



**Piceance Creek Unit (PCU) FED B27 197 Well Pad**

## Stormwater Management Plan

Piceance Basin, Colorado



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## Stormwater Management Plan



### INTRODUCTION

Caerus has created the following Stormwater Management Plan (Plan) as required by the Colorado Oil and Gas Conservation Commission (COGCC) Rule 304.c.(15). This Plan, per Rules 1002.f.(2), describes the Best Management Practices (BMPs) that will be implemented to address the potential pollutant sources that may reasonably affect the quantity and/or quality of stormwater discharge at the proposed oil and gas facility. Caerus will maintain the site-specific BMPs until the facility is abandoned and Final Reclaimed, per Rule 1004. The site-specific stormwater BMPs employed at the PCU FED B27 197 will comply with COGCC, Colorado Department of Public Health and Environment (CDPHE) and White River Field Office Bureau of Land Management (BLM) stormwater regulations.

The PCU FED B27 197 will be incorporated into Caerus' North Piceance field wide Stormwater Management Plan (SWMP) in compliance with CDPHE Water Quality Control Division (WQCD) General Permit No. COR400000, will abide by COGCC's stormwater Rule 1002.f., and follow BLM Gold Book expectations. Per COGCC Rule 1002.f.(3), Caerus has developed a field wide Post-Construction Stormwater Program. The Post-Construction Stormwater Management Plan (PC-SWMP) goes into effect when a disturbance meets final stabilization requirements set forth by CDPHE WQCD General Permit.

## OIL AND GAS LOCATION AND CONSTRUCTION SITE DETAIL / INFORMATION

The PCU FED B27 197 pad is a new well pad located in Rio Blanco County, Colorado in QTRQTR Lot3, Sections 27, Township 1 South, Range 97 West, Sixth Principal Meridian. The proposed project would be located on a ridgetop north of Lee Gulch and east of Piceance Creek at an elevation of approximately 6,500 feet. Terrain in the general vicinity is composed of rolling ridges divided by draws and drainages that flow west toward Piceance Creek. The current primary uses of the land are natural gas development, rangeland, and wildlife habitat. The historical and current land use description at the site (per COGCC descriptions on Form 2A) is Rangeland.

Caerus plans to drill and complete twenty-two (22) directional wells from the PCU FED B27 197 well on Federal surface, managed by White River Field Office. The breakdown for disturbance acres is as follows:

Project Component	Initial Disturbance Acres	Interim Reclamation Disturbance Acres	Final Abandonment Disturbance Acres
<b>B27 197 Well Pad</b>	~5.8	2.0	0
<b>Access Road</b>	~13.5	~9	0
<b>Pipeline</b>	~2.5	0	0

Caerus prepared a Construction Plat and Interim Reclamation Plat which both depict the preliminary site-specific stormwater BMPs.

The National Resource Conservation Services (NRCS) identifies four soil types within the boundary of the PCU FED B27 197, as depicted in Table 1. The soils are noted to be well drained. A well-drained soil will retain

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water long enough for roots to absorb what water the plants will need and dries out sufficiently between rain events allowing for oxygen diffusion into the soil structure. Puddling that can form after a heavy rain is expected to be absorbed quickly by the well-drained soil.

**Table 1. Soils occurring in the project area**

Map Unit Symbol	Soil Name	Description
70	Redcreek-Rentsac complex	5 to 30 percent slopes, well drained
73	Rentsac channery loam	5 to 50 percent slopes, well drained

The vegetation communities present in the project area is primarily composed of pinyon/juniper woodlands and barren, rocky hillsides. Basin big sagebrush shrublands are present along the draws within the survey area. Native forbs and grasses dominate the understory in all vegetation communities present. Percent foliar cover is approximately 40% pre-disturbance. The only noxious weed listed by the State of Colorado that was observed during surveys was cheatgrass. The nearest downgradient State surface Water is 1,319 feet west of the PCU FED B27 197.

An improved drive-through access road will be constructed following the existing two-track road. The road will provide long-term access to and through the well pad.

The proposed Pipeline corridor will be for a: 12-inch 3-Phase gathering lines that connects the PCU Fed B27 197 to the PCU A27 197 Central Delivery Point (CDP) that will deliver 3-Phase production consisting of Natural Gas, Produced Water and some Condensate to the CDP, an 8-inch Remote Frac Line that will transport water for downhole operations during completion activities for the B27 197 wells, and a 6-inch Gas Lift line. All new flowline/pipeline installations will be performed per new flowline guidance and requirements in the COGCC 1100 Series Rules. All new offsite pipelines will be registered in accordance with the 1100 Series Rules.

Prior to initial pad construction, Caerus Construction Team will have the proposed pad location, access road, and pipeline corridors staked for construction and will hold a pre-construction onsite with the excavation/stormwater contractor to review proposed site construction. Caerus Qualified Stormwater Management (QSM) Team will review the preliminary erosion control plan and determine if any additional BMPs may be needed. Any new BMPs implemented because of this review or requested by the surface owner will be documented as required by Federal and/or State regulations.

Caerus Construction and Environmental Health and Safety (EHS) teams, along with contracted third-party stormwater inspectors, will oversee the installation of the stormwater BMPs. Once the perimeter Wattles are installed, the area within the project disturbance boundary will be hydro-axed. Topsoil will then be stripped and stockpiled according to the Topsoil Protection Plan.

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Stormwater runoff from all disturbed areas will flow to at least one Control Measure to minimize sediment in the discharge. The Control Measure may contain or filter sediment from the discharging flow. Temporary controls, such as wattles, will be used to control sediment and erosion during preconstruction, construction (active and complete) activities. Permanent controls, such as berm(s) and stormwater catchment basin(s), may also be used during the initial phases of the project. Permanent controls are preferred during interim reclamation and final stabilization. Temporary controls may be converted into permanent controls, such as revegetating a diversion. The primary control used during interim and final stabilization will be revegetation. Seeding will occur as soon as possible after disturbance of an area is complete. If the seeding is not successful, the area will either be reseeded, or additional erosion controls will be put in place until reseeding can occur.

The proposed production equipment, on-location flowlines, and well conductors will be installed. The area beneath the proposed rig footprint will be compacted to ensure stability of the rig during drilling operations. The pad working surface will be bladed level and graveled with six-inches (6") of three-quarter inch minus (3/4" minus) on top of six-inches (6") of crushed shale, surfacing materials imported from a local source or sourced during the initial construction of the pad and sorted on location.

Topsoil stockpiles will be hydro-seeded and mulched following stripping of all topsoil during pad construction to minimize the potential for site degradation during the initial drilling and well completion phase of the project.



## SPILL PREVENTION AND RESPONSE PLAN

The Oil Pollution Prevention Regulations (40 CFR 112) requires Caerus to prepare and implement a Spill Prevention, Control and Countermeasure Plan (SPCC Plan) for facilities (as defined in 40 CFR 112.2) that have discharged or could reasonably be expected to discharge oil into or on navigable waters of the United States or adjoining shorelines. The plan describes the engineering and administrative controls employed at/by the facility to comply with the requirements set forth.

Where sized secondary containment is required, containment capacity to be sufficiently sized to contain at least 150% of the volume of the largest single Tank within the containment. The containment systems and procedures utilized are designed to be capable of containing oil and have been constructed so that any discharge from a container, such as a tank, will not escape the containment system before cleanup occurs.

For specifics on permanent, temporary, mobile and portable containers, please refer to the current version of the SPCC Plan, which will be made available during an inspection. If contracted activities, such as drilling and completion operations are occurring on a disturbance, all applicable chemical storage protocols are to fall under the contracting companies SPCC Plan and Spill Response procedures.

Caerus has developed, trained on and implemented an Incident Response Plan (IRP). Caerus personnel will activate the IRP in the event of a significant incident, involving Caerus property, that adversely affects or has the potential to adversely affect the health and safety of employees, the general public, or the environment. Incidents are to be reported immediately to Gas Control, **970-285-2615**, upon discovery. If the incident poses a risk to human health, personnel will be immediately cleared from the area. If safe to do so, Caerus personnel will try to control the situation with available equipment until emergency response personnel arrive, or until all attempts have been exhausted. For specifics on incident response and cleanup procedures, please refer to the current version of the IRP.

Spill Kits and Environmental Response Trailers have been strategically placed throughout the field to facilitate quick spill response and aid in cleanup efforts. Spill Kits are inspected and replenished on a quarterly basis. The most current map of Spill Kit locations can be found in the Oil Spill and Contingency Plan (OSCP) Section 4.0 Resources - Equipment & Supplies for Oil Spill Response.

A qualified Caerus Representative will report all Colorado reportable environmental hazards and chemical spills/releases to the applicable entity.

If an incident requires reporting to CDPHE WQCD under the General Permit No. COR400000, for Stormwater Discharges Associated with Construction Activities, a Qualified Stormwater Manager will make the appropriate notification. Below is the contact information for CDPHE:

Colorado Department of Public  
Health and Environment (CDPHE)  
**1-877-518-5608** (24 hour)

In general, spill prevention and response procedures provide guidance on how to cleanup spills and ensure that materials and wash water cannot discharge from the site, and never into a storm drain system or state waterway.

## MATERIAL HANDLING

Proper handling, storage and disposal of materials can prevent pollutants from entering stormwater. Material management reduces the risk of spills or other accidental exposure of materials and substance.

### Material Delivery and Storage

The good housekeeping practices listed below will be followed on-site during construction and oil and gas operations:

- An effort will be made to store only enough product required for task completion.
- All materials stored on site will be stored in a neat and orderly manner in appropriate containers and, where possible, under a roof or other enclosure, and/or within secondary containment areas to avoid contact with stormwater. Bulk storage, 55 gallons or greater, for petroleum products and other liquid chemicals shall have secondary containment, or equivalent protection to prevent spilled material from entering state waters.
- Products will be kept in their original containers with the original manufacturer's label.
- Substances will not be mixed with one another unless recommended by the manufacturer.
- Whenever possible, all of the product will be used before disposing of the container.
- Manufacturer's recommendations for proper use and disposal will be followed.

### Waste Management and Disposal

As required by Caerus' Master Service Agreement(s) and drilling contract(s), contracting companies and/or vendors are required to manage all waste generated by their activities at Caerus facilities, in compliance with local, state, and federal guidelines.

Typical waste management procedures are provided below:

- Proper bins will be provided for trash collection and disposal and will be in compliance with local, state, and federal guidelines.
- Samples of the impacted soil will be collected, and a complete characterization analysis will be performed. When applicable, the impacted soil will be sent to a licensed disposal facility or managed in place following proper remediation procedures.
- Potentially impacted stormwater that accumulates within secondary containment(s) will be vacuumed up via Vac Truck and processed at Caerus Water Treatment Facilities.
- The contractor will provide portable toilets. Sanitary waste will be regularly collected by a licensed sanitary waste management contractor and disposed of in an approved manner.

On well pads, concrete may be used as an interior conductor pipe ballast. Concrete washout water can NOT be discharged to surface waters or to storm sewer systems.



#### Vehicle Cleaning, Fueling, Maintenance, and Tracking Controls

As required by Caerus' Master Service Agreement(s) and drilling contract(s), contracting companies and/or vendors are required to service all vehicles and equipment prior to entering Caerus facilities. However, in the event maintenance procedures are required at Caerus facilities, all fluids transferred must utilize secondary containment and drip pans and/or absorbent diapers to minimize a release of materials and properly dispose or recycle spent materials in compliance with local, state, and federal guidelines.

While on site, equipment will be parked, serviced, and fueled within designated areas. Equipment fueling on pipeline rights-of-way will be completed where necessary during active construction. Periodic inspections of equipment and control procedures will be implemented. Selected equipment may be fueled in place using fuel trucks.

Vehicle tracking of sediments is not expected to be a problem as a result of proper construction scheduling and implementation of Control Measures. Construction vehicles will remain on-site throughout earth-moving activities. All other vehicles typically remain in stabilized areas and do not enter the construction area until that area is stabilized. If vehicle tracking does become a pollutant source, Control Measures could include but are not limited to: scheduling to reduce site access, stabilized construction entrances via Vehicle Tracking Pad, and reverse grading. If tracking occurs or is allowed to occur, at a minimum, stormwater runoff will flow to at least one Control Measure to minimize sediment discharge. Control Measures that filter, settle or strain sediment may be implemented.

Sites in the interim reclamation phase typically have stabilized unpaved working surfaces, such as compacted gravel surfacing or compacted soils. Grading is also typically used as a Control Measure to help water drain away from driving pathways and prevent pooling in high traffic areas.



## STORMWATER MANAGEMENT PROGRAM

Best Management Practices (BMPs) will be implemented during, on and around the disturbances associated with the well pad, soil stockpiles, access road(s), tank battery, and pipeline rights-of-way. With the proposed location being on top of a ridge line, there is little to no Run-On for this disturbance. BMP sizing was based on the regional 25-year 24-hour storm event. Stormwater Catchment Basins were sized using 2-year 24-hour storm event, method SCS TR-55. Various BMPs will be implemented and maintained during separate phases of the project. A description of each phase is as follows:

### Pre-Construction Phase:

The main objective of the Pre-Construction phase is to gather site-specific data on soils, natural landform, receiving waters, wetlands, weeds, vegetative cover and density, and any other pertinent information prior to initial disturbance. This baseline data is summarized in a Biological Survey Report (Report). The Report helps with site planning and management to determine needed site-specific Best Management Practices, Control Measures, location for drainages outfalls, and other site-specific considerations prior to site excavation.

Prior to initial construction activities or ground disturbance, stormwater control measures shall be implemented at construction sites to aid in controlling erosion and sediment, as well as, to protect existing vegetation outside of the permitted disturbance.

To minimize contact of stormwater runoff with Caerus construction activity (COGCC Rule 1002.f(2)A & C) Caerus utilizes perimeter wattles (temporary and/or permanent) to divert stormwater around or away from the planned disturbance area. Vehicular traffic will stay on the established dirt two-track road. Limiting access, strategic staging of materials and earthmoving equipment and leaving as much undisturbed vegetation as possible are important administrative control. No material handling will occur at this stage (COGCC Rule 1002.f(2)B & E). Caerus does not anticipate needing tracking controls on the established dirt two-track per COGCC Rule 1002.f(2)F.

### Construction Phase:

The main objective of the Construction Phase is to implement structural and/or nonstructural control measures that effectively minimize erosion, sediment transport, and the release of other pollutants related to construction activity. During the construction phase, vegetation will be cleared and grubbed, accessible topsoil is to be removed from areas that are to be excavated and managed per the Topsoil Protection Plan. The site will be graded to provide suitable surfaces for vehicle traffic and/or building sites and will be graded to establish surface drainage patterns and promote dewatering of high traffic areas, by way of, grading, berms and roadside ditches (COGCC Rule 1002.f(2)A). Limiting site access and strategic staging is another important administrative control used until the access road and working surface can be stabilized with blading, compaction, and gravel.

Stormwater volumes and velocity are reduced through land grading and water retention area placement. Collected stormwater will be allowed to infiltrate and evaporate via the stormwater retention areas.



Stockpiled sub-soil material will have perimeter sediment controls in place i.e., wattle or berm. Material may also be stabilized with surface roughening or compaction.

Compacted perimeter berm will be installed at the toe of the fill slope. This berm will reside inside the exterior pre-construction perimeter wattles. A compacted working surface/pad berm will serve as a general containment berm for materials stored on-site. A compacted berm will be installed between the Topsoil stockpile.

Caerus' focus is to minimize the amount of soil exposed during this phase, including the disturbance of steep slopes. Scheduling and temporary/final stabilization efforts will help ensure soil exposure amounts and timing are limited. Individual facilities may require additional excavation to allow for construction of foundations. Excess sub-soil will typically be used in general site grading. Unused disturbed areas will be stabilized with seeding and/or mulch and/or Erosion Control CMs (COGCC Rule 1002f(2)C), such as surface roughening or perimeter Sediment CMs. Operational areas that are not vegetated and are typically stabilized with compaction and/or gravel.

Per COGCC Rule 1002.f(2)B, Spill prevention and control measures will be implemented any time chemicals or hazardous substances are used, stored, or handled on-site. Fueling material and equipment will be managed with properly sized secondary containment and handling practices. Working Surface Berm, perimeter Wattles and Berms will serve as a tertiary control for materials stored on location. Areas and activities that are most vulnerable to spills include: transportation areas, loading and unloading areas, fuel and chemical storage areas, process activities, dust or particulate generating processes and waste disposal activities. Caerus staff and contractors are expected to follow Caerus' Incident Response Plan (IRP), Spill Prevention and Countermeasure Controls (SPCC) Plan, Leak Detection Plan and Waste Management Plan. The plan is to have no Oil or Condensate Tanks on-sites, fluids will be piped to the PCU A27 197 CDP. There will be temporary Produced Water Frac Tanks on-site to support completions activities. During Completions the facility will be manned 24/7.

Per COGCC Rule 1002.f(2)F, Caerus has implemented the BMPs for Sediment Tracking Controls document, which outlines the numerous BMPs implemented at active and complete construction sites as well as Interim Reclaimed sites. Reverse grading/Drive-over Berm will be utilized along the access road before it drops into the location. Reverse grading reduces the amount of stormwater that can run onto the pad, as well as prevents material from being tracked off location. Driving Surface Gravel will be installed and will serve as an additional tier of protection. Stormwater will be collected from the stabilized driving surface via in-sloped roadside ditches. Channelized water will be managed with appropriately spaced de-water roadside CMs.

### Interim Reclamation:

During Interim Reclamation, the main objective is to reduce the footprint of the overall operational working surface of the location by returning most of the disturbance, not necessary for long-term well production, to the original grade and restored hydrologic function. Redistribution of topsoil on the reclaimed area helps to maintain healthy, biologically active topsoil which in-turn aids in controlling dust and minimizing erosion (Rule 1002f(2)C). This phase also involves the installation of additional permanent Control Measures that may be needed, as well as the continued maintenance and inspections of all Control Measures.



Sites in the interim reclamation phase typically have stabilized unpaved working surfaces, such as compacted gravel surfacing or compacted soils. Grading is also typically used as a Control Measure to help water drain away from driving pathways and prevent pooling in high traffic areas (COGCC Rule 1002.f(2)A). Wattles will be used downgradient from the remaining stockpiled topsoil.

Final stabilization occurs once all surfaces are built on, paved or graveled, and/or a uniform stabilized vegetative cover with a density of 70 percent of pre-disturbance levels has been established or when an equivalent permanent, physical erosion reduction method has been employed. At which time the disturbance will be managed under the Post-Construction SWMP (PC-SWMP).

#### Final Reclamation:

For pipelines, this phase involves seeding of all disturbed areas, and the installation of any additional permanent Control Measures that may be needed, as well as the continued maintenance and inspections of all Control Measures until final stabilization occurs. For roads, well pads, facilities, etc., this phase occurs when operation of the area is no longer necessary, and the disturbance is returned to original contours. This phase will include the installation of any additional Control Measures required during facility decommissioning as well as the spreading of any remaining topsoil, the application of seed, and the inspection/maintenance of all Control Measures (COGCC Rules 1002f(2)C) until final stabilization occurs.

No chemicals or hazardous substances are expected to remain on-site following Final Reclamation efforts (COGCC Rule 1002.f(2)B). All access roads and associated facilities will be removed, and the disturbance will be restored and revegetated.

## POST-CONSTRUCTION STORMWATER MANAGEMENT

As soon as practicable after construction activities have been completed on a disturbed area. All disturbed areas (except for the surface of dirt roads, and areas used during operation of a well) will generally be stabilized with temporary and or final stabilization Control Measures. Soil compaction will be minimized in areas of revegetation. The most common measure used to achieve final stabilization is revegetation. Mulching, seeding, surfacing with gravel, and/or other methods may also be used. Structural controls (such as diversions, berms, and sediment traps) may be revegetated and used as permanent measures to control pollutants in stormwater discharges that will occur after construction operations have been completed.

Once a location has reached final stabilization, a Final Stabilization Vegetation Monitoring Inspection will be completed by a Caerus QSM. For all Oil and Gas locations, the disturbance will then be managed under the COGCC Post Construction Stormwater Management Plan.

Caerus has been actively managing and updating a Post-Construction Stormwater Management Program (PC-SWMP) as required per COGCC Rule 1002.f(3). The objectives of this Post-Construction SWMP are to:

- Identify all potential sources of pollution which may reasonably be expected to affect the quality of stormwater discharges associated with post-construction activity;
- Describe the practices to be used to reduce the pollutants in stormwater discharges associated with post-construction activity, also known as Best Management Practices (BMPs), and ensure the BMPs are selected and described in accordance with good engineering practices, including the installation, implementation and maintenance requirements;
- Be properly prepared and updated to ensure compliance with the applicable COGCC rules and regulations;
- Serve as an education tool and comprehensive reference/guide to stormwater management for inspectors, surveyors, engineers, and Encana employees and contractors.

### Identification of Potential Pollution Sources and associated BMPs/CMs

The following items are potential sources of pollutants during the post-construction period and have been considered when selecting implemented BMPs. Each of the potential sources of pollutants will be controlled using one or more of Caerus Control Measures: Erosion Controls, Drainage Controls, Sediment Controls or Non-Stormwater Controls.

### Transport of Chemicals and Materials, Including Loading and Unloading Operations

Personnel will be trained in the safe handling of chemicals and materials, including loading and unloading operations. In addition to the material storage practices that will be used to reduce the risk of spills or other accidental exposure of chemicals and materials, the Control Measure Manual provides more detailed information on spill prevention and control. Furthermore, the Spill Prevention, Control and Countermeasure (SPCC) Plan will be followed for the control of hydrocarbons. In general, spill prevention and response



procedures will include notification (CDPHE 24-hour spill reporting line 1-877-518-5608), clean-up with the use of spill kits and absorbents, and ensuring that materials and wash water cannot discharge from the site, and never into a storm drain system or stream.

#### **Outdoor Storage Activities, Including those for Chemicals and Additives**

The good housekeeping practices listed below will be followed on-site during post-construction activities:

- An effort will be made to store only enough product required for task completion.
- All materials stored on-site will be stored in a neat and orderly manner and, where possible, under a roof or other enclosure, and/or within secondary containment areas to avoid contact with stormwater.
- Products will be kept in their original containers with the original manufacturer's label.
- Substances will not be mixed with one another unless recommended by the manufacturer.
- Whenever possible, all of the product will be used before disposing the container.
- Manufacturer's recommendations for proper use and disposal will be followed.

#### **Produced Water and Drilling Fluids Storage**

Produced water and drilling fluids will not be allowed to flow into drainage ways, inlets, or receiving waters. Such fluids will be contained in holding pits, or portable tanks. Designated containment areas will be located away from drainage ways, inlets, receiving waters, areas of high traffic, and areas susceptible to flooding. Precautions shall be taken to ensure that proper spill prevention and control measures are being implemented to avoid accidental spills.

#### **Outdoor Processing Activities and Machinery**

Outdoor machinery is regularly maintained, cleaned, and kept in working order. If a leak does occur, the failing piece of equipment is immediately repaired or taken out of service and any spills are cleaned up.

#### **Significant Dust or Particulate Generating Processes**

The primary post-construction site activity with the potential to generate significant dust or particulates is vehicle traffic on dirt or graveled roadways during dry and hot times of the year. If necessary, irrigation practices will be applied.

#### **Erosion and Vehicle Tracking from Well Pads, Road Surfaces, and Pipelines**

Earth moving construction vehicles will remain in construction areas throughout excavation and grading activities. Most other vehicles remain in stabilized areas and do not enter construction areas until that area is stabilized. Post-construction areas are expected to be stabilized to at least 70% of pre-existing conditions. However, applicable tracking BMPs (such as scheduling to minimize site access, stabilized construction entrances, compacting driving surface, grade reversal, etc.) will be utilized Per COGCC Rule 1002.f(2)F. if sediment tracking does become a problem.



### **Waste Disposal Practices**

As required by Caerus master service agreement(s) and drilling contract(s), contracting companies and/or vendors are required to manage all waste generated by their activities at Caerus facilities in compliance with local, state, and federal guidelines.

A few of the waste management procedures that will be followed include the following:

- Proper bins will be provided for trash collection and disposal in compliance with local, state, and federal guidelines.
- Contaminated soils will be placed into a lined and bermed area. Samples of the impacted soil will be collected, and a complete characterization analysis will be performed. When applicable, the impacted soil will be sent to a licensed disposal facility.
- The contractor will provide portable toilets. Sanitary waste will be regularly collected by a licensed sanitary waste management contractor and disposed of in an approved manner.

### **Leaks and Spills**

In addition to the good housekeeping practices and waste management procedures that will be used to reduce the risk of spills or other accidental exposure of chemicals and materials, the SPCC Plan will be followed for the control of hydrocarbons. In general, spill prevention and response procedures will include notification (CDPHE 24-hour spill reporting line 1-877-518-5608), clean-up with the use of spill kits and absorbents, and ensuring that materials and wash water cannot discharge from the site, and never into a storm drain system or stream.

### **Ground Disturbing Maintenance Activities**

If necessary, newly disturbed areas or areas that become un-stabilized over time due to erosive conditions will be seeded or otherwise stabilized with erosion controls such as erosion control blankets, mulching, or gravel surfacing. Drainage controls or sediment controls may also be used down-slope of the disturbed area to route and capture sediment-laden stormwater.

## INSPECTIONS

Per COGCC Rule 1002.f(2)D. Self-Inspection, maintenance and good housekeeping procedures and schedules to facilitate identification of conditions that could cause breakdowns or failures of BMPs.

Inspections and maintenance are an extremely important part of a successful Stormwater Program. Caerus will ensure that all stormwater management controls are constructed or applied in accordance with governing specifications or good engineering practices. Experienced earthwork contractors will be used during construction activities. In addition, earth workers on the site will be trained to the location and use of the selected Control Measures. The goal is to minimize the potential for inadvertent removal or disturbance of Control Measures and to prevent the off-site transport of sediment and other pollutants.

Inspections will be conducted by a Qualified Stormwater Manager (QSM) on the following areas:

- Construction site perimeter;
- All disturbed areas;
- Designated haul roads;
- Material and waste storage areas exposed to precipitation;
- Locations where stormwater has the potential to discharge offsite;
- Locations where vehicles exit the site; and
- All Control Measure utilized at the site.

These areas will be inspected to determine if there is evidence of, or the potential for, pollutants leaving the construction site boundaries, entering the stormwater drainage system, or discharging to state waters. All Control Measures will be evaluated to determine if they still meet the design and operational criteria in the CDPHE General Construction SWMP and/or PC-SWMP and if they continue to adequately control pollutants at the site (see Control Measure Specifications section). Any Control Measures not operating as per specification will be addressed as soon as possible to minimize the discharge of pollutants.

CDPHE Inspections are required to start within 7 days of the commencement of construction. The minimum inspection schedule applies to those disturbances under active construction, which includes the period from when the ground is initially disturbed to when construction activity is completed, including the preparation of areas that will be temporarily or permanently stabilized. During the active construction period, a thorough inspection of the site stormwater management system (which includes all utilized Control Measures) must be conducted at least once every 7 calendar days, or at least once every 14 calendar days. If minimum inspection frequency is every 14 calendar days, a post-storm event inspection must be conducted within 24 hours after the end of any precipitation or snowmelt event that causes surface erosion.

Once construction activities that disturb the ground surface are complete and the site has been prepared for the construction complete phase, interim reclamation, or final reclamation (completion of appropriate soil preparation, amendments and stabilization practices), the site (or portion of the site) is considered Completed (for purposes of the stormwater permit). Completed Sites qualify for a reduced inspection schedule, as the potential for pollution is reduced if the site has been adequately prepared and/or seeded.

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However, because slopes and other disturbed areas may not be fully vegetated, erosion in these areas may still occur which would require maintenance activities such as regrading and seeding of problem areas. As such, inspections must continue to address these situations. During the Completed Site period, a thorough inspection of the site stormwater management system (which included all utilized Control Measures and potential pollutant sources) is required every 30 days.

The COGCC does not mandate a post-construction inspection frequency. However, Caerus's post-construction inspection frequency will be as follows:

- An initial inspection will occur upon termination of the CDPHE construction permit (at the start of the post-construction period).
- A bi-annual inspection will occur each year throughout the post-construction period.
- Lease Operators/Pumpers and other contractors that visit Caerus locations, are trained and instructed to contact Gas Control or QSM if a stormwater issue or concern is identified.

Once a facility is abandoned and final reclamation is achieved (as discussed earlier within this document), post-construction inspections under COGCC's Post-Construction Stormwater Program are no longer required.



## MAINTENANCE

Maintenance activities will help ensure that all Control Measures are functioning at prescribed levels (see Control Measure Specifications section) and will be in proper working order during a runoff event or spill condition. Any maintenance deemed necessary after required inspections will be corrected as soon as possible to minimize the discharge of pollutants. Since Caerus utilizes third-party contractors to complete stormwater inspections, there may be a short delay between the time the stormwater inspector discovers the issue in the field and when it is communicated to Caerus staff (generally, the notification will be received within 24-hours). In addition, it is important that all proper safety precautions are followed, such as a “one call” for utilities, if the maintenance involves excavation of sediment located above a buried pipeline, and consideration for weather and other potential hazards that could make maintenance more difficult or dangerous, and these considerations may delay the start of work.

The process to begin maintenance will be initiated immediately after receiving notification that it has been identified, which includes planning (in some cases, a larger fix or re-working of a location may be needed to prevent stormwater issues from occurring in the future; multiple departments may need to be involved), selecting a maintenance contractor, which may include requesting bids from multiple contract companies, and establishing a timeline for work.

Maintenance will include, but is not limited to:

- Pickup or otherwise prevention of litter, construction debris, and construction chemicals from becoming a pollutant source prior to anticipated storm events.
- Removal of sediment from wattles, sediment traps, and pulling roadside ditches.

Detailed maintenance requirements for each BMP/CM are identified in Control Measure Specifications section.

When maintenance is required, the following process will typically be followed:

1. Perform inspections according to the minimum inspection schedule.
2. Note the need for maintenance on the inspection form.
3. If inspection is completed by a third-party inspector, the issues will be communicated to Caerus QSM via Work Orders which are generated from the inspection form automatically.
4. If necessary, collect the additional materials and/or resources needed to perform the maintenance activity.
5. Select a contractor to perform maintenance.
6. Ensure safety precautions are followed, including a one-call prior to completing groundbreaking activities
7. Perform maintenance and note the date performed and the action taken on the Workorder Closure Report.
8. Re-inspect the area to ensure compliance (note that additional inspections to check work are not always documented).

## Piceance Creek Unit (PCU) FED B27 197 Well Pad

### Stormwater Management Plan



Maintenance items will be tracked to closure via ACTS Work Order Report. Workorder closure date and general comments for work completed will be recorded either on an inspection form or the Workorder Closure Report.



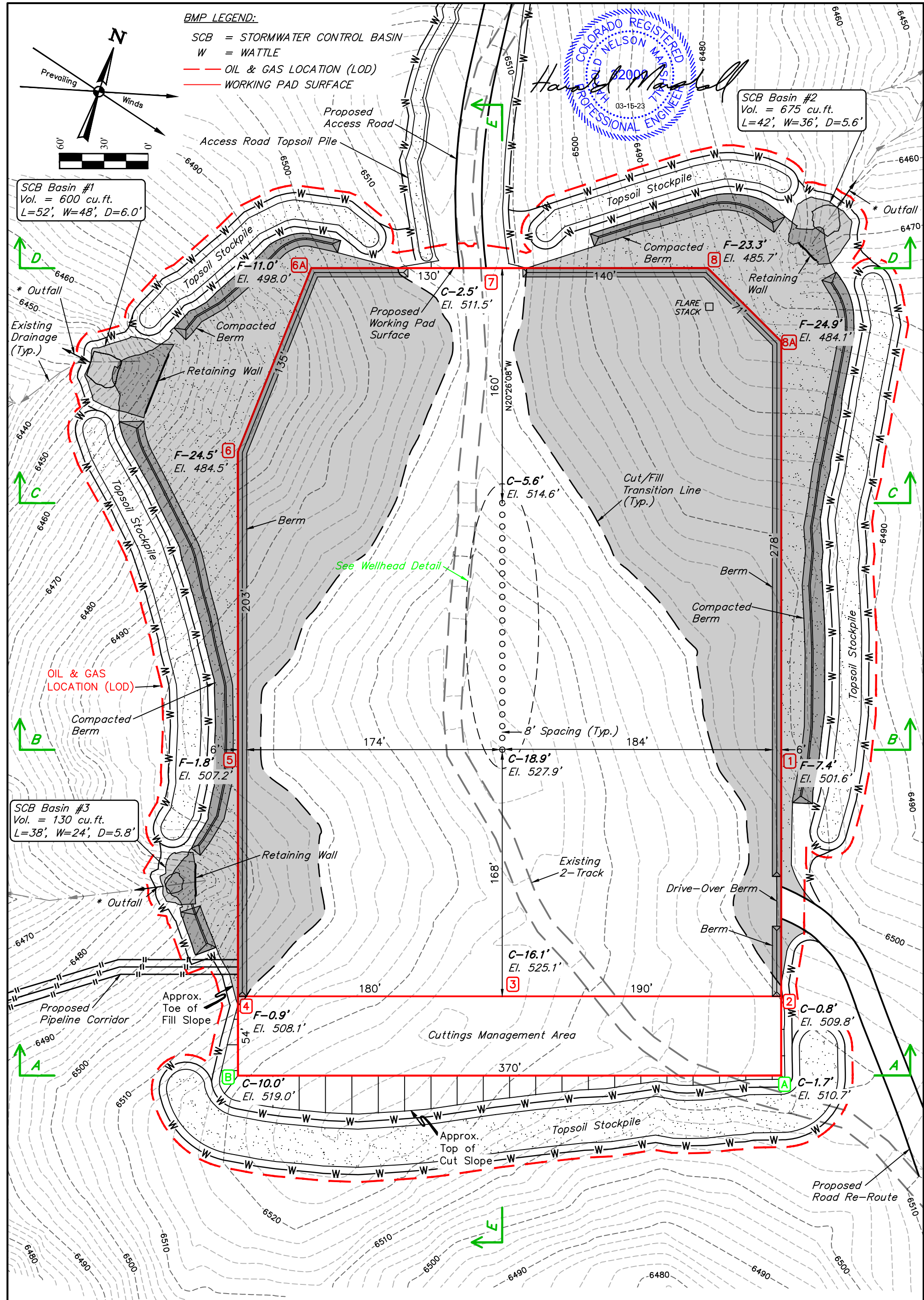
## SITE SPECIFIC STORMWATER MANAGEMENT DRAWINGS

The following stormwater drawings have been included depicting the proposed stormwater control measures to be implemented at PCU FED B27 197. These drawings are a point in time plan, as field conditions change and pad construction begins, field conditions may not reflect these drawings.

Construction Layout

Interim Reclamation Plan Layout

Final Reclamation Layout



**NOTES:**

- Flare stack is to be located a min. of 100' from the wellhead.
- Construct diversion ditches as needed.
- Contours shown at 2' intervals.
- Cut/Fill slopes 1 1/2:1 (Typ. except where noted).
- Stormwater calculated for the 2 Yr. - 24 Hr. SCS TR-55 method.
- \* See Figure ST-1 of Caerus Control Measure Manual.

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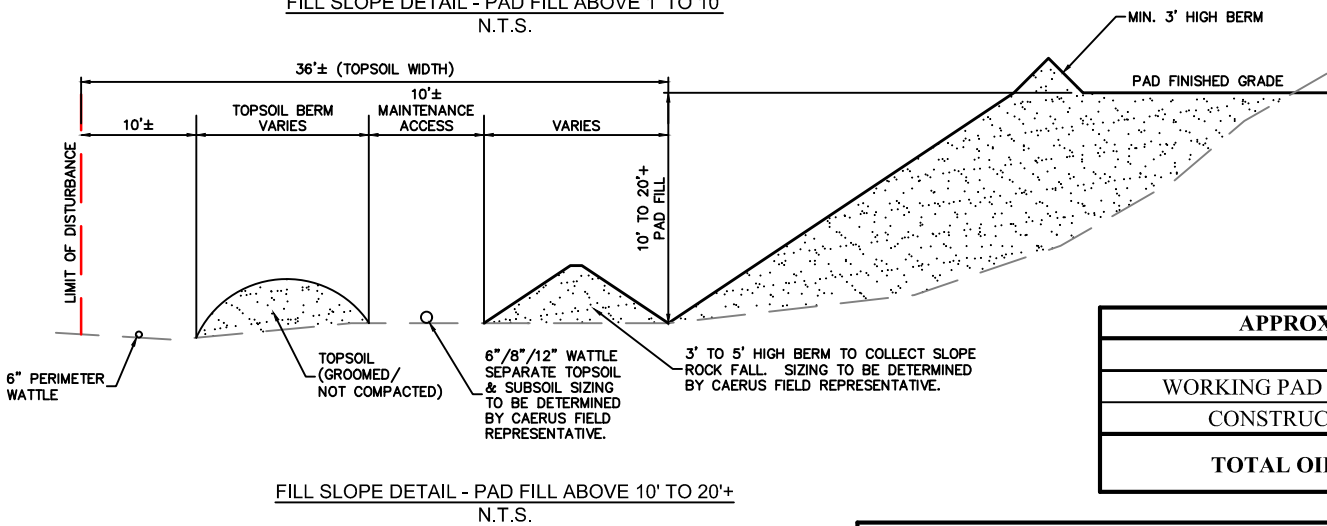
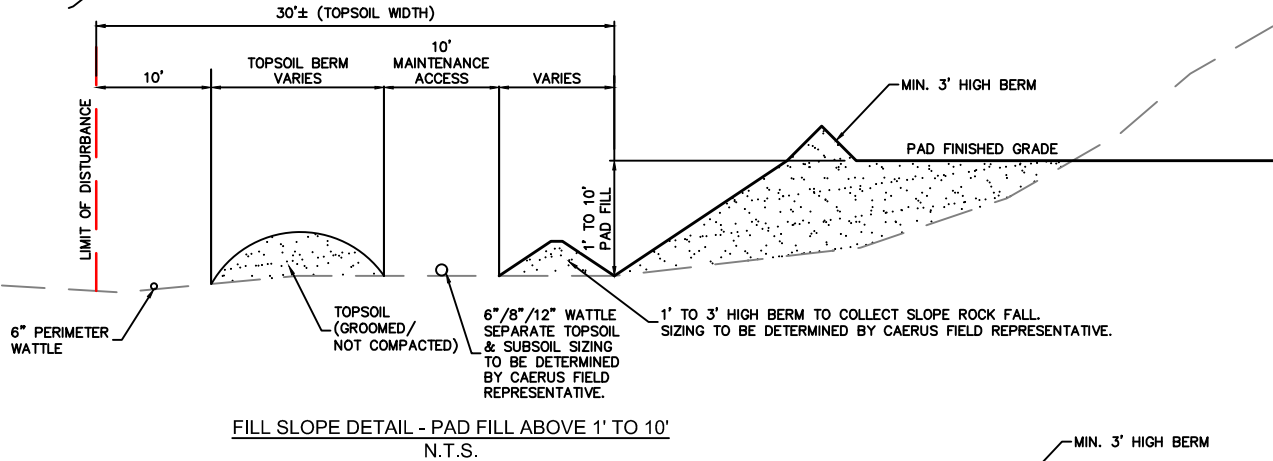
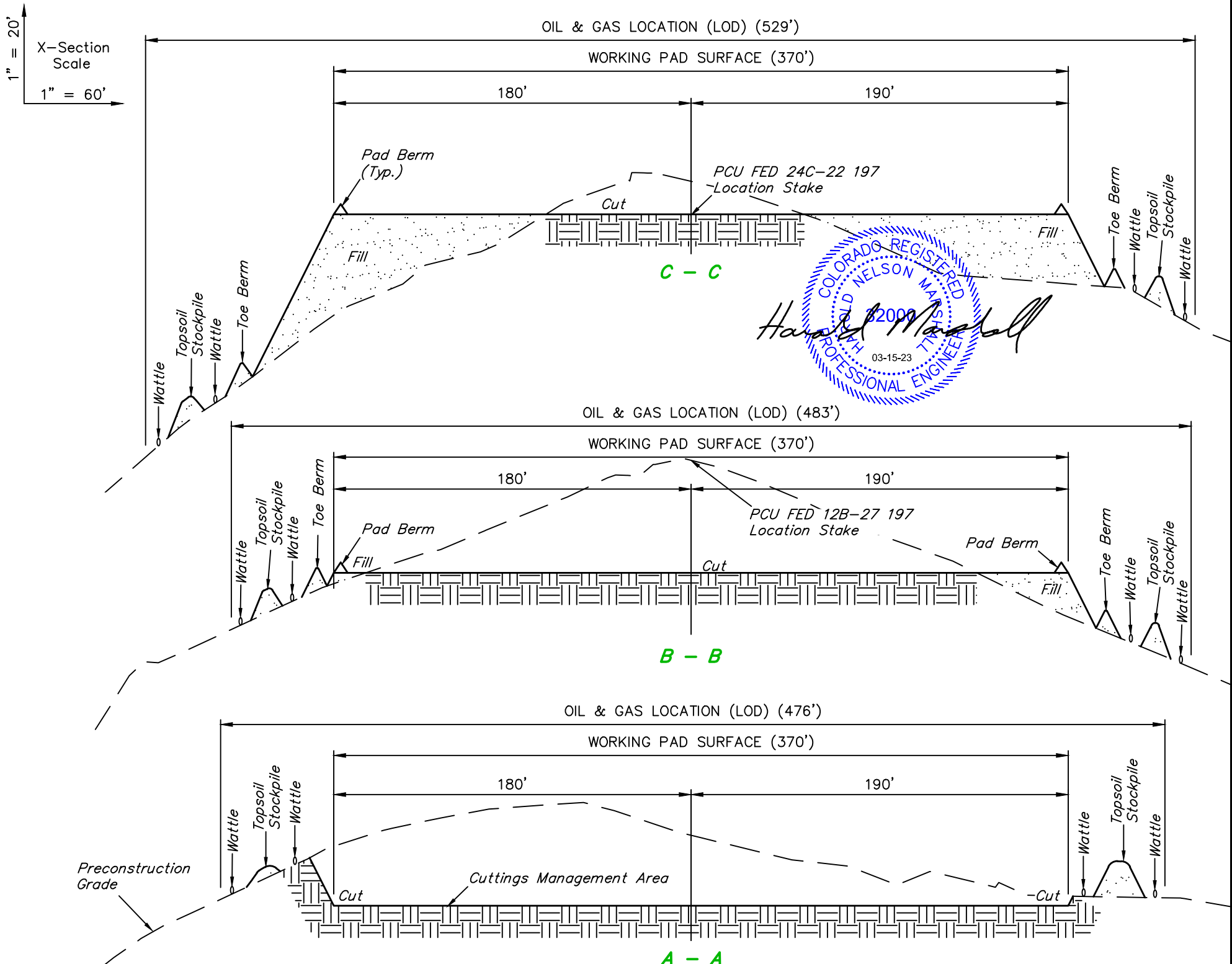
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SURVEYED BY	DAYTON SLAUGH	11-18-21	SCALE
DRAWN BY	T.L.L.	11-29-21	1" = 60'

**CONSTRUCTION LAYOUT - PLAN VIEW**





APPROXIMATE SURFACE DISTURBANCE AREAS		
	DISTANCE	ACRES
WORKING PAD SURFACE DISTURBANCE	NA	±4.571
CONSTRUCTION DISTURBANCE	NA	±2.784
TOTAL OIL & GAS LOCATION		±7.355

APPROXIMATE EARTHWORK QUANTITIES	
(VARIABLE) TOPSOIL STRIPPING	3,360 Cu. Yds.
REMAINING LOCATION	38,130 Cu. Yds.
TOTAL CUT	41,490 Cu. Yds.
FILL	38,130 Cu. Yds.
EXCESS MATERIAL	3,360 Cu. Yds.
TOPSOIL	3,360 Cu. Yds.
EXCESS UNBALANCE (After Interim Rehabilitation)	0 Cu. Yds.

\*NOTE:

- 550 Cu. Yds. of material used to construct toe berms.

APPROXIMATE SURFACE DISTURBANCE AREAS		
	DISTANCE	ACRES
ACCESS ROAD DISTURBANCE (NEW CONSTRUCTION)	±2,455'	±13.483 (LOD)
ACCESS ROAD DISTURBANCE (EXISTING ROAD NEEDS UPGRADE)	±4,736'	
30' WIDE ROAD RE-ROUTE R-O-W DISTURBANCE	±240'	±0.165
60' WIDE PERMANENT PIPELINE CORRIDOR R-O-W DISTURBANCE	±1,398'	±1.926
10' WIDE TEMPORARY PIPELINE CORRIDOR R-O-W DISTURBANCE EACH SIDE - (20' TOTAL WIDTH)	±1,398'	±0.642
TOTAL R-O-W DISTURBANCE		±16.216

REV: 10 03-15-23 T.L.L. (UPDATE ACCESS ROAD & PIPELINE DATA)

- NOTES:
- Fill quantity includes 10% for compaction.
  - Calculations based on 6" of topsoil stripping.
  - Cut/Fill slopes 1 1/2:1 (Typ. except where noted).

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PCU FED B27 197 PAD  
LOT 3, SECTION 27, T1S, R97W, 6th P.M.  
RIO BLANCO COUNTY, COLORADO

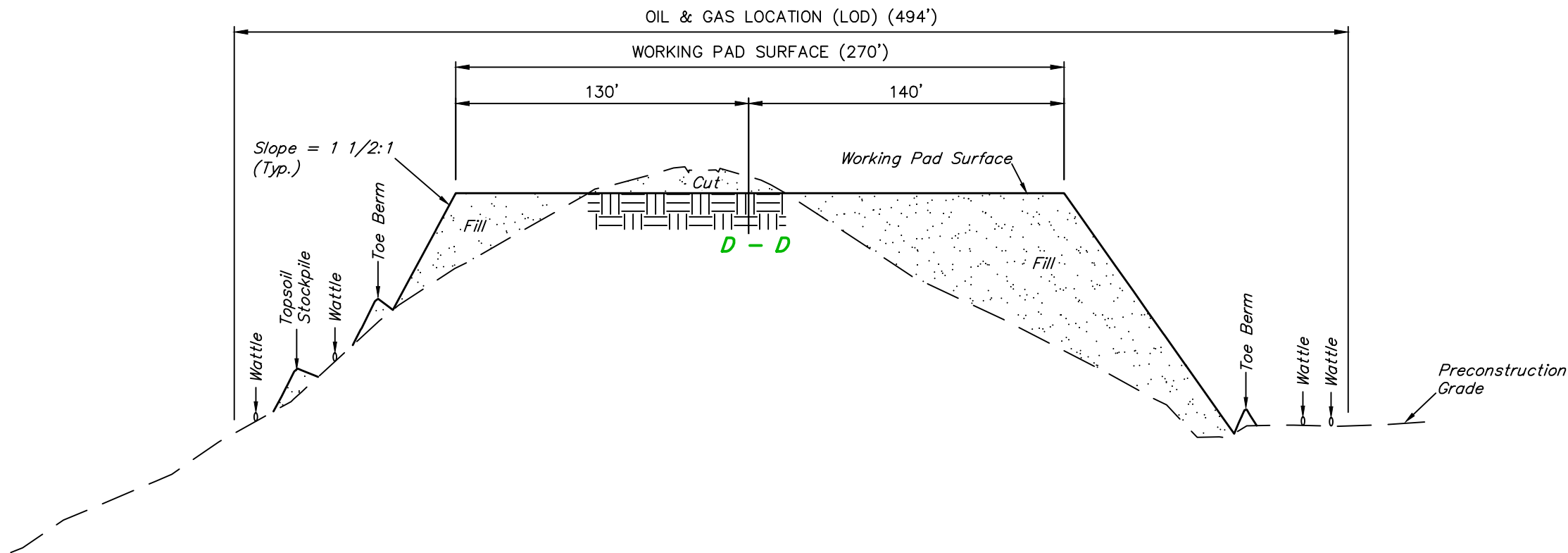
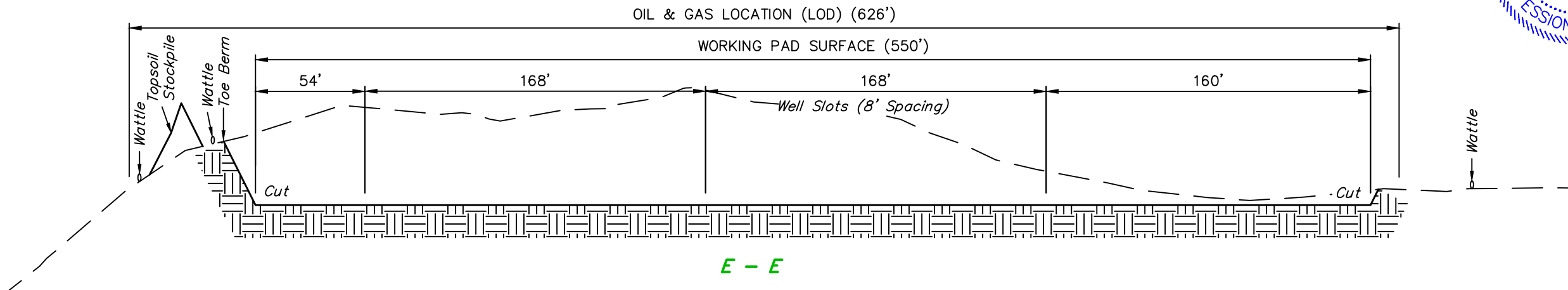
SURVEYED BY	DAYTON SLAUGH	11-18-21	SCALE
DRAWN BY	T.L.L.	11-29-21	AS SHOWN

CONSTRUCTION LAYOUT CROSS SECTIONS



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1" = 20'  
X-Section  
Scale  
1" = 60'



REV: 8 12-12-22 T.L.L. (REMOVE DIVERSION DITCHES)

**NOTES:**

- Fill quantity includes 10% for compaction.
- Calculations based on 6" of topsoil stripping.
- Cut/Fill slopes 1 1/2:1 (Typ. except where noted).

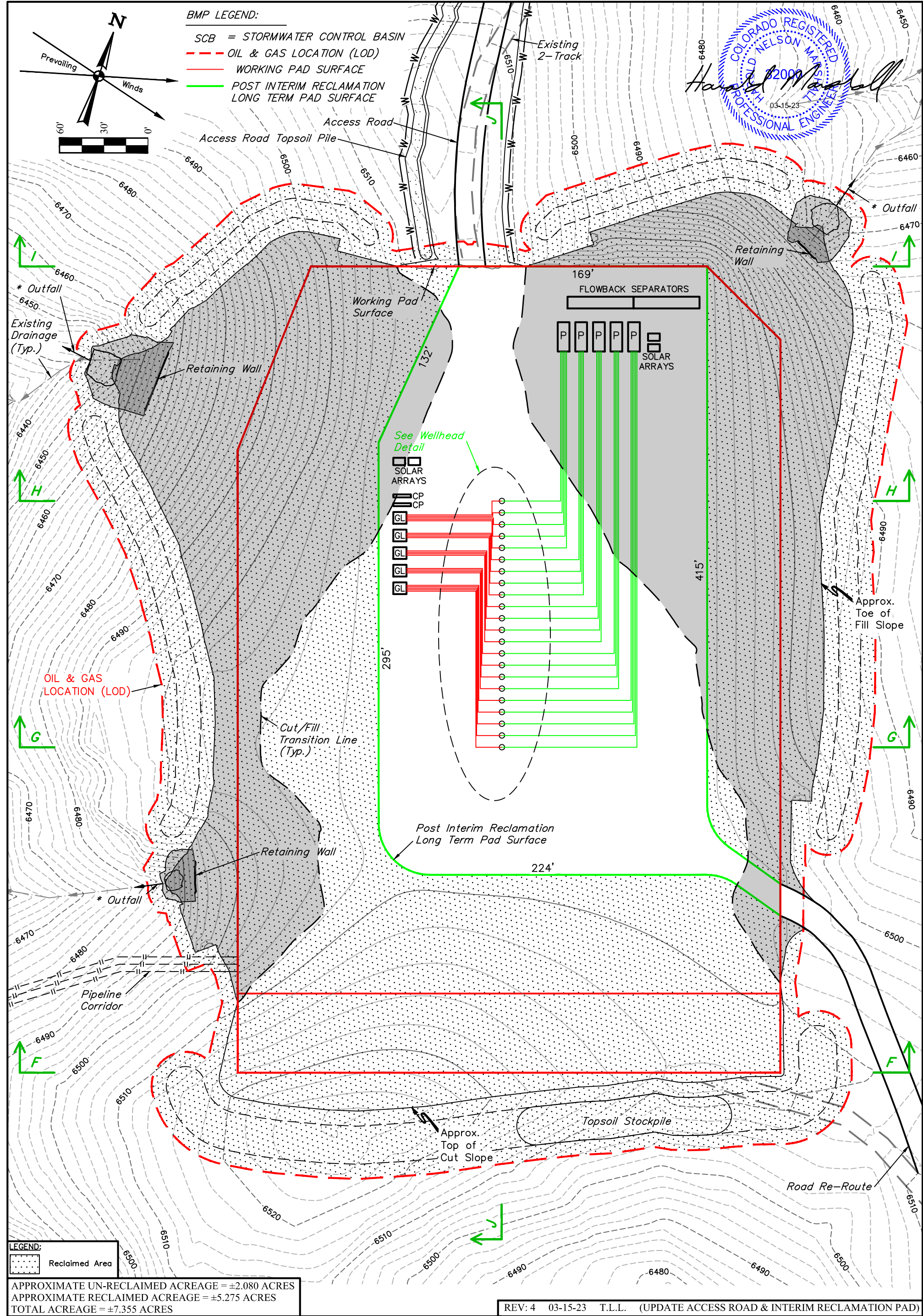


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**RIO BLANCO COUNTY, COLORADO**

SURVEYED BY	DAYTON SLAUGH	11-18-21	SCALE
DRAWN BY	T.L.L.	11-29-21	AS SHOWN
CONSTRUCTION LAYOUT CROSS SECTIONS			



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**PCU FED B27 197 PAD**  
**LOT 3, SECTION 27, T1S, R97W, 6th P.M.**  
**RIO BLANCO COUNTY, COLORADO**

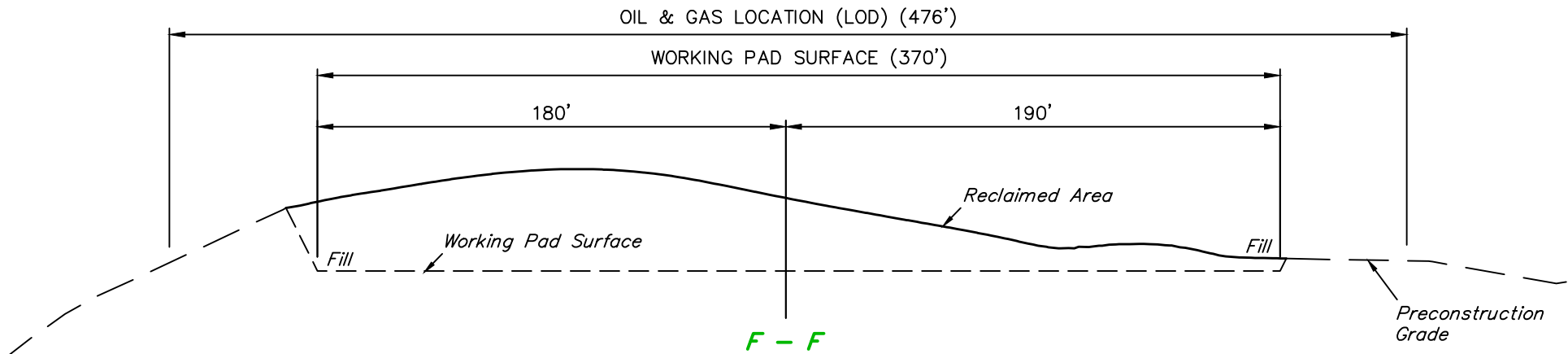
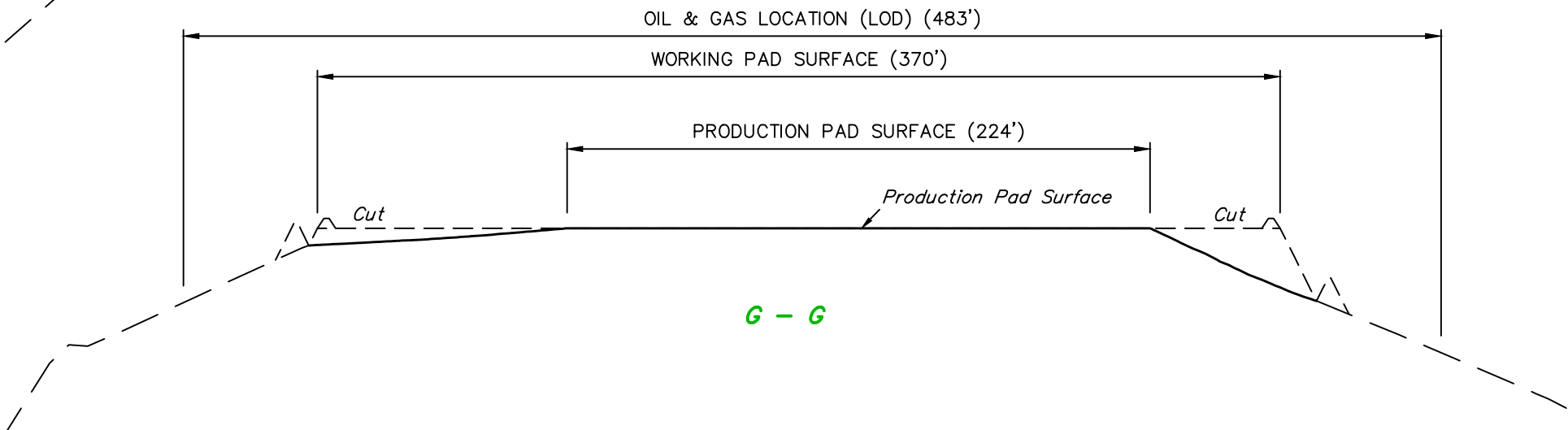
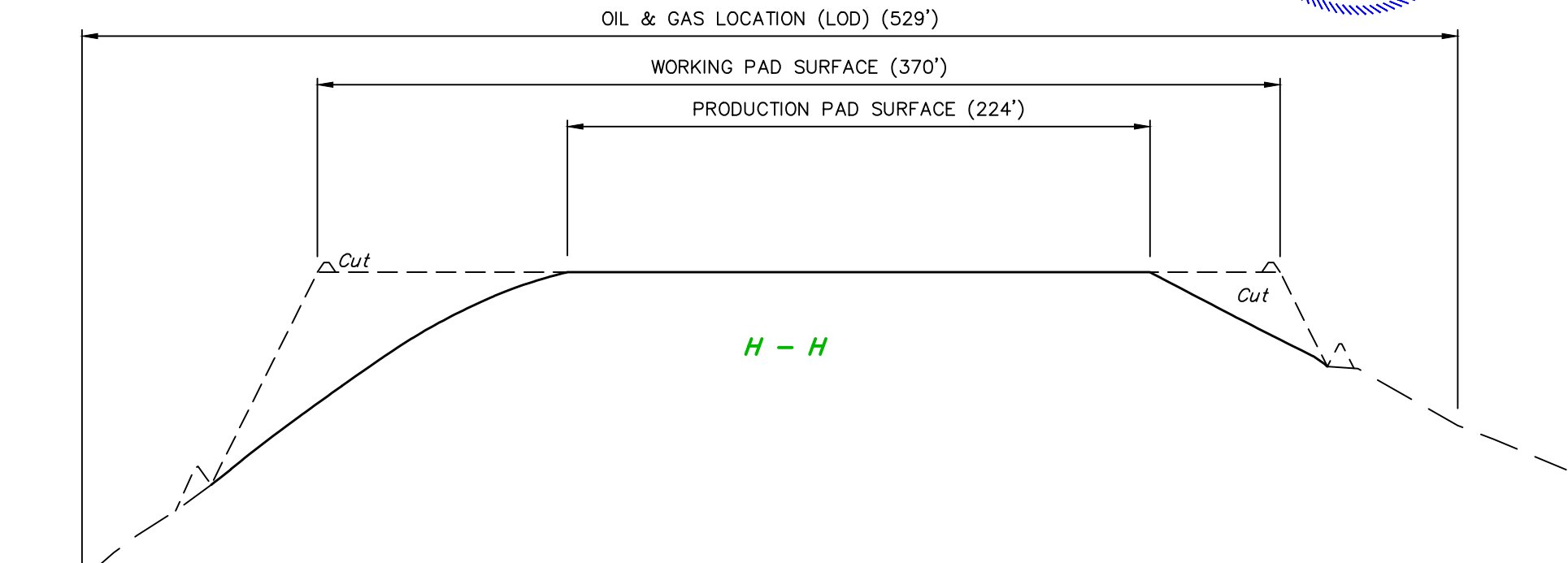
SURVEYED BY	DAYTON SLAUGH	11-18-21	SCALE
DRAWN BY	T.L.L.	10-17-22	1" = 60'
INTERIM RECLAMATION PRODUCTION SCHEMATIC			



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1" = 20'  
X-Section  
Scale  
1" = 60'



REV: 2 12-07-22 T.L.L. (UPDATE LOD)

**NOTES:**  
• Cut/Fill slopes 1 1/2:1 (Typ. except where noted).

**Caerus Piceance LLC**

**PCU FED B27 197 PAD  
LOT 3, SECTION 27, T1S, R97W, 6th P.M.  
RIO BLANCO COUNTY, COLORADO**

SURVEYED BY	DAYTON SLAUGH	11-18-21	SCALE
DRAWN BY	T.L.L.	10-17-22	AS SHOWN

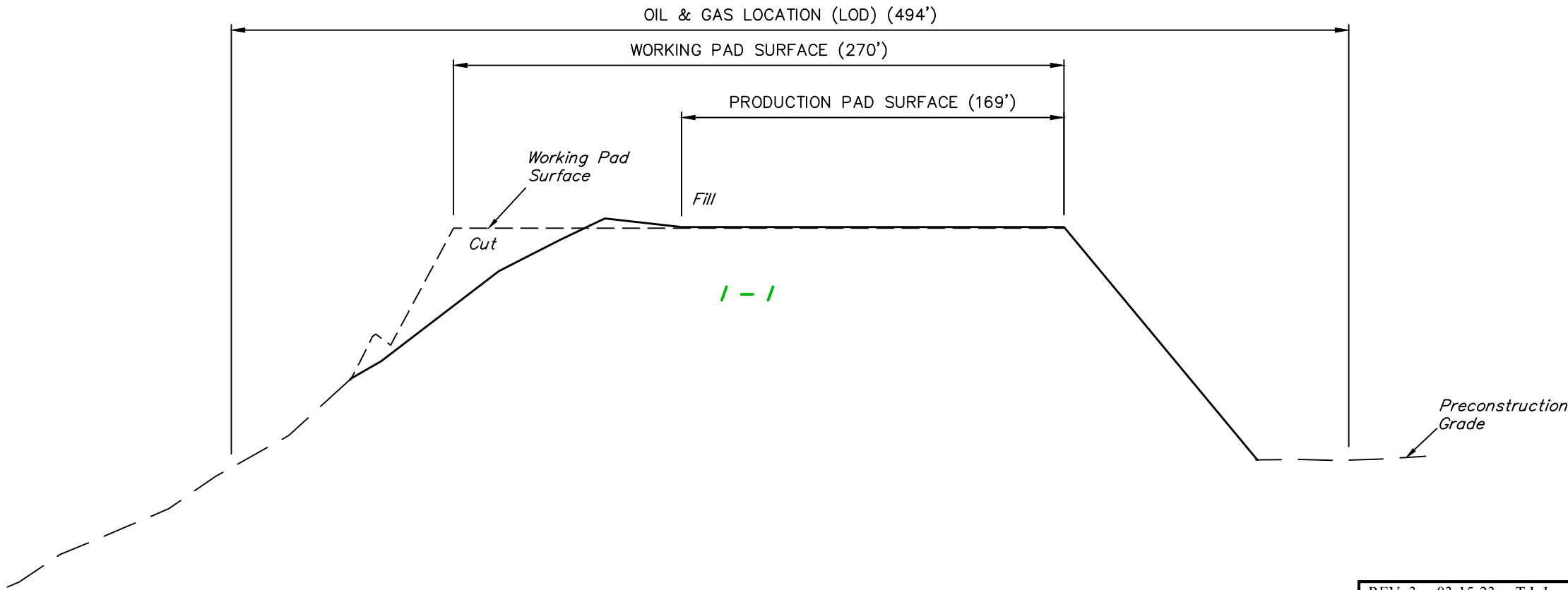
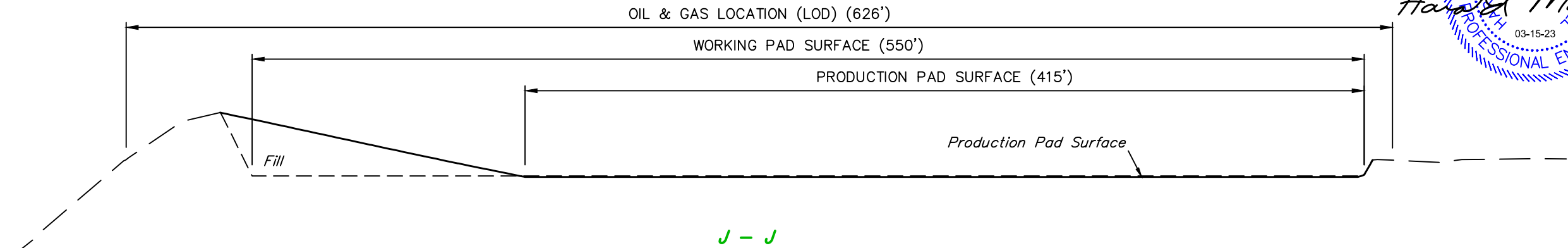
**INTERIM RECLAMATION CROSS SECTIONS**



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1" = 20'  
X-Section  
Scale  
1" = 60'



REV: 3 03-15-23 T.L.L. (INTERIM RECLAMATION PAD)

- NOTES:**
- Cut/Fill slopes 1 1/2:1 (Typ. except where noted).

**Caerus Piceance LLC**

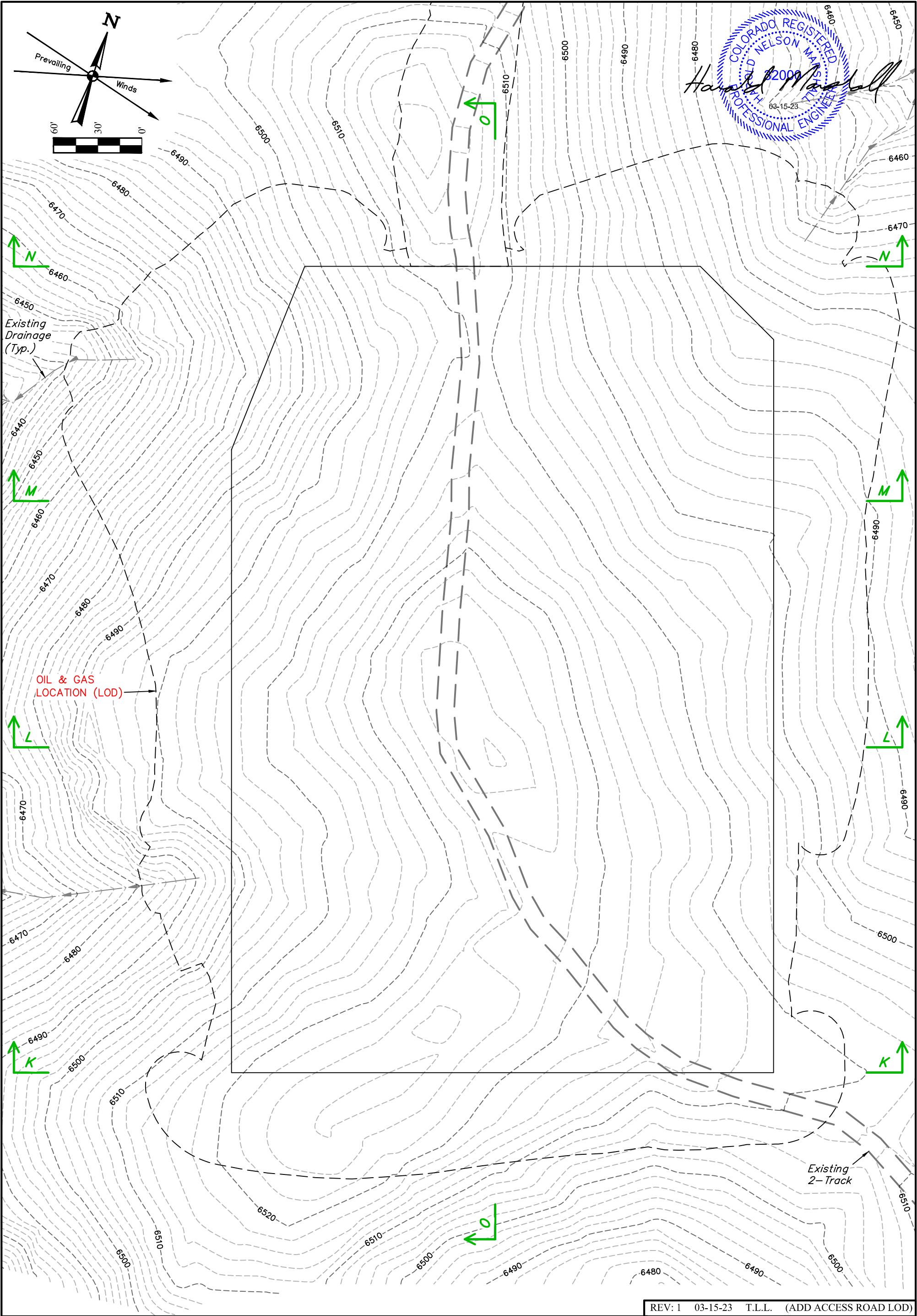
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LOT 3, SECTION 27, T1S, R97W, 6th P.M.  
RIO BLANCO COUNTY, COLORADO**

SURVEYED BY	DAYTON SLAUGH	11-18-21	SCALE
DRAWN BY	T.L.L.	10-17-22	AS SHOWN

**INTERIM RECLAMATION CROSS SECTIONS**



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**NOTES:**

- Contours shown at 2' intervals.

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**PCU FED B27 197 PAD**  
**LOT 3, SECTION 27, T1S, R97W, 6th P.M.**  
**RIO BLANCO COUNTY, COLORADO**

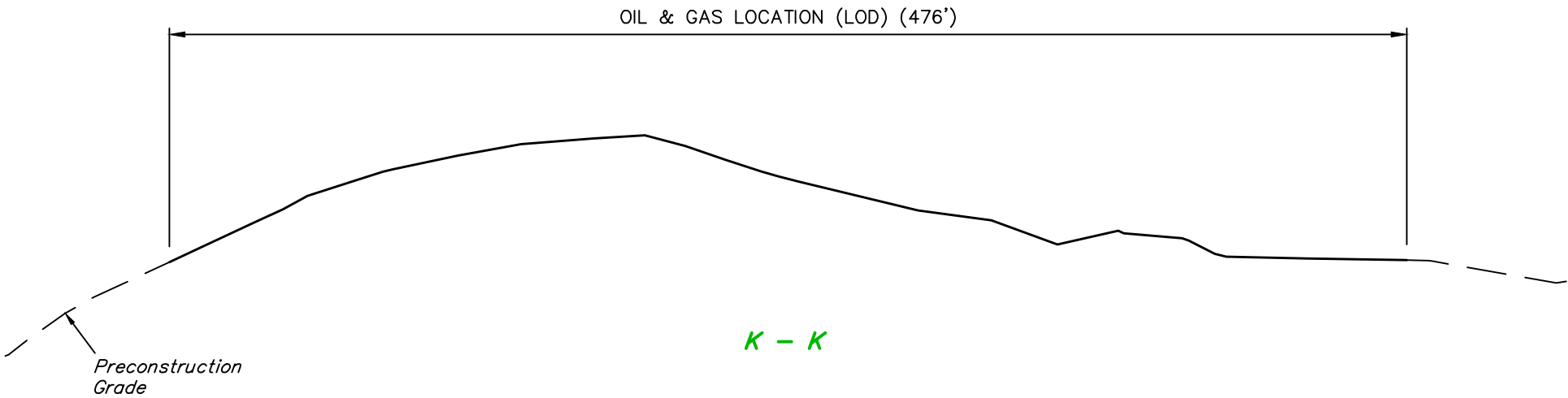
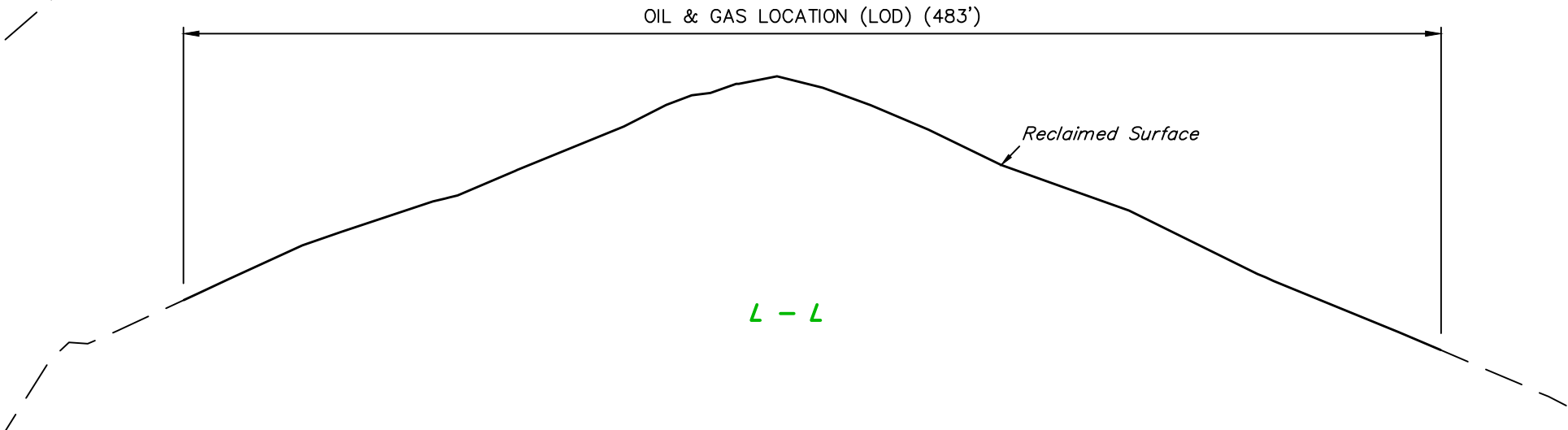
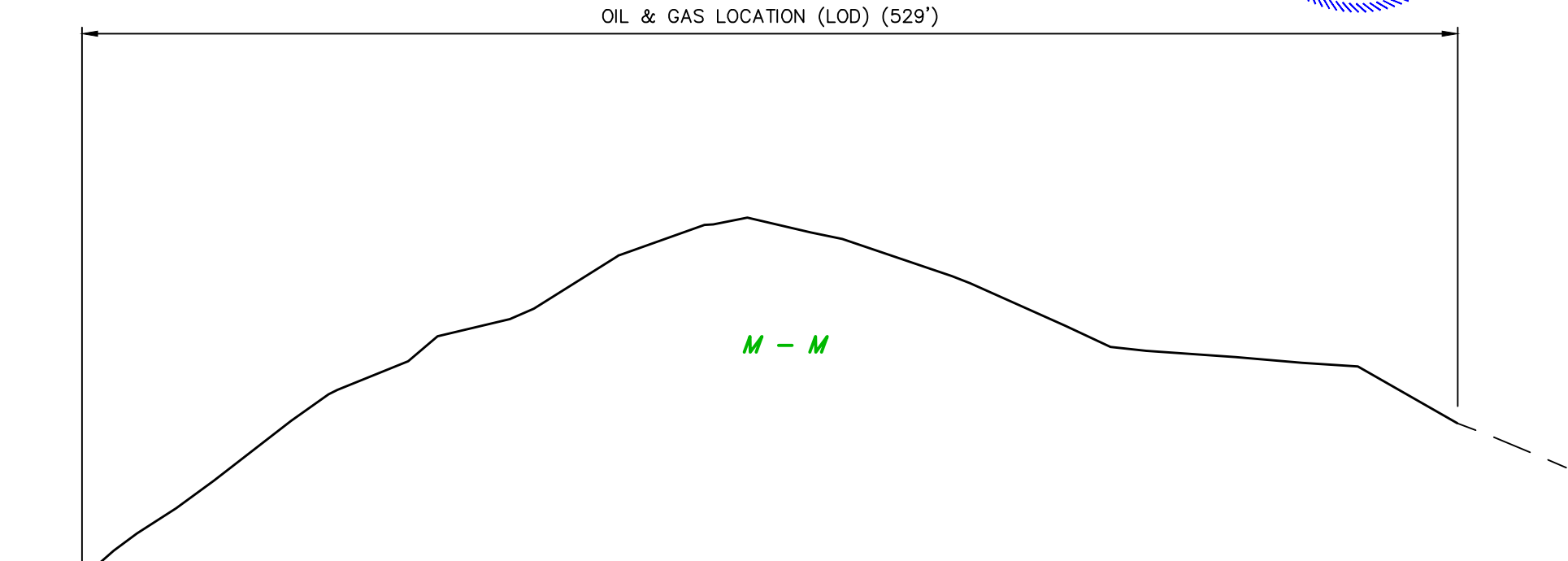
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<b>DRAWN BY</b>	T.L.L.	12-07-22	1" = 60'

**FINAL RECLAMATION PLAN**

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**UINTAH**  
ENGINEERING & LAND SURVEYING

1" = 20'  
X-Section  
Scale  
1" = 60'



Caerus Piceance LLC

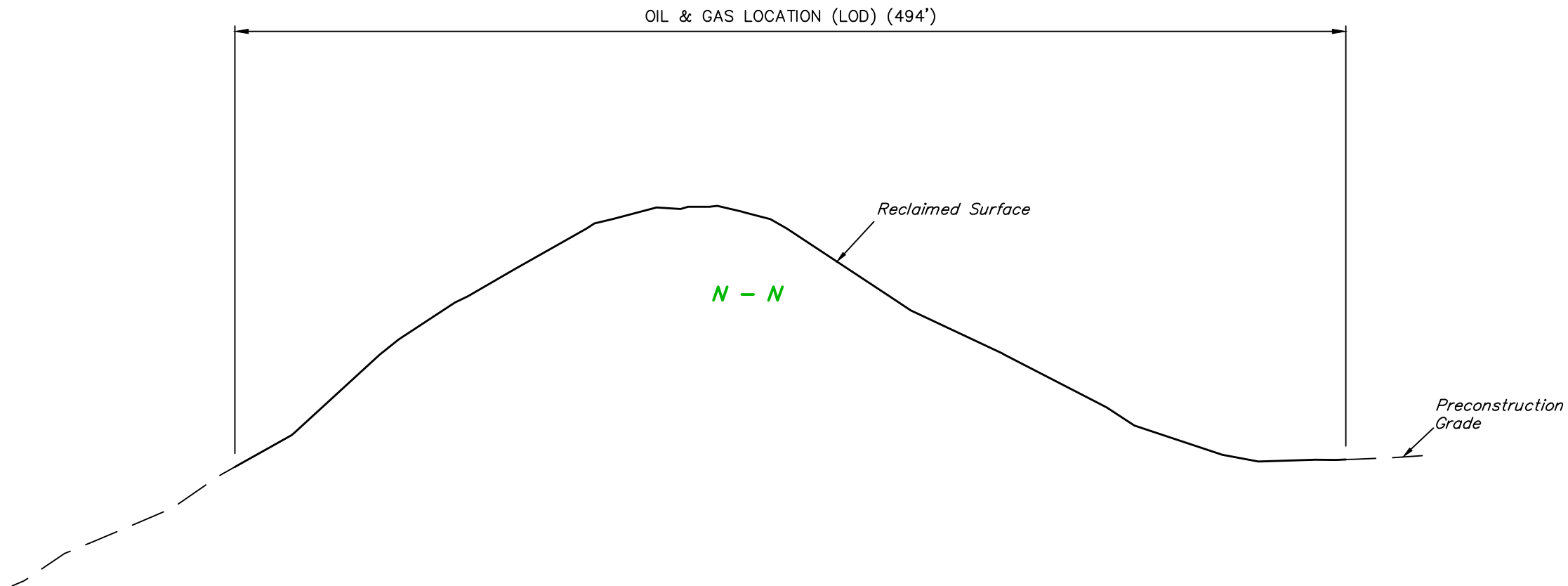
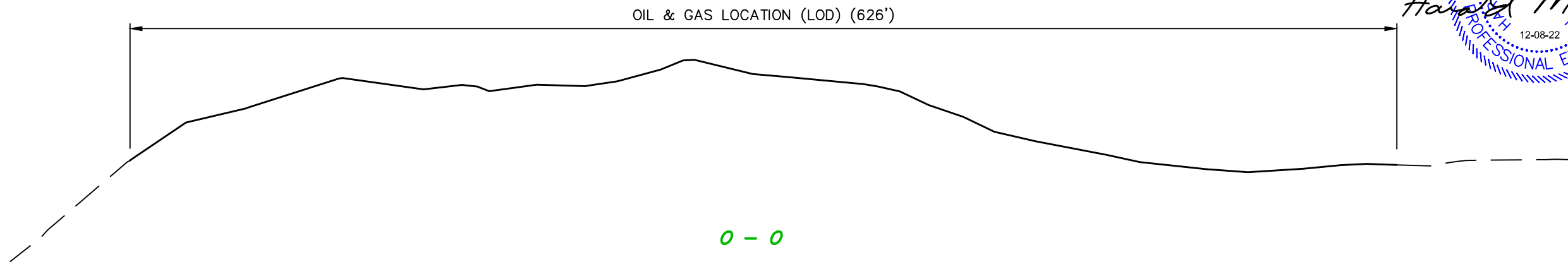
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LOT 3, SECTION 27, T1S, R97W, 6th P.M.  
RIO BLANCO COUNTY, COLORADO

SURVEYED BY	DAYTON SLAUGH	11-18-21	SCALE
DRAWN BY	T.L.L.	12-07-22	AS SHOWN
FINAL RECLAMATION CROSS SECTIONS			



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1" = 20'  
X-Section  
Scale  
1" = 60'



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DRAWN BY	T.L.L.	12-07-22	AS SHOWN
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## CONTROL MEASURE SPECIFICATIONS

### Erosion Control Measures:

- Armoring
- Land Grading
- Mulching
- Revegetation
- Stabilized Unpaved Surface/Gravel Surfacing
- Subsoil Segregation
- Surface Roughening
- Topsoil Conservation and Segregation

### Drainage Control Measures:

- Berm/Working Surface Perimeter Berm
- Roadside Ditches

### Sediment Control Measures:

- Stormwater Collection Basin
- Wattles

## Armoring (AR)



### Description

Armoring is a permanent, erosion-resistant layer made of native rocks/stones/boulders or crushed concrete. It is intended to stabilize areas subject to erosion and protect against scour of the soil caused by concentrated, high velocity flows.

### Applicability

Armoring can be used for areas subject to erosion or weathering, particularly where conditions prohibit the establishment of revegetation or where flow velocities or soil types have a potential to be erosive. Armoring may be used in the following applications:

- Channel side slopes and/or bottoms
- Inlets and outlets to culverts and sediment traps
- Check dams
- Roadside ditches

Armoring inlet protection should be used where velocities and energies at the inlets of culverts are sufficient to erode around the inlet structure. Armoring may also be used to help channel the stormwater to the inlet of the culvert. Culvert outlet protection should be used where discharge velocities and energies at the outlets of culverts or channels are enough to erode the next downstream reach

### Limitations

Armoring is limited by steepness of slope, because slopes greater than 1.5:1 have potential armoring loss due to erosion and sliding.



## Design criteria

### Gradation

A well-graded mixture of rock sizes should be used instead of one uniform size (with the exception of dry stacking boulders). When dry stacking up a slope, boulders may be uniform in size or may get gradually smaller as the boulders are placed up the slope.

### Quality

Armoring will be durable so that freeze/thaw cycles do not decompose it in a short time. Angular rock is preferred, although cobble maybe the only available option (check with local quarries). Rock should not be subject to breaking down when exposed to water or weathering.

### Filter material

Filter material may be used between armoring and the underlying soil surface to prevent soil from moving through the armoring. Filter cloth material or a layer of sand and/or gravel is usually used for the filter.

### Apron Armoring as culvert outlet protection

Armoring aprons at culvert outlets shall be designed as follows:

If the pipe discharges directly into a well-defined channel, the apron shall extend across the channel bottom and up the channel banks to an elevation 1 foot above the maximum tailwater depth or to the top of the bank, whichever is less. The upstream end of the apron, adjacent to the pipe, shall have a width two (2) times the diameter of the outlet pipe, or conform to pipe end section if used.

**Armoring materials.** The outlet protection may be done using rock armoring. Armoring shall be composed of a well-graded mixture of different sized stones. A well-graded mixture, as used herein, is defined as a mixture composed primarily of larger stone sizes, but with a sufficient mixture of other sizes to fill the smaller voids between the stones.

**Apron thickness.** The minimum thickness of the armoring layer shall be 1.5 times the maximum stone diameter of 15 inches or less; and 1.2 times the maximum stone size greater than 15 inches.

## Construction specifications

The performance-oriented specification for armoring is that erosion is not observed on the area with armoring application and that sediment is not observed to leave the armored area. If erosion or sediment is observed, the armoring should be re-designed and/or re-installed.

### General

See Figure R-1 for armoring slope stabilization and stream bank protection. See the **Sediment Trap (ST)** Control Measure for a detail of an armored channel leading into a sediment trap.

1. **Subgrade Preparation.** Prepare the subgrade for armoring to the required lines and grades shown on the plans. Compact any fill required in the subgrade to a density approximating that of the undisturbed material or overfill depressions with armoring. Remove brush, trees, stumps, and other objectionable material. Cut the subgrade sufficiently deep so that the finished grade of the armoring will be at the elevation of the surrounding area. Channels should be excavated sufficiently to allow placement of

the armoring in a manner such that the finished inside dimensions and grade of the armoring meets design specifications.

2. Sand/gravel filter blanket. If using a granular filter, spread filter stone in a uniform layer to the specified depth. Where more than one layer of filter material is used, spread the layers with minimal mixing.
3. Synthetic filter fabric. If using a filter fabric, place the cloth directly on the prepared foundation. Where large stones are to be placed, a 4-inch layer of fine sand or gravel is recommended to protect the filter cloth. Filter fabric is not recommended as a filter on slopes steeper than 2:1.
4. Stone placement. Place armoring so that it forms dense, well-graded mass of stone with a minimum of voids. The desired distribution of stones throughout the mass may be obtained by selective loading at the quarry and controlled dumping during final placement. Place armoring to its full thickness in one operation. Do not place armoring by dumping through chutes or other methods that cause segregation of stone sizes. If a filter is used, be careful not to dislodge the underlying base filter or damage the filter cloth when placing the stones. If damage occurs, remove the armoring and repair filter.
5. The toe of the armoring should be keyed into a stable foundation at its base as shown in Figure R-1 if required for slope stabilization and stream bank protection. The finished slope should be free of pockets of small stone or clusters of large stones. Hand placing may be necessary to achieve proper distribution of stone sizes to produce a relatively smooth, uniform surface. The finished grade of the armoring should blend with the surrounding area.

### **Culvert inlet protection**

Figure R-2 shows typical culvert inlet protection. However, site specifics shall dictate actual design.

1. After installation of a culvert, examine the stream channel for the amount of debris, logs, and brushy vegetation present. In channels with large amounts of debris, consider using oversized pipes.
2. Typically, the culvert inlet will have a sediment trap and a slide (head) gate that will normally be kept closed. In this case, sediment will settle out of runoff prior to washing through the culvert. If used, the slide gate will be opened only after collected water within the sediment trap is visually checked for any oil sheens.
3. Boulders may be dry-stacked around the culvert inlet and up the slope to the edge of the road.

### **Culvert outlet protection**

1. Prepare the sub-grade for the armoring to the required lines and grades. Any fill required in the sub-grade shall be compacted to a density of approximately that of the surrounding undisturbed material.
2. Construct apron to the design length and width with no slope. The invert elevations will be equal at the receiving channel and the apron's downstream end. No over-fall at the end of the apron is allowed. The elevation of the downstream end of the apron shall be equal to the elevation of the receiving channel or adjacent ground. The outlet protection apron shall be located so that there are no bends in the horizontal alignment.
3. Line the apron with armoring. Place armoring in accordance with the above general specifications.
4. If a culvert discharges at the top of cuts/fills or on slopes steeper than 10 percent one of the following two options is suggested:
  - a. Transition culvert to a slope drain according to the **Slope Drain (SD)** Control Measure. The slope drain shall convey stormwater to the bottom of the slope where an armored apron, as designed above, shall prevent erosion at the slope drain outlet.



- b. Line slope below culvert outlet with an armored channel to convey stormwater to the bottom of the slope with an armored apron, as designed above, shall prevent erosion at the bottom of the slope. The armored channel shall dip into the slope so that all water is contained within the channel, flows to an armored outlet apron at the base of the slope, and does not spill over the sides onto unprotected soil.

### Maintenance Specifications:

- Buildup of debris; or
- Sedimentation occurring in the spaces between material; or
- Occurrence of scouring/undercutting

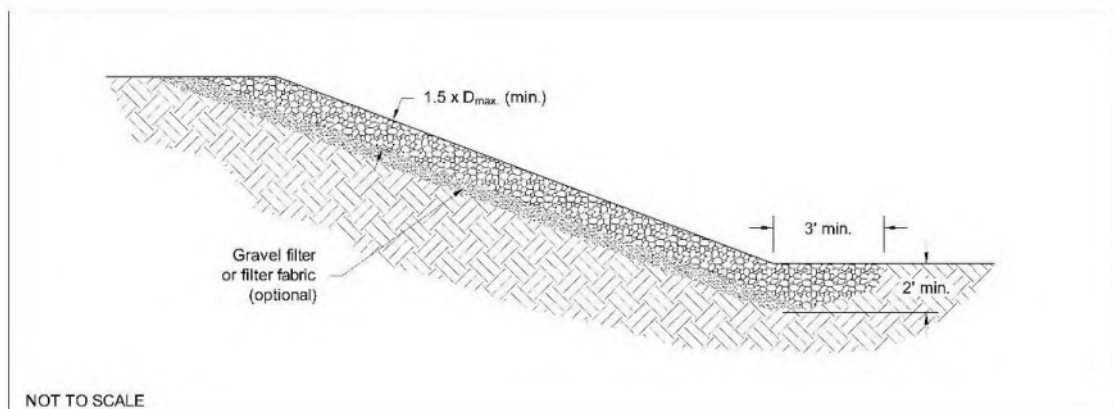
### Corrective Action Specifications:

- Dislodged rock that leaves exposed soils; or
- Sedimentation occurring over more than  $\frac{1}{2}$  of the armoring material; or
- Need for continuation or additional armoring above or below pre-installed armoring; or
- Improper installation

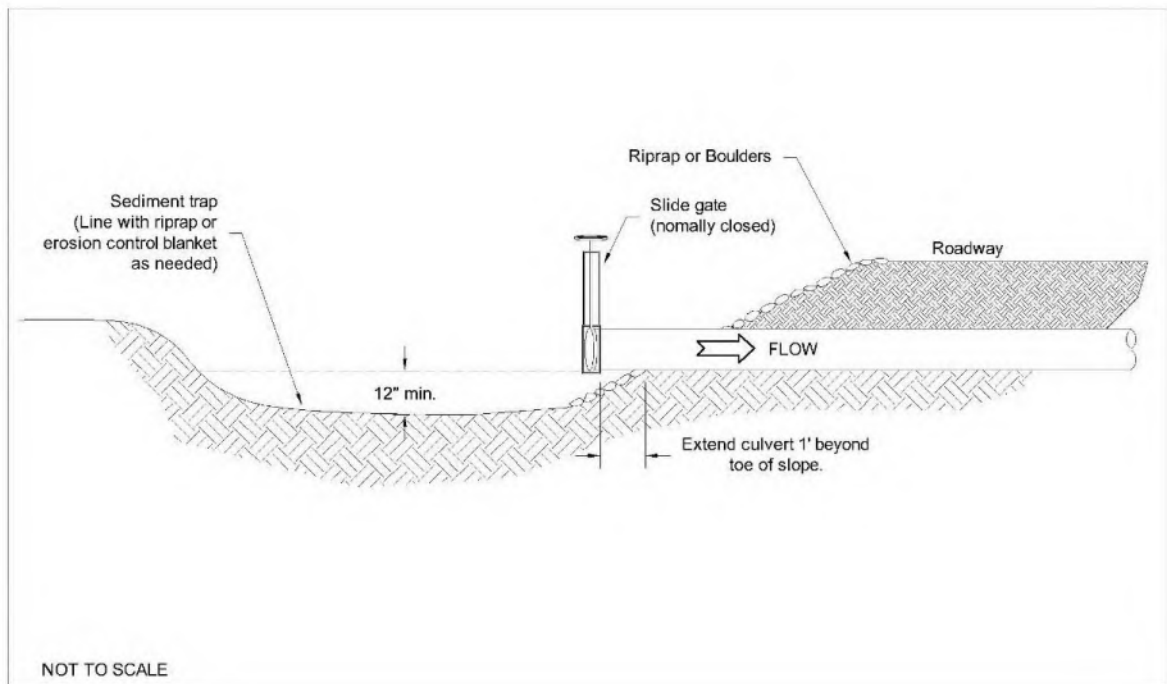
### Removal/Abandonment

Armoring is generally removed during Final Reclamation.

**Figure R-1**  
**Typical Armoring Slope Protection Detail**



**Figure R-2**  
**Typical Inlet Protection**



## References

Environmental Protection Agency (EPA), National Pollutant Discharge Elimination System (NPDES).  
Construction Site Storm Water Runoff Control. Washington, D.C., February 2003.  
<[http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con\\_site.cfm](http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con_site.cfm)>

New York State Department of Environmental Conservation, New York Guidelines for Urban Erosion and  
Sediment Control. New York. Fourth Edition, 1997.

## Land Grading (LG)



### Description

Land grading involves reshaping the ground surface to planned grades as determined by an engineering survey, evaluation, and layout. Land grading provides more suitable topography for roads, well pads, and facilities, and helps to control surface runoff, soil erosion, and sedimentation during and after construction in these areas. This Control Measure shall include the following:

- Proper cut and fill techniques to ensure roads, well pads, and facilities remain stable over time.
- Road crowning or sloping to properly route runoff off the roadway.
- Well pad and facility sloping to properly route runoff off the work areas.

### Applicability

- Land grading is applicable to sites with uneven or steep topography or easily erodible soils, because it stabilizes slopes and decreases runoff velocity.
- This Control Measure is applicable to the construction and maintenance of any road, well pad, or facility, but particularly those located on steep topography or easily erodible soils.
- This Control Measure is applicable to the construction and maintenance of stockpiles, borrow areas, and spoil.

### Limitations

- Improper cut and fill slopes that disrupt natural stormwater patterns might lead to poor drainage, high runoff velocities, and increased peak flows during storm events.
- Clearing and grading of the entire site should include vegetated buffers or other controls to control off-site transport of sediments and other pollutants. Grading will be designed with erosion and sediment control and stormwater management goals in mind.

### Design criteria

#### Grading plan

A grading plan should establish the extent to which the construction area will be graded, how drainage patterns will be directed, and how runoff velocities will affect receiving waters. The grading plan should also include; when earthwork will start and stop, establish the degree and length of finished slopes, and dictate

where and how excess material will be disposed of (or where borrow materials will be obtained if needed). Practices will be developed for erosion control, slope stabilization, and safe disposal of runoff water and drainage, such as ditches and culverts, grade stabilization structures, retaining walls, and surface drains. Berms, roadside ditches, and other stormwater practices that require excavation and filling also should be incorporated into the grading plan.

The grading plan should incorporate landforming techniques, as described in the **Landforming (LF)** Control Measure.

Land grading should be based upon layouts that fit and utilize existing topography and desirable natural surroundings to avoid extreme grade modifications. Clearing and grading should only occur at those areas necessary for land grading activities and equipment traffic. Maintaining undisturbed temporary or permanent buffer zones in the grading operation provides a low-cost sediment control measure that will help reduce runoff and off-site sedimentation.

### **Slope failures**

Landslides and failed cuts and fills can be a major source of sediment. Slope failures, or landslides, typically occur where a slope is over-steep, where fill material is not compacted, or where cuts in natural soils encounter groundwater or zones of weak material. When failures do occur, the slide area should be stabilized by removing the slide material, flattening the slope, adding drainage, or using structures, as discussed below. Designs are typically site specific and may require input from geotechnical engineers and engineering geologists. Failures that occur typically impact operations and can be costly to repair. Failures near streams and channel crossings have an added risk of impact to water quality.

### **Road slope**

See Figure LG-1. All roads should be designed with one of the following three slope types:

- Outsloped roads minimize the concentration of water and minimize road width by avoiding the need for an inside ditch but may require roadway surface and fill slope stabilization. Outsloped roads with clay rich, slippery road surface materials often require surface stabilization with gravel or limited use during rainy periods to assure traffic safety. On road grades over 10 to 12 percent and on steep hill slope areas, out-sloped roads are difficult to drain and can feel unsafe.
- Insloped roads are the best method to control surface water. However, insloped roads also concentrate water and require a system of roadside ditches with wing ditches or periodic culverts to relieve water within the roadside ditches. See the **Roadside Ditches (RSD)** Control Measure, the **Wing Ditch (WD)** Control Measure, and/or the **Culvert (C)** Control Measure.
- Crowned roads are appropriate for higher standard, two lane roads on gentle grades. They may or may not require roadside ditches, wing ditches, and/or culverts to relieve water within the roadside ditches. It is difficult to create and maintain a crown on a narrow road, so generally in-sloped or out-sloped road drainage is more effective.

## **Construction specifications**

### **Cut and fill slopes**

1. All applicable perimeter erosion and sediment control practices and measures (berms, diversions, vegetated buffer, or wattles) shall be constructed prior to any road grading activities and maintained in accordance with their applicable Control Measures and the Stormwater Management Plan (SWMP). Perimeter controls should remain in place until all graded or disturbed areas, including slopes, are adequately stabilized.

2. All areas to be disturbed (both cut and fill) shall be cleared, grubbed, and stripped of topsoil to remove trees, vegetation, roots, or other objectionable material.
3. Fill material shall be free of brush, logs, stumps, roots, or other objectionable materials that would interfere with, or prevent, construction of satisfactory fills. This material can be set aside and later used at the toe of fill slopes as filter berms
4. Table LG-1 presents a range of commonly used cut and fill slope ratios appropriate for the soil and rock types described. Figures LG-2 and LG-3 present typical cut slope and fill slope design options for varying slope and site conditions. Vertical cut slopes should not be used unless the cut is in rock or very well cemented soil. Ideally, both cut and fill slopes should be constructed with a 2:1 or flatter slope to promote growth of vegetation, but cut slopes in dense, sterile soils or rocky material are often difficult to vegetate.
5. All fills shall be compacted as required to reduce erosion, slippage, settlement, subsidence, or other related problems.
6. Topsoil required for the establishment of vegetation shall be stockpiled in the amount necessary to complete finished grading of all exposed areas. See the **Topsoil Conservation and Segregation (TopS)** Control Measure.
7. Where possible, pocking is the preferred method for short term stabilization. Terraces or contour trenches (see **Terracing (T)** Control Measure) shall be provided whenever the vertical interval (height) of any 2:1 cut or fill slope exceeds 20 feet; for 3:1 slope it shall be increased to 30 feet and for 4:1 to 40 feet.
8. All graded cut and fill areas shall be stabilized, either structurally or vegetatively, following finished grading. Some common slope stabilization options include hydroseeding, hydromulching, erosion control blankets, armoring, and retaining walls.

#### **Road slope**

1. See Figure LG-1. Compact soil or road base material to direct runoff.
2. If crowning a road, runoff is directed to both sides of the road requiring two roadside ditches, unless runoff will drain directly to well-stabilized areas.
3. If using an inslope design, runoff is directed toward the hillside and requires a roadside ditch with periodic wing ditches or periodic culverts to relieve water within the roadside ditches.
4. If using an outslope design, ensure a moderate road slope with dense vegetative cover.
5. When a pipeline crosses a road, the road should be re-compacted and re-sloped according to the original design and applicable road specifications.

#### **Maintenance Specifications:**

- Forming of rills; or
- Cracking around shoulder of slopes; or
- Loss of crown, out-slopes, and in-slopes

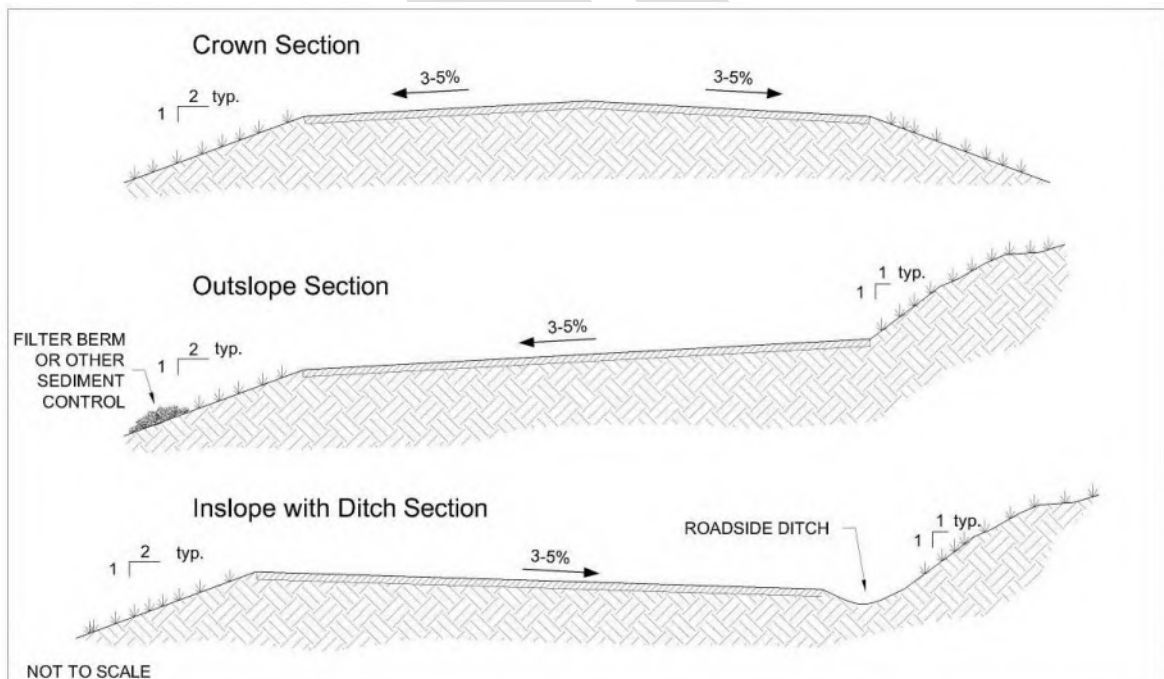
#### **Corrective Action Specifications:**

- Mass sloughing of material; or
- Forming of gullies; or
- Pooling of large volumes of water that can lead to a super saturated state

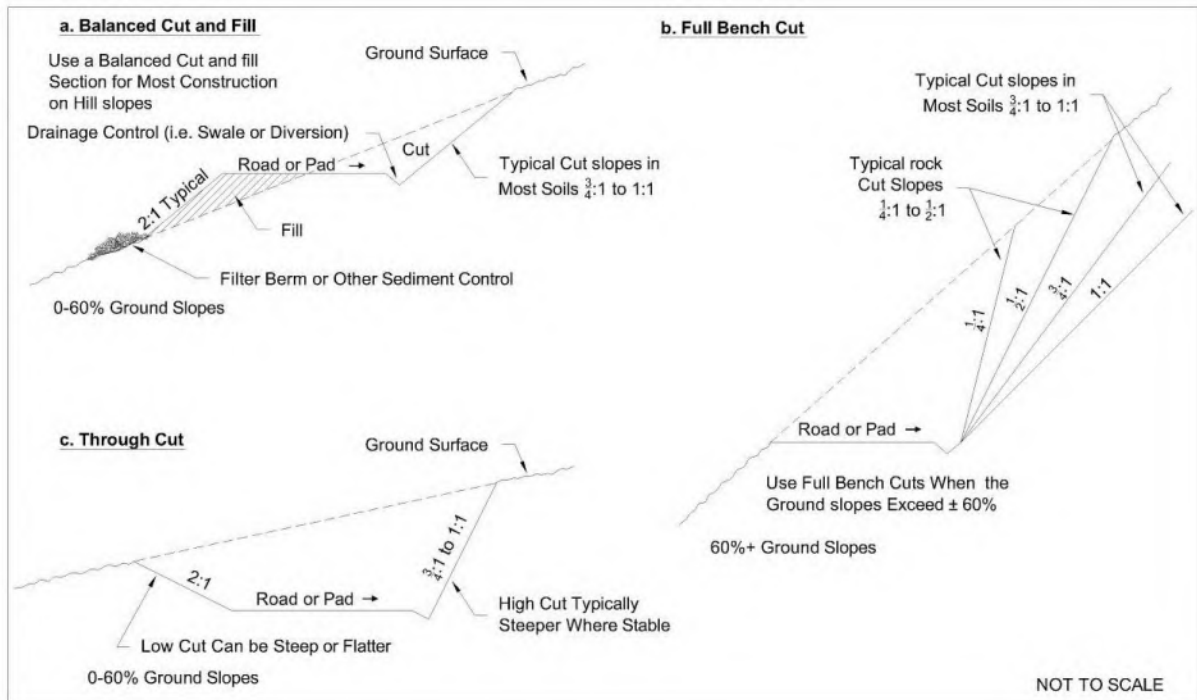
**Table LG-1**  
**Stable Slope Ratios for Various Conditions**

Soil/Rock Condition	Slope Ratio
Most rock	1/4:1 to 1/2:1
Very well cemented soils	1/4:1 to 1/2:1
Most in-place soils	3/4:1 to 1:1
Very fractured rock	1:1 to 1 1/2:1
Loose coarse granular soils	1 1/2:1
Heavy clay soils	2:1 to 3:1
Soft clay rich zones or wet seepage areas	2:1 to 3:1
Fills of most soils	1 1/2:1 to 2:1
Fills of hard, angular rock	1 1/3:1
Low cuts and fills (<10 ft high)	2:1 or flatter (for revegetation)

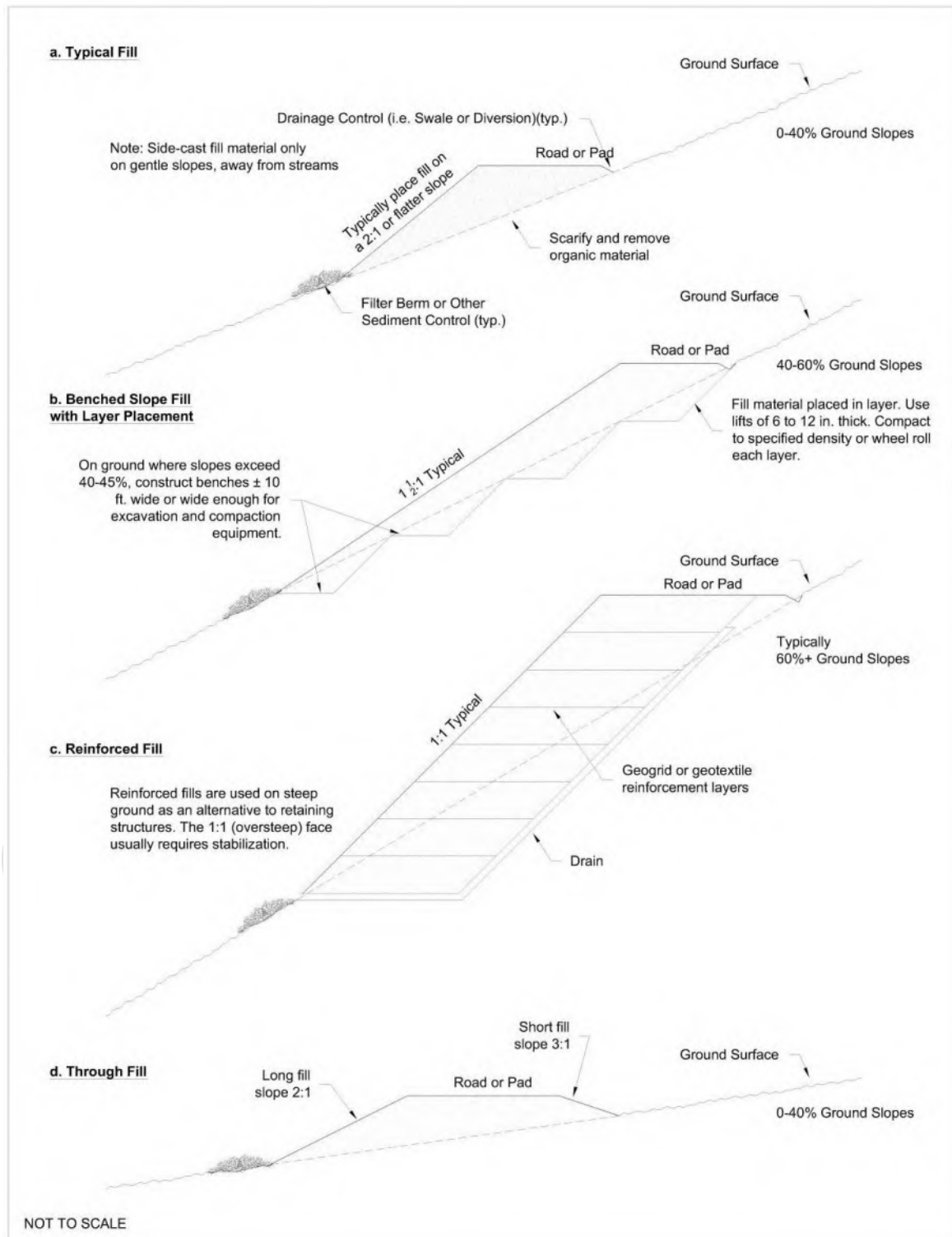
**Figure LG-1**  
**Typical Road Surface Drainage Options**



**Figure LG-2**  
**Typical Cut Slope Design Options**

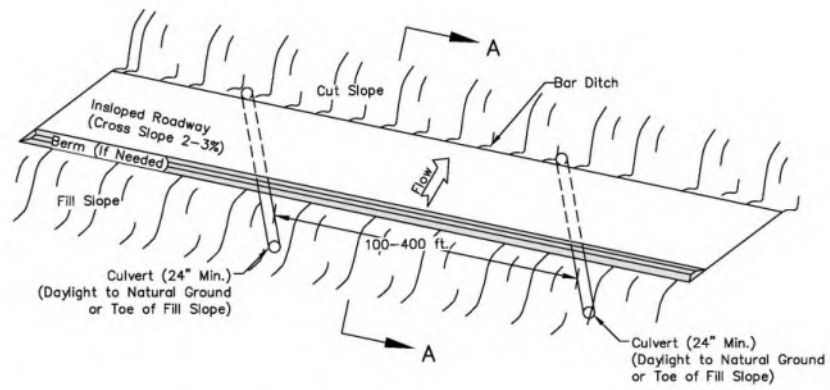


**Figure LG-3**  
**Typical Fill Slope Design Options**

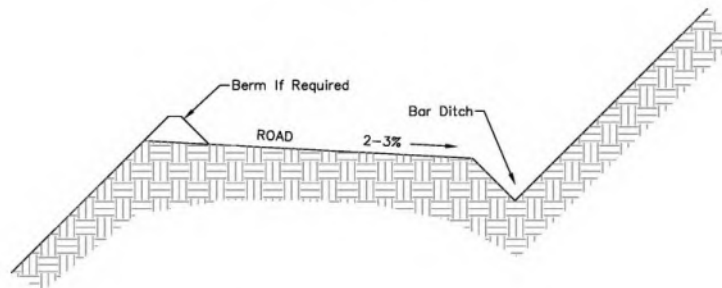




## INSLOPED ROAD



PROFILE VIEW



SECTION A-A

NOT TO SCALE

## References

- Environmental Protection Agency (EPA), National Pollutant Discharge Elimination System (NPDES). Construction Site Storm Water Runoff Control. Washington, D.C., February 2003. <[http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con\\_site.cfm](http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con_site.cfm)>
- Horizon Environmental Services, Inc, Guidance Document Reasonable and Prudent Practices for Stabilization (RAPPS) of Oil and Gas Construction Sites. April 2004.
- Keller, Gordon, and James Sherar, Low-Volume Roads Engineering, Best Management Practices Field Guide. United States Department of Agriculture (USDA), Forest Service, US Agency of International Development (USAID), 2005. <[http://ntl.bts.gov/lib/24000/24600/24650/Index\\_BMP\\_Field\\_Guide.htm](http://ntl.bts.gov/lib/24000/24600/24650/Index_BMP_Field_Guide.htm)>
- New York State Department of Environmental Conservation, New York Guidelines for Urban Erosion and Sediment Control. New York. Fourth Edition, 1997.
- Schor, Horst J., and Donald H. Gray, Landforming: An Environmental Approach to Hillside Development, Mine Reclamation and Watershed Restoration. John Wiley & Sons, Inc., 2007.
- United States Department of the Interior and United States Department of Agriculture. Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development "Gold Book." BLM/WO/ST-06/021+3071. Bureau of Land Management (BLM). Denver, Colorado. Fourth Edition, 2006.

## Mulching (M)



### Description

Mulching is a temporary erosion control practice in which materials such as grass-hay, wood fibers, or straw are placed on exposed or recently planted soil surfaces. Mulching stabilizes soils by minimizing rainfall impact and reducing stormwater runoff velocity. When used in combination with seeding or planting, mulching can aid plant growth by holding seeds, fertilizers, and topsoil in place, preventing birds from eating seeds, retaining moisture, and insulating plant roots against extreme temperatures.

Hydro-mulch is a hydraulically-driven mechanical agitation to make sure that the materials are thoroughly blended, and a centrifugal pump achieves even application. Hydro-mulch is a fast, economical and efficient method from applying seed, fertilizer and mulch together or in some combination. Hydro-mulch wicks up available water in order to keep the seed moist for longer periods of time, which results in faster seed germination and establishment.

### Applicability

Mulching in almost all situations is required after re-seeding. Mulching is also often used in areas where temporary seeding cannot be used because of environmental constraints. Hydraulic mulches can be used on slopes as steep as 1:1. Mechanically applied mulches can be used on seeded and planted areas where slopes are steeper than 3:1 or less and where sensitive seedlings require insulation from extreme temperatures or moisture retention.

### Limitations

- Mulching might delay seed germination because the cover changes soil surface temperatures.
- The mulches themselves are subject to erosion and may be washed away in a large storm.
- Straw mulch should be free of any weeds and any unwanted seed is desirable. Need to cut seed heads off the straw mulch.
- Maintenance is necessary to ensure that mulches provide effective erosion control.
- Hydraulic application of mulch will be done when no rainfall is expected, preferably within a 24-hour time period.

### Construction specifications

1. Site preparation:
  - a. Prior to mulching, install the necessary temporary or permanent erosion control practices and drainage systems within or adjacent to the area to be mulched.

- b. Slope, grade, and smooth the site to fit needs of selected mulch products.
  - c. Remove all undesirable stones and other debris to meet the needs of the anticipated land use and maintenance required.
2. Mulching & anchoring for relatively flat slopes (3:1 or less):
- a. Select the appropriate mulch and application rate that will best meet the need and availability of material. When possible, organic mulches should be used for erosion control and plant material establishment. Mulches and application rates are listed in the General Reclamation Surface Management Guideline. Typically, straw mulching at 2 tons per acre with tackifier is used on flatter slopes. See Table M-1 for suggested materials and application rates. All materials should be free of weed and seed.
  - b. Apply mulch immediately after soil amendments and planting is accomplished or simultaneously if hydroseeding is used. See Table M-1 for installation guidelines.
  - c. Mulch before seeding if construction or restoration activity is interrupted for extended periods, such as when seeding cannot be completed due to seeding period restrictions. If mulching before seeding, increase mulch rate of application on all slopes within 100 feet of water bodies and wetlands.
  - d. Use a mulch crimper to apply and anchor mulch. Crimper should have approximately 6-inch cleats with perpendicular, dull, disc blades. If a crimper is unavailable the Contractor shall apply mulch and anchor it to the soil using one of the methods described in Table M-2. The mulch should be anchored the same day as mulch application. Materials that are heavy enough to stay in place (for example, bark or wood chips on flat slopes) do not need anchoring. Mulches may or may not require a binder, netting, or tacking. Mulch binders should be applied at rates recommended by the manufacturer. Effective use of netting and matting material requires firm, continuous contact between the materials and the soil.
3. Hydro-mulching for steeper slopes (3:1 or steeper):
- a. For steep slopes an Erosion Control Mulch (ECM) consisting of a hydraulic matrix such as a Engineered Fiber Matrix (EFM) or Fiber Reinforced Matrix (FRM) may be used. An EFM refers to a continuous layer of elongated wood fiber strands that are held together by a water-resistant bonding agent to form a water-absorbing crust. FGM refers to a three-dimensional composite of wood fibers, crimped man-made fibers, and performance enhancing additives.
  - b. The ECM shall be a hydraulically-applied, flexible erosion control blanket composed of long strand, thermally refined wood fibers, crimped, interlocking fibers, and performance enhancing additives. The ECM shall require no curing time period and upon application shall form an intimate bond with the soil surface to create a continuous, porous, absorbent and erosion resistant blanket that allows for rapid germination and accelerated plant growth.
  - c. 3:1 or up to 2.5:1 use the ECM
  - d. 2.5:1 or greater use the FRM
  - e. Step One: Apply seed, fertilizer and other soil amendments with tackifier and a small amount of ECM for visual metering (see **Revegetation (RV)** for application rates).
  - f. Step Two: Mix 50 lbs. of ECM per 115 to 125 gallons of water.
  - g. Install materials at the typical application rates of 3,000 lbs. per acre or a minimum of 100% coverage.

### **Maintenance Specifications:**

- Formation of rill erosion; or
- Loosening of newly applied mulch (wind erosion)

## Corrective Action Specifications:

- Bare spots larger than 5 ft by 5 feet, caused by wind erosion or other factors; or
- Application rate was less than needed; or
- Impact to mulched area that compromise its ability to retain moisture; or
- Formation of gully erosion

## Removal/Abandonment

Mulch and anchoring material should be 100% biodegradable and should not require removal. However, any artificial anchor netting or other artificial mulch material should be removed when protection is no longer needed and disposed of in a landfill.

**Table M-1**  
**Typical Mulching Materials and Application Rates**

Material	Rate per Acre	Requirements	Application
<b>Organic Mulches</b>			
Straw	1 - 2 tons	Dry, un-chopped, un-weathered; certified weed free.	Spread by hand or machine; will be tacked or tied down. Typically used in flatter/open areas.
Wood fiber or wood cellulose	½ - 1 ton		Use with hydro-seeder; may be used to tack straw. Do not use in hot, dry weather.

**Table M-2**  
**Mulch Anchoring Guide**

Anchoring Method or Material	Kind of Mulch to be Anchored	How to Apply
Wood cellulose fiber with chemical application	Hay or straw	Apply hydro-mulch immediately. After mulching, use 500 lbs. Wood fiber per acre. Some products contain an adhesive material, possibly advantageous. Apply Tackifier 150 lbs./ac. In 480 gal. of water (#156/ac.). Avoid application during rain. A 24-hour curing period and a soil temperature higher than 45 deg. Fahrenheit are required.
Mulch anchoring tool/Crimper	Hay or straw	Apply mulch and pull a mulch anchoring tool (blunt, straight discs) over mulch as near to the contour as possible. Mulch material should be "tucked" into soil surface about 3".

Note: Manufacturer specifications may vary with site conditions.

## References

California Stormwater Quality Association, Stormwater Best Management Practice (BMP) Handbook – Construction. January 2003. <<http://www.cabmphandbooks.com/Construction.asp>>

Environmental Protection Agency (EPA), National Pollutant Discharge Elimination System (NPDES). Construction Site Storm Water Runoff Control. Washington, D.C., February 2003.

<[http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con\\_site.cfm](http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con_site.cfm)>

Horizon Environmental Services, Inc, Guidance Document Reasonable and Prudent Practices for Stabilization (RAPPS) of Oil and Gas Construction Sites. April 2004.

New York State Department of Environmental Conservation, New York Guidelines for Urban Erosion and Sediment Control. New York. Fourth Edition, 1997.

United States Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS), Field Office Technical Guide. 2002. <[www.nrcs.usda.gov/technical/efotg](http://www.nrcs.usda.gov/technical/efotg)>

Caerus

## Revegetation (RV)



### Description

Revegetation involves planting seed to establish a vegetative cover on disturbed areas. Revegetation reduces erosion and sedimentation by stabilizing disturbed areas in a manner that is economical, adaptable to site conditions, and allows selection of the most appropriate plant materials. Revegetation also:

- Absorbs the impact of raindrops
- Reduces the velocity of runoff
- Reduces runoff volumes by increasing water percolation into the soil
- Binds soil with roots
- Protects soil from wind
- Improves wildlife habitat
- Enhances natural beauty
- Increase soil fertility

### Applicability

Revegetation is most effective on slopes steeper than 2:1 and may be used in areas where exposed soil surfaces are not to be regraded for periods longer than 30 days. Such areas include denuded areas, soil stockpiles, berms, temporary road banks, etc. Seed may also be effectively hydraulically applied with mulch to steeper areas (see the **Mulching (M)** Control Measure). Another option for steeper areas is to use revegetation in combination with erosion control blanketing (see the **Erosion Control Blanket (ECB)** Control Measure).

### Limitations

The effectiveness of revegetation can be limited due to the following:

- High erosion potential during establishment.
- The need for stable soil temperature and soil moisture content during germination and early growth.
- The need to reseed areas that fail to establish.

Proper seedbed preparation and the use of quality seed are important in this practice. Failure to carefully follow sound agronomic recommendations will often result in an inadequate stand of vegetation that provides little or no erosion control.

Seeding does not immediately stabilize soils. Prior to seeding, install necessary erosion and sediment control practices such as diversions, straw bales, and basins until vegetation is established.

## Design criteria

Successful plant establishment can be maximized with proper planning; consideration of soil characteristics; selection of plant materials that are suitable for the site; adequate seedbed preparation, and fertilization; timely planting; and regular maintenance.

## Construction specifications

All revegetation activities (including soil amendments, seeding, planting, mulching, etc.) should be in accordance with the General Reclamation Surface Management Guideline. This Guideline provides information on seed quality and storage; drill seeding, hand seeding, and hydroseeding; seeding depths, dates, mixtures, and establishment; and soil amendments.

If used, see the **Erosion Control Blanket (ECB)** Control Measure.

Fencing can be installed around newly seeded areas in order to keep traffic away from reclaimed areas until vegetative growth has been fully established. Fencing may also be used where grazing by domestic livestock or wildlife can damage newly revegetated areas. Fencing details are provided in the General Reclamation Surface Management Guideline and represent BLM design details found in the BLM Oil and Gas Exploration and Development Gold Book.

## Seeding

- If applicable, use surface roughening prior to seeding (see **Surface Roughening (SR)** Control Measure).
- Do not use wet seed or seed that is moldy or otherwise damaged in transit or storage.
- Seed shall be uniformly sown by drill, by hydro-seeding (without mulch admixture), or by broadcasting. Seed shall be applied at the recommended rates for the application. Broadcast seeding shall be raked, or chain drag into the soil to a depth of approximately one-quarter inch (1/4") to one-half inch (1/2").
- Protect seeded areas against erosion by uniformly spreading mulch after completion of seeding operations in accordance with the **Mulching (M)** Control Measure.

## Maintenance Specifications:

- <3 ft of inter-canopy gaps; or
- First year growth of:
  - Non-native invasive plant species
  - Plant species of management of concern
- Lack of vegetation composition; or
- No germination, unless seed is still dormant due to drought conditions

## Corrective Action Specifications:

- No germination and establishment; or
- <3 living healthy seeding per square foot, after the first growing season; or
- Establishment of:



- Non-native invasive plant species
- Plant species of management of concern
- Proportion of soil surface in large inter-canopy gaps; or
- Loss of soil stability, susceptibility to wind and water erosion

## References

Environmental Protection Agency (EPA), National Pollutant Discharge Elimination System (NPDES). Construction Site Storm Water Runoff Control. Washington, D.C., February 2003.  
<[http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con\\_site.cfm](http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con_site.cfm)>

High Mesa Water Park Seeding Specifications. April 2006.

Horizon Environmental Services, Inc, Guidance Document Reasonable and Prudent Practices for Stabilization (RAPPS) of Oil and Gas Construction Sites. April 2004.

Keller, Gordon, and James Sherar, Low-Volume Roads Engineering, Best Management Practices Field Guide. United States Department of Agriculture (USDA), Forest Service, US Agency of International Development (USAID), 2005. <[http://ntl.bts.gov/lib/24000/24600/24650/Index\\_BMP\\_Field\\_Guide.htm](http://ntl.bts.gov/lib/24000/24600/24650/Index_BMP_Field_Guide.htm)>

United States Army Corps of Engineers (USACE), Engineering and Design - Handbook for the Preparation of Storm Water Pollution Prevention Plans for Construction Activities. February 1997.

## Soil Stabilizers (SS)

### Description

Soil stabilizers (also known as soil binders) consist of stabilizing emulsions that are applied directly to the surface of disturbed soil to temporarily reduce soil erosion. Soil binders are categorized as:

- Gelling Agents – Guar Gum Powder
- Copolymer Emulsion Dust Suppressant – Gorilla Snot
- Polymeric emulsion blends – Soil Sement

### Applicability

Soil binders are used in the summer months on bare soil areas where vegetation may not be desired (such as near compressor stations and helicopter pads) in order to reduce soil loss. Soil binders are also suitable for use on stockpiles and in some cases as a less expensive alternative to mulch as a dust suppressant and soil stabilizer.

### Limitations

- Soil binders are a temporary measure.
- Product may need be reapplied 6-12 months after initial application.
- Soil binders may not be compatible with certain soils.
- Runoff can penetrate a treated area at the top of a slope, undercut the treated soil, and cause spot failures by discharging at a point further down the slope.
- Performance depends on temperature, humidity, and traffic across treated areas.

### Construction specifications

Soil binders shall be applied per manufacturer specifications.

1. Soil binder will be non-toxic to plant and animal life. Some examples include Guar, Starch, Pitch & Rosin Emulsion, Liquid Polymers of Methacrylates & Acrylates, and Gypsum. However, many others are available and may be used. Select a soil binder that is appropriate for the region, use and soil type.
2. Soil binder is typically mixed in a water truck or hydro-seeder and applied in a liquid state. Use emulsion formulas for applications with water trucks.
3. Apply soil binder in the summer months over a roughened soil surface on slopes not greater than 1:1. Do not apply immediately before or during a rain event or where standing water is present.

### Maintenance Specifications:

- Formation of rill erosion; or

### Corrective Action Specifications:

- Formation of gully erosion

### References

Colorado Department of Transportation (CDOT), Erosion Control and Stormwater Quality Guide. 2002.  
<http://www.dot.state.co.us/environmental/envWaterQual/wqms4.asp>

Caerus

## Stabilized Unpaved Surface/Gravel Surfacing (GS)



### Description

Stabilized unpaved surfaces are used on roads, well pads, or other facilities to reduce erosion, limit dust from passing vehicles, and to reduce the amount of mud that may develop during wet weather. Stabilized unpaved surfaces can be made of any of the following materials:

- Gravel
- Stone
- Compacted soil
- Recycled Asphalt Product (RAP)

A stabilized unpaved surface includes the surface of dirt roads and those areas used during operation of wells or other facilities that are prepared in such a way as to prevent ongoing erosion issues (i.e. with gravel surfacing, proper land grading, and compaction). Areas developed as stabilized unpaved surfaces as needed for operation of the facility will qualify, according to the SWMP, as “finally stabilized.”

### Applicability

Stabilized Unpaved Surface may be used for any road, well pad, or other facility, particularly “soft” sections, steep grades, highly erosive soils, or locations where all-weather access is needed. Gravel or compacted soil may be used as “fill” material in ruts or as a full structural section over the entire road or well pad.

### Limitations

- Rutting and wash-boarding may develop if the surface gravel is too thin, has poor gradation, has little or no binding characteristic, or has a low percentage of fractured stone.
- Flat-blading to maintain the roadway will be done properly to avoid changes in gravel thickness, road slope, and road grade.
- Material sizing is dependent upon what is available at the gravel pits.

### Construction specifications

1. Maintain a road cross-slope with in-sloping, out-sloping, or a crown to rapidly move water off the road surface. Also maintain a slight slope on well pads or around other facilities.
2. Gradation of gravel shall be in accordance with applicable specifications (BLM, forest service, private landowner, etc...). Ideally, aggregate surfacing material is (1) hard, durable, and crushed or screened

to a minus 2-inch size; (2) well graded to achieve maximum density; and (3) contains clayey binder to prevent raveling.

3. Gravel may be placed with a minimum thickness of four inches; however, any amount of gravel is often useful. Geotextile or geogrid sub-grade reinforcement is sometimes used over soft soils to separate the gravel from the soil, keep it uncontaminated, and extend the useful life of the gravel.
4. The same gravel used to surface roadways may also be used to surface roadside ditches and create small check dams within those roadside ditches.
5. Gravel may be compacted during construction and maintenance to achieve a dense, smooth surface and thus reduce the amount of water that can soak into the ground.
6. "Spot" stabilization, local wet areas and soft areas with coarse rocky material as needed.
7. Stabilize the surface in sensitive areas near streams and at drainage crossings if necessary, to minimize surface erosion.
8. Control excessive dust.
9. Blend coarse aggregate and fine clay-rich soil (when available) to produce a desirable composite surface material that is coarse yet well-graded with fines for binder.

### **Maintenance Specifications:**

- Loss of implemented slope and grade for desired dewatering; or
- Loss of aggregate material; or
- Loss of compaction; or
- Buildup of debris; or
- Occurrence of rutting; or
- Minor tracking of material off-site

### **Corