ohio. For site conditions which exceed average conditions or have severe limiting factors, contact your local Soil and Water Conservation District (SWCD) office.

Although the use of any practice or combination of practices will effectively control runoff and prevent erosion, there is no substitute for properly planning road placement and site location. Planning may help avoid the expense and trouble of installing some practices and repairing erosion or water quality problems.

Access Roads

Recent studies have indicated the greatest amount of erosion attributed to oil and gas well drilling activity occurs on access roads. Roads may act as a diversion, collecting and directing runoff as it crosses the slope. Without methods of properly managing storm runoff, tremendous soil losses may occur.

Planning, design and proper construction of access roads is imperative due to the heavy load and amount of use they must withstand. Water control structures such as water bars and culverts may help control erosion, but they are no substitute for proper location and construction of the access road.

A. Description
   A roadway constructed to provide access to the well site.

B. Purpose
   To provide a route for travel for moving equipment and materials used for drilling, operating and maintaining well sites.

C. Design Guidelines
   1. Minimum roadbed width should be 14 feet for a single lane and 20 feet for a double lane.
   2. Side slopes for excavated cuts should, in no case, exceed 2:1.
   3. Earthen fill slopes should be no steeper than 2:1.
   4. Install side ditches on road sections where surface runoff endangers fill areas.
   5. Install adequate culverts under the road and in natural drainage ways unless a bridge is needed for larger drainage areas.
   6. Place culverts across roadways to handle flows from the side ditch when permissible velocity is exceeded in the ditch. For spacing requirement, see Table # 1.
   7. Provide headwalls or drop inlets if erosion of the inlet is a problem.
   8. Headwalls can be constructed of rock riprap, logs or concrete.

9. Grades should normally not exceed 15% except for short lengths but maximum grades of 20% may be used, if necessary, for special purposes.
10. Do ***not*** locate roads near water courses whenever possible.
11. Areas having soils that are slide prone should be avoided. If these areas cannot be avoided the access road should be located in a manner that would minimize cuts and fills.
12. Reseed, mulch, etc., roadbanks, roadbeds and all other disturbances promptly and in accordance with the recommended rates.

D. Construction Guidelines
The area to be excavated or occupied by a fill should be cleared and grubbed of all trees, stumps, large roots, boulders and debris. All such material should be disposed of by burning, burial or removal from sites. With landowner approval, brush piles may be created to enhance wildlife habitat.

Water Bars

Water bars (also known as water breaks or cross drains) are the most commonly used conservation practices. They can be constructed during or immediately following drilling and fracturing of the well. A bulldozer or tractor with blade can easily construct water bars. To work effectively, the structures must be adequately spaced and sized.

Water Bars for Access Roads

A. Description
A channel or open ditch constructed diagonally across roads to carry surface runoff.

B. Purpose
To prevent accumulation of large volumes of water by diverting surface runoff from road surface at designed intervals. Erosion in the form of gullies may be prevented by construction of water bars.

C. Construction Material
Compacted soil.

D. Design guidelines
1. Minimum height-8 inches.
2. Minimum top width-2 feet (6 feet including downhill toe)
3. Water bars should be at a 30 degree angle to the road at an outslope of 2-4%.
4. Cross section should be parabolic (see figure 1.)
5. Provide a safe outlet to prevent erosion caused by water discharge. Material for an outlet may be rock, concrete, etc., of sufficient composition and quantity to prevent soil detachment.

E. Construction Guidelines
Construct water bars to a specified line and grade. The soil should be well graded and ready for seeding.
1. Location – Place water bars at the head of any slope (or edge of a wellsite) and then spaced appropriately down the slope.
2. Spacing – Water bars are only effective when spaced at recommended distances. For spacing recommendations see Table 1.

Table 1. Spacing of Water Bars (per U.S. Forest Service)

Road Grade (%)	Distance Between Bars (feet)
2	300
3	235
4	200
5	180
6	165
7	155
8	150
9	145
10	140

F. Maintenance

Where access roads will be used frequently when soil conditions are wet, the roadway will require frequent grading unless a crushed rock surface is installed. Water bars should be reshaped after each grading operation.

Broad Based Dips

Broad based dips can be used where no intermittent or permanent streams cross the road. They are particularly effective when constructed on an access road that intersects small swales or drainage patterns. Because of the construction techniques this type of dip should not be used on roads exceeding 10% grade. Dips should be lined with crushed rock or gravel. They do no increase wear on vehicles or reduced hauling speed when properly installed.

Use Table 2 to calculate proper spacing.

Table 2. Spacing of Broad Based Dips

Road Grade (%)	Distance Between Bars (feet)
2	300
3	235
4	200
5	180
6	165
7	155
8	150
9	145
10	140

Protect the discharge area from erosion. The outlet may require stone or a good grass sod.

A. Description
A constructed dip or swale across a road surface with the dip sloped to the outslope for drainage. See Figure 2.

B. Purpose
To provide cross drainage on roads during and after well development to prevent excessive buildup of surface runoff.

C. Design/Construction Guidelines
1. Maximum road grade on which dips can be constructed is 10%.
2. Minimum width should be 20 feet.
3. Construct a 3% reverse grade in an existing roadbed by cutting upgrade of the dip location.
4. Spacing – See Table 2.

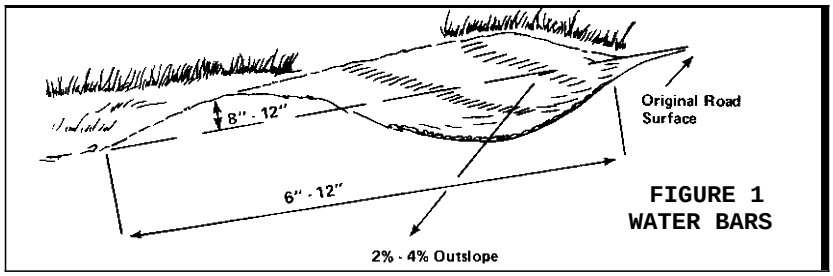


FIGURE 1
WATER BARS

FIGURE 2
Broad Based Dip

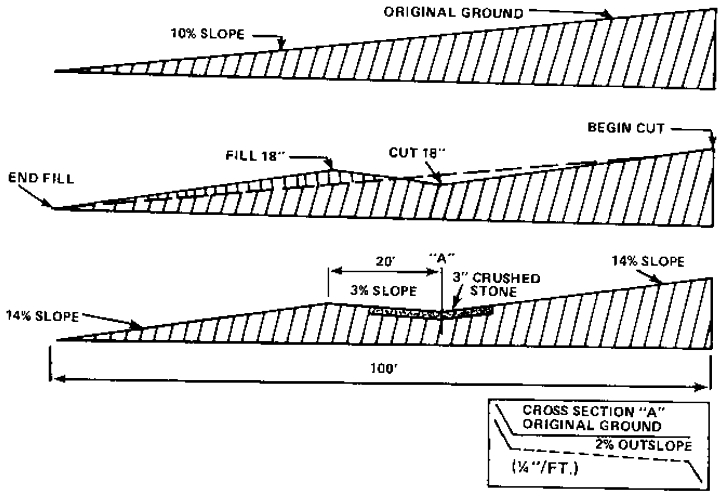
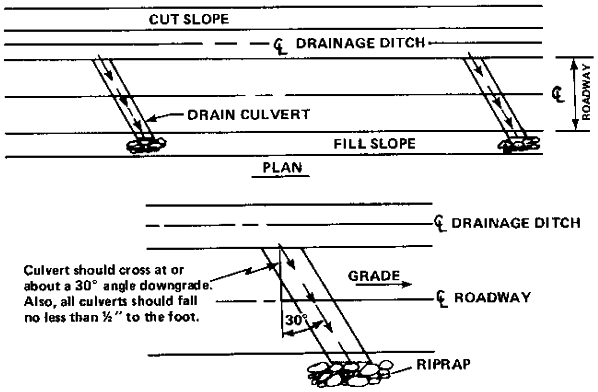


FIGURE 3
Culvert Detail



Pipe Culverts for Access Roads

Pipe culverts are usually installed on permanent roads at the time of construction. They are commonly used where vehicle traffic will be relatively heavy following drilling activity or where access roads cross significant drainage patterns. Pipe structures are the most expensive type of cross drain but are quite effective in controlling water. Because of the additional cost, it is important to properly install and maintain the culvert.

A. Description

Pipe buried under the road to carry surface water from the road ditches and natural drainage ways.

B. Purpose

Pipe culverts are primarily used to channel uphill drainage water under roadways. They also can be used to divert water collected in road side ditches.

C. Materials

1. Steel
2. Concrete
3. Cast Iron
4. Aluminum
5. Plastic (heavy wall)

D. Design Guidelines

1. For pipe culverts used to divert road side ditch water, use same spacing requirements as water bars. See Table 1.
2. For culverts located below sizable watersheds (between 10-500 acres) see Table 3.
3. Minimum suggested culvert size is a 15 inch diameter.
4. Position culverts at approximately 30° downgrade. See Figure 3.
5. Culvert grade should be less than ½ inch per foot of pipe (4.0%)
6. Use at least 12 inches of earth cover or ½ of the diameter of the pipe, whichever is greater, to cover the pipe. See Figure 4. Culverts should extend to the lower edge of fill.
7. Provide adequate materials to prevent erosion at pipe discharge. See Figure 5.
8. Pipes should have headwalls at their inlet when collecting water from road side ditches. See Figure 4.

E. Construction Guidelines*****

Install culverts to a specified line and grade. The ditch should be excavated to a depth and grade to insure adequate cover for the pipe. A minimum of one foot of cover or half the diameter of earth cover, whichever is greater, is considered adequate. If adequate cover cannot be achieved, install an arch pipe or two smaller pipes.
A firm foundation is needed to support the pipe. The soil should be well compacted along the pipe and free of rock, roots and clumps. A back hoe is recommended for pipe culvert installation.

*Install plastic pipe per manufacturer's recommendations which may require special techniques.

TABLE 3
Pipe Sizes for Culverts Across Road

Drainage Area (Acres)	Pipe Diameter (Inches)	Pipe Capacity (cu. ft. / sec.)
10	15	5
20	18	9
30	21	12
50	24	18
80	27	24
100	30	29
230	36	50
400	42	72

FIGURE 4
Culvert Installation

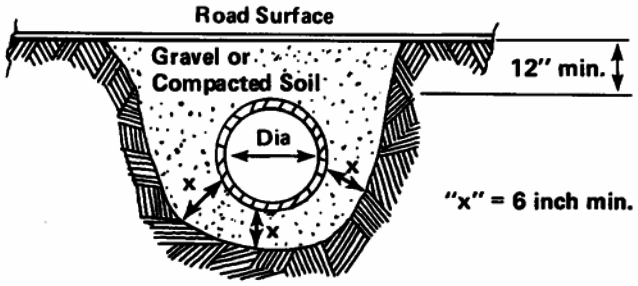
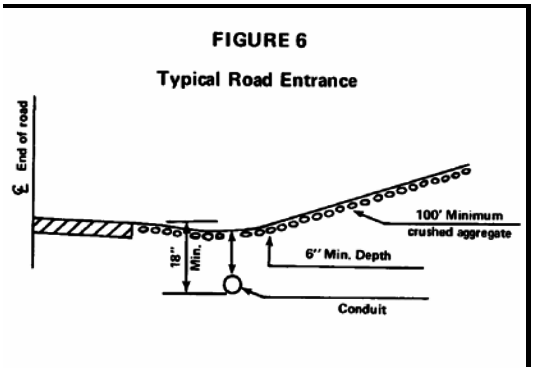


FIGURE 5
Culvert Placement

Access Road Entrance

Erosion often occurs where an access road joins an established roadway. Steep slopes and concentrated run off may cause severe gully erosion and result in sedimentation on the roadway and/or in the ditch.
Most local governments have restrictions and standards for entrances. Generally, requirements include culvert pipes and a stone roadbed for a specific distance. Producers should check with officials for local regulations.
Properly designed access road entrances should permit a clear view of the highway. They should be constructed so water or stone will not run on to the road pavement. Whenever possible, avoid making excessive cuts when constructing the access road entrance. Figure 6 shows a typical road entrance.



Road matting works effectively in supporting and preventing stone from incorporating into the soil. Road matting may greatly extend the lifetime of the stone roadbed.

Diversion Ditch

Diversion ditches are an important element in protecting the site from erosion and surface water problems. They should be constructed while the site is being prepared. Diversions, when constructed at the top of the cut slope and at the base of the site, will effectively reduce erosion and drainage problems.

A. Description

A channel or ridge constructed across a slope for diverting surface runoff.

B. Purpose

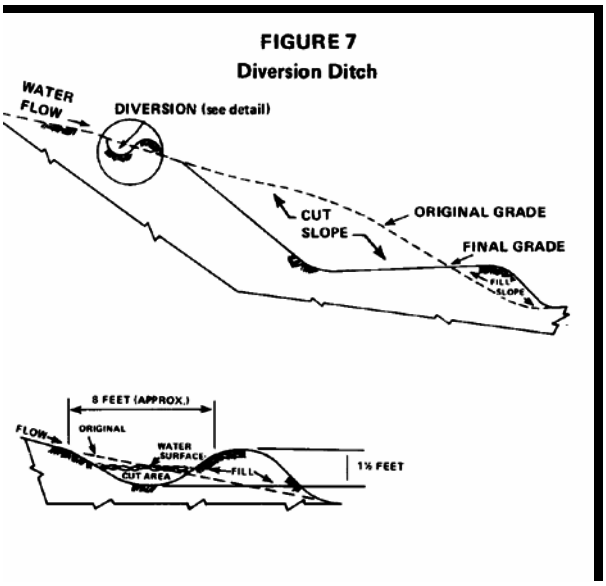
To intercept surface water before it enters an erodible area and to channel the runoff to a safe outlet.

C. Design Guidelines

1. For drainage area less than 2 acres see Figure 7.
    a. Minimum depth of 18 inches
    b. Minimum top width – 8 feet
    c. Maximum ditch grade 2%
    d. Minimum ditch grade 0.5%

2. For drainage area greater than 2 acres and when area being protected is of high value:

    a. Capacity of the ditch should handle a 10 year frequency storm for a 24 hour duration.



Surface Drains

Surface drain may be needed where drilling activity intercepts or blocks natural drainage patterns, or where excavation may trap runoff. Surface drains are used in flat areas with low grades, usually less than 2% and small drainage areas. When properly designed, a drained site may dramatically improve working conditions and reduce maintenance costs and restoration problems.

A. Description

An open drainage ditch constructed to a specific size and grade.

B. Purpose

To drain surface depressions, to collect and convey surface water. This does not apply to major drainage ways and open ditches.

C. Design Guidelines

1. Ditch side slopes should not be steeper than 3:1 when excavated in soil.
2. Base capacity of ditch on handling 0.1 cubic feet per second (CFS) per acres of drainage. Minimum depth should be 1.5 foot with 3:1 side slopes and should not exceed 2.0% grade.
3. Cross section of the ditch should be V-shaped for ditches 1% or less. Ditches over 1% should be flat bottomed or parabolically shaped.
4. Ditches should be seeded, lined or paved with stone, riprap, etc., to prevent erosion.

D. Construction Guidelines

1. Cut the ditch to a designated line and grade. The spoil should be spread and leveled so that the surface water can flow into the ditch.
2. Excavated surfaces should be reasonably uniform and smooth. Areas to be excavated should be cleared of trees and brush and should be disposed of by burning, burying or removal.

Table 4
Permissible Velocities

Soil Texture	Max. Velocity feet/second
Sand & sandy loam (noncolloidal)	2.5
Silt Loam (also high lime clay)	3.0
Sandy clay loam	3.5
Clay loam	4.0
Stiff clay, fine gravel, graded loam to gravel	5.0
Graded silt to cobbles (colloidal)	5.5
Shale. hardpan & coarse gravel	6.0

Table 5
Recommended Widths for Vegetation Strips Between Earthmoving Activities and Streams

Slope Between Disturbed Surface & Streams (%)	Width of filter strip	
	In Forested Area (in feet)	In Municipal Watersheds & Critical Areas (in feet)
0	25	50
10	45	90
20	65	130
30	85	170
40	105	210
50	125	250
70+	165+	330+

Filter Strips

Filter strips are the last line of defense to stop sediment from reaching streams. They help maintain water quality by trapping erosion sediments between the disturbed area and the stream system. By leaving essentially undisturbed buffer strips of vegetation between the streams, access roads, well sites and other disturbed areas, the existing vegetation will help trap sediment and prevent it from reaching the stream. Filter strips, however, are no substitute for protecting the disturbed area and cannot be expected to protect water quality alone.

A. Description

An undisturbed natural vegetative strip left between the disturbed area and a water course.

B. Purpose

The filter strip acts as a buffer area to catch sediment before it enters the water course.

C. Design Guidelines

1. Roads and other disturbed areas located above a stream course need a filter strip. The width of the filter strip depends on the slope of the land between the disturbed area and the water course. See Table 5 for spacing requirements.

2. In areas where a filter strip may have to be constructed, follow critical area treatment procedures. See Table 8.

D. Construction Guidelines

The filter strip areas should not be disturbed. No equipment operation that will expose the soil should be allowed in this area.

Sediment Barriers

Sediment barriers should be used in areas where excessive soil loss or sediment loads to a water course could cause serious problems. They should be used when activity above the barrier leaves bare soil even for a short period.

A. Description

A temporary restriction or barrier across a slope or at the toe of a slope.

Types of Barriers:
1. Hay or straw bales. See Figure 8 (1-3)
2. Silt fences. See Figure 9 (1-4)

B. Purpose

To trap sediment from a disturbed area by retarding and filtering storm water runoff.

C. Design Guidelines
1. Place straw bale dikes and silt fence on contour.
2. Spacing is governed by slope. Use the following guideline.

Table 5

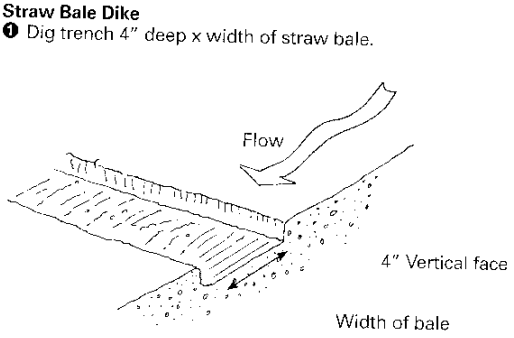
% Slope	Distance between barriers in feet
2-8	110-92
8-12	92-75
12-18	80-60
18-24	60-52

D. Construction Guidelines

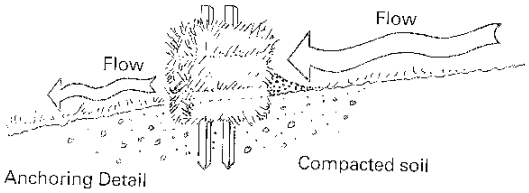
1. Place hay or straw bales in a row along the contour with adjacent bales securely tied with either wire or nylon string. Anchor each bale with two metal or wooden stakes at least 2" x 2" and driven into the ground a minimum of 1½ feet apart. Bales should be placed in the ground at least four inches.

2. Place silt fences on the contour. Space fence posts not more than 10 feet apart. If woven wire fencing is used, fasten it securely on the upstream side of the fence posts.

Figure 8 (1-3)

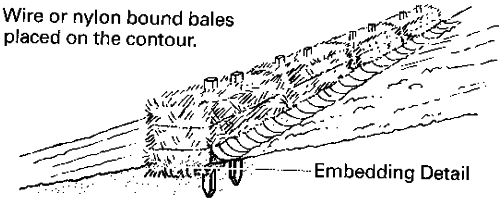


❷ Fit straw bales into trench and secure with 2 re-bars, steel pickets, or 2" x 2" stakes 1½' to 2' in ground.

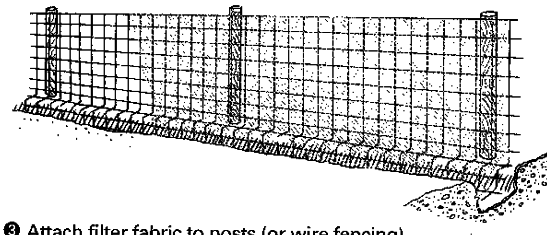


Anchoring Detail

❸ Wire or nylon bound bales placed on the contour.

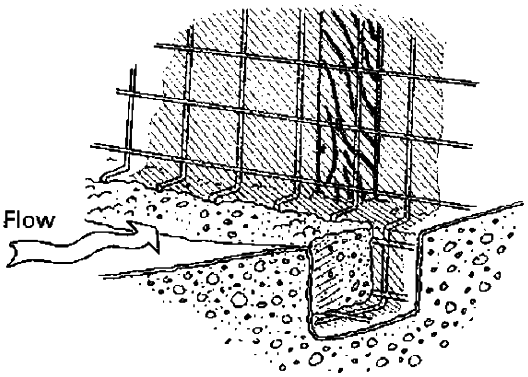


❶ Set posts and excavate trench.
❷ If utilizing wire fencing, staple wire fencing to posts. Otherwise, skip to step 3.



❸ Attach filter fabric to posts (or wire fencing) allowing extension into trench as shown.

❹ Backfill and compact excavated soil.



3. Road Matting/Filter Fabric

High traffic areas often require placement of gravel or stone to prevent erosion and to keep the area accessible during wet periods. After a short period of time the gravel seems to disappear as it's pressed into the subsoil, along with your investment.

Road matting or filter fabric is designed to provide support for the layer of stone while allowing water to drain into the soil. It is particularly effective in wet soils or heavy use areas but requires careful installation to work properly. The following steps are installation guidelines to be used with manufacturer's instructions:

a. Scalp topsoil from area keeping it evenly distributed so as not to affect road drainage. Salvaged topsoil could be used on the well site itself.

b. Place fabric on firm, level subsoil. Lap seams at least 1 foot and anchor all edges. Anchoring may consist of manufactured staples placed on 3 foot centers, burying the edges of the fabric 6 inches or hand spreading 4 inches of No. 1 stone along all edges at least 1 foot wide.

c. Place 6 inches of angular No. 304 stone over the fabric while avoiding misplacing the fabric. Placement may be by tailgating, or shoveling. The maximum drop must be 3 feet or less. Extend stone 1 foot beyond the edge of the fabric.

d. Compact stone with a farm tractor or similar vehicle. Top off road with 3 inches of screenings or other road surface material.

VEGETATIVE PRACTICES

General Information

The guidelines in this chapter have been developed as methods for minimizing soil erosion and sedimentation of surface water. These are guidelines for selecting, planning and designing erosion control measures and for obtaining quality restoration results. They should be adjusted and modified to meet individual site design requirements. Soil and water conservation district personnel may offer seeding recommendations which have been successful locally. *It is highly recommended that native species be used whenever possible* as well as restoration practices to enhance wildlife.

For best results, the disturbed areas should be seeded and mulched as soon as possible after they are no longer necessary in the drilling or producing

of the well. Cut slopes and diversion ditches should be treated immediately after their construction Remember, dormant sowings and other late sowings may require a "nurse" companion crop and increased mulch rates.
Inoculum should be added to legume seed. Inoculum is bacteria which assists the legume in nitrogen fixation. Inoculate the seed at the manufacturer's recommended rate.

Successful seeding requires following a planned course of action which is simplified into six easy steps. See Table 6.

Table 6
Six Steps To A Successful Seeding

1. **Stockpile topsoil**
2. **Replace and grade topsoil**
3. **Prepare seedbed**
4. **Spread and incorporate lime and fertilizer**
5. **Seed proper (native) species**
6. **Spread mulch**

Neglecting any one of these steps greatly reduces your chance of producing an adequate vegetative cover. Every step is important, like a link in a chain; however, stockpiling topsoil is the one factor which increases the chances for a successful seeding. The layer of topsoil, no matter how thin, contains many nutrients and is high in organic matter. Topsoil is much more productive than the subsoil and is a perfect medium for establishing a grass and legume cover. Topsoil is too valuable to be discarded during well site construction.
Often, new seedings need protection from grazing livestock. It is mutually beneficial for the producer and the landowner to work together to protect the seeded area until vegetation is well established.

Temporary Vegetative Cover Guidelines
Temporary vegetative cover is needed on disturbed areas where earthmoving activities will be stopped for a period of more than two months, but less than six months. The vegetation will provide short term, rapid cover for the control of surface runoff and erosion until permanent vegetation can be established or earthmoving activities can resume. Temporary cover is especially important in protecting stockpiled topsoil.
Temporary seedings may require fertilizer, lime, mulch, etc., for quick plant growth. Individual sites should be evaluated to determine these needs. For ground cover other than listed here, contact the local soil and water conservation district office.

GUIDELINES
Site Preparation

A. Install needed surface water control measures.
B. Seedbed should be prepared by disking or using other suitable equipment on the contour. The seedbed should be firm and have been worked at a depth of two to three inches.
C. Perform all tillage and planting operations at right angles to slopes.

Establishment

A. Select a species from Table 7.
B. Apply seed by broadcasting, drilling or hydraulic application according to the rate indicated in Table 8. All seed should be covered by approximately ¼ inch of topsoil.

Table 7
Temporary Seeding for Critical* Areas

Recommended Seeding Period	Species/ Mixture	Seeding Rates in lbs. / acre
March 1 to June 15	Oats	128
June 16 to Aug. 15	Perennial Ryegrass	40
	Oats & Sundangrass	64 80
	Perennial Ryegrass	40
Aug. 16-Nov. 1	Rye	112
	Wheat	120
	Perennial Ryegrass	40

*** "Critical Areas" are highly erodible or critically eroding sites. These areas usually cannot be stabilized by ordinary conservation treatment and management and if left untreated can cause severe erosion or sediment damage. Examples of critical areas are cuts, fills. denuded or gullied areas, steep slopes and areas of concentrated flows of water (diversions, waterbars, etc.).**

Permanent Vegetation

Permanent vegetative cover is needed on disturbed areas when earthmoving activities have ceased. Vegetation will re-establish ground cover to control (in association with other conservation practices) water runoff and erosion. The seedbed for permanent vegetative cover should be prepared to a depth of 2-3 inches with lime and fertilizer incorporated. Mulch should be applied to conserve soil moisture and provide temporary erosion control.

Table 8
Permanent Seeding for Critical Areas

Recommended Seeding Period	Species or Mixture	Seeding Rates Pounds per Acre
Year Around	Creeping Red Fescue	20
	Perennial Ryegrass	10
	Bluegrass	10
	Tall Fescue	40
	Creeping Red and Tall Fescue	20
	Tall Fescue	15
For critical areas in pastures of 8% slope or less, use any of the above or..		
Year Around	Orchard Grass	16
	Red Clover	8
	Creeping Red Fescue	20
For special areas: steep banks or cuts, ditch bank and reclaimed land.		
March 1 to June 15	Crownvetch** Tall Fescue	10 20
	Deer Tongue Tall Fescue	15 15
	Deer Tongue	20
	Birdsfoot Trefoil ** Creeping Red Fescue	10 20
	Flatpea ** Tall Fescue	20 20
	Korean Lespedeza** (Southern Ohio)	8
Year Around	Tall Fescue	40

****Inoculate Legume Seeds Using Four Times the Normal when Hydro-Seeding.**

Table 9
Permanent Hayland and Pasture Plantings*

Species	Rate lb./acre
Alfalfa	10-12
Red Clover and Timothy/1 or Bromegrass or Orchardgrass Alfalfa	2-4 2-4 6 4 6-8
Birdsfoot Trefoil Timothy (optional)/1	6 2-4
Bromegrass Ladino	10 1-1½
Tall Fescue Ladino	10-15 1-1½
Kentucky Bluegrass Ladino	10 1-1½
Red Clover /2 and Alsike or Ladino and Timothy/1 or Bromegrass or Orchardgrass	6 2 ¼ 2-4 6 5
Korean Lespedeza/4 (Southern Ohio)	8

/1 Timothy rates should be 4 lb./ac. for summer seedings

/2 For poorly drained soils with low to moderate productivity

/3 For excessively drained soil with low to medium productivity.

***These are general seeding rates applicable for soils ranging from well drained to imperfectly drained and high to moderate productivity. For more information refer to Agronomy Guide, OSU Cooperative Extension Bulletin #472 or contact your local soil and water conservation district office. Seed dealers may offer premixed seed for pasture and hayland. Check contents before using. Whenever possible we recommend the use of native species. (see glossary)**

Table 8 represents recommended seed species or mixtures, rates and seeding dates. For alternative rates or mixtures, contact the local soil and water conservation district. As Always, whenever possible use native species when planting.

Guidelines

Site Preparation

Strip and stockpile topsoil before the site is excavated. If the site will be leveled from a hillside, store topsoil beyond the area under construction.

A. Install needed surface water control measures.
B. Seedbed should be prepared to a depth of 2-3 inches by disking or other suitable equipment with adequate amounts of lime and fertilizer incorporated during seedbed preparation.
C. Perform all planting and tillage operations at right angles to slopes. (along the contour)

Establishment

A. Select species from Table 9.
B. Apply seed by broadcasting, drilling, or hydraulic application according to rates therein. All seed should be covered by ¼ inch of topsoil.
C. Mulch netting may also be necessary on steep slopes.

Management and Maintenance

A. Delay mowing for one year. Remove heavy residue after mowing to prevent smothering.
B. Mow as needed to control weeds, improve appearance and maintain a stand of desired vegetation. As much as possible, mowing should be done after August 15 to prevent destroying wildlife nests.

Not all seedings made in the restoration of well sites necessitate "Critical Area" treatment. Many sites may be located in pasture or cropland. The ground may be nearly level or have gentle slopes which remain part of the farm. However, care should be taken in these areas to protect topsoil. The landowner has invested a good deal of time and money in lime, fertilizer and chemicals to maintain productivity levels.

The present or planned use of the site should be considered. In a pasture or hayland situation, a grass-legume mixture is usually needed. The exact mixture will depend on the soil suitability, the type of farming operation and the land owners' preference. Often times it may be advantageous to have the farmer perform the seedbed preparation, fertilizer application, seeding, etc. Most farm operator are better equipped and have more expertise in these matters than do oil and gas producers.

For general seeding recommendations see Table 9. Table 10 contains recommended seeding periods. To determine necessary quantities use Table 11.

Table 10
Seeding Periods for Permanent Hayland and Pasture Plantings

Seeding Period		
Southern Ohio	**Northern Ohio**	
Spring Seedings		**Species**
Mar. 1 – Apr. 15	Mar. 10 – May 10	Alfalfa, Red Clover, Birdsfoot Trefoil, Bromegrass, Orchardgrass, Tall Fescue, Timothy
Summer Seedings		**Species**
Aug. 1- Sept. 15	Aug. 1- Sept. 1	Alfalfa, Bromegrass, Orchardgrass, Timothy, Tall Fescue

Alternative Seedings for Wildlife

A correctly restored well site can provide important wildlife cover. In a forested area, the site may be beneficial as a "wildlife opening". A site located near cropland may also act as an odd lot. In either setting, the change in habitat and the "edge effect" created can be effective in providing nesting, resting, loafing and feeding areas. The lush

vegetation will be readily utilized by nearly all game and non-game animals.

Most grass-legume mixtures provide excellent wildlife habitat. Mixtures with high rates of legumes are most suitable. Tall fescue is not considered acceptable nest cover. Tall fescue should be used for seeding the critical areas.

The level well site also lends itself to establishing food plots for wildlife. A food plot of ¼ acre or less seeded with appropriate amounts of soybeans, corn dwarf sorghum, millet, sunflowers, buckwheat and lespedeza will provide a quality winter food source. Occasionally, the Ohio Department of Natural Resources' Division of Wildlife has food plot seeding materials available for distribution.

Brush and trees cleared from the site can be used construct brush piles. A landowner waiver may be necessary. Rows of evergreens can also be planted along the site to promote wildlife cover. Once mature, these trees can also be used as a visual barrier. Tree packets (at minimal cost) or additional information are available from local soil and water conservation districts or from the Ohio Department of Natural Resources' Division of Forestry.

How to Calculate Seed & Fertilizer Needs for Roads and Disturbed Areas

A. Road Area (Acres)
B. Other Areas

1. To determine acreage and pounds of seed needed for other areas such as loading decks, turnouts, tank batteries, etc., use the following formula:

   Average length x average width = sq. ft.
   Sq. ft. x .000023

Multiply answer times pounds per acres as recommended in seed mixture tables to determine amount of seed

2. To determine fertilizer and mulch needs use the above procedures.

Example:
An access road is 12' wide and 500' long.
The well site is 200' wide and 250' long.
What is the total area?

Area of Road from Chart=0.14 acres
Area of Well Site = 1.15 acres
1.29 acres total

Use 1.29 x recommended seeding rates/acre to determine quantities needed.

Road Length (feet)	Road Width (feet)					
	8'	10'	12'	14'	18'	20'
50	0.01	0.01	0.01	0.02	0.02	0.02
100	0.022	0.02	0.03	0.03	0.04	0.05
250	0.05	0.06	0.07	0.08	0.10	0.11
500	0.09	0.12	0.14	0.16	0.21	0.23
750	0.144	0.17	0.21	0.24	0.31	0.34
1000	0.18	0.24	0.28	0.32	0.41	0.46
1500	0.28	0.34	0.41	0.48	0.62	0.69
2000	0.36	0.48	0.56	0.64	0.83	0.92
5000	0.92	1.15	1.38	1.61	2.07	2.30
5280	0.97	1.21	1.45	1.70	2.18	2.43

Multiply the appropriate table figure times the pounds per acre that is recommended for seed mixtures.

Mulching

Mulch can be used alone or in conjunction with other structural or vegetative erosion control measures. Mulch is applied to any disturbed area which is subject to erosion to protect bare soil or newly seeded areas. The recommended rates of mulch are seldom achieved. Many producers don't recognize the value of adequately covering the seeding.

Hand spreading mulch is very labor intensive. However, all the time and money spent on seeding may be wasted if only a half-hearted attempt at mulching is made. A 90% cover should be your goal. Mechanical straw blowers do a fine job of distributing mulch even in hard to reach places. They are easy to use and are highly recommended.

Guidelines

Application

A. Select the type of mulch and application rate from Table 12 which will best meet the use and performance requirements.
B. Determine anchoring requirements if needed and select a method of
C. Anchoring from Table 13 which best meet the specific job requirements.
D. Spread immediately after seeding to prevent excessive moisture loss and possible damage to newly sprouted seedings.

Table 12
Guide to Mulch Materials
(Rates and Use)

Mulch Material	Quality Standards	Application Rates		Depth of Application
		lbs./100 sq. ft.	lbs/acre	
Hay or straw	Air dried free from coarse materials	100 lbs. or 2-3 bales	2 tons 80-100 bales	Lightly covered 75-90% of surface

Table 13
Mulch Anchoring Guide

Anchoring Method and Material	Type of Mulch to Be Anchored	How to Apply
1.Manual A. Peg and Twine	Hay or Straw	After mulching, divide areas into blocks approximately 1 sq. yd. in size. Drive 4-5 pegs per block to within 2-3" of soil surface. Secure mulch to soil surface by stretching twine between pegs in a crisscross pattern on each block. Secure twine around each peg with two or more turns, drive pegs flush with soil where mowing and maintenance is planned.
B. Mulch netting	Hay or Straw	Staple light weight paper, jute, wood fiber or plastic netting to soil surface according to manufacturer's recommendations.
C. Mechanical Mulch Anchoring Tool or Crimping	Hay or Straw	Apply mulch and pull a mulch anchoring too over mulch. When a disk is used, set in the straight position and pull across the slope with suitable power equipment. Mulch material should be "tucked" into the soil surface about 3 inches.

Lime and Fertilizer

Lime and fertilizer should be applied to assure an adequate stand. When lime and fertilizer are *not* used, reseeding and resurfacing are often necessary the following year. The importance of these items cannot be overemphasized. Well sites are often located in soils which are strongly acid and of low productivity. Some these soils are shaley and may have a very low available water capacity. To successfully establish a vegetative cover in such adverse conditions, generous applications of lime and fertilizer are necessary.

Application Guidelines

A. When possible, a soil sample should be taken and tested to determine specific needs. In lieu of a test, use Table 14. For information concerning soil testing, contact the Cooperative Extension Service.
B. Determine the type of soil on the project site and the acid content of the soil. Once these facts are known, select the amount of lime and fertilizer from Table 14 which best meet the use and performance required.
C. Lime and fertilizer should be incorporated to a depth of 2-3 inches during the seedbed preparation process.

Table 14
General Guidelines for Lime and Fertilizer Rates

pH	Reaction	Soils	Liming Rates in Tons/ acre
8.5	Alkali	All soils	0
8.0	Alkaline		0
7.0	Neutral		0
6.5	Neutral		0
6.0	Slightly acid	Sandy loams, clay	2 2
5.5	Medium acid	Sandy loams, clay	3 4
5.0	Strongly acid	Sandy loams, clay	4 5
4.5	Strongly acid	Sandy loams, clay	5 6
4.0	Very strong acid +	Sandy loams, clay	6 7

Note: Apply 1000 pounds of type 12-12-12 or equivalent fertilizer per acre. One ton per acre is approximately equal to five pounds per 100 sq. feet. Lime type: ground agricultural lime.

GLOSSARY

Arch pipe: an elliptical curved pipe which provides increased flow without need for increased height.

Buffer zone:
An undisturbed area of vegetation used for screening roads or other sensitive areas.

Cfs: Cubic feet per second

Contour: An imaginary or measured line that is kept at the same elevation (level) for its entire length, usually in reference to tillage or terracing at right angles to the direction of the slope. (See below for example)

Design criteria:
Information and calculations used to determine dimensions, grades, etc., in engineering plans.

Discharge rate of flow:
A volume of fluid passing a point per unit of time, commonly expressed as cubic feet per second.

Drop inlet:
A structure for safely dropping water to a lower level and into a pipe conduit.

Erosion: The wearing away of land surface through the action of wind or water.

Excessive erosion:
The rate of erosion exceeding a limit where the productivity level can be maintained. Expressed in tons per acre per year. Most soils in Ohio have a permissible soil loss between 1-5 tons/acre/year.

Fill: An area upon which earth has been placed to raise elevation.

Geo-Textile fabric:
Woven, non-woven or knitted fabric that is water permeable and usually non-biodegradable used to separate, filter, and reinforce aggregate stone.

Grade: see slope

Habitat: A geographical area that can provide for the needs of wildlife.

Inoculate:
Introduction of bacterium to legume seed to ensure adequate numbers of specific bacteria are present to assist in nitrogen fixation.

Native grasses of Ohio:
Examples include: big bluestem, Side oats gramagrass, Dark green bulrush, Gray's sedge, Wool grass, Canada wild rye, Virginia wild rye, purple love grass, soft rush, deer tongue grass, switchgrass, little bluestem, Indian grass and prairie cord-grass.

Odd lot: A small, unmanaged, irregularly shaped area such as a fence corner that may be used to produce wildlife habitat.

Parabolic:
A concave curve with gently sloping sides near a flattened bottom.

Sediment: Soil that settles to the bottom of bodies of water.

Silt: Soil particles suspended in water.

Slope: The degree of deviation from horizontal measured as a numerical ratio, a percentage or degrees.

Water bars:
Water diversion structure.

ACKNOWLEDGMENTS

Our thanks to the Oil and Gas Advisory Council for their contributions to this booklet.

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View the most current version of this booklet on the Division of Oil and Gas Resources Management website; Best Management Practices (BMPs) for Oil and Gas Well Site Construction (pdf).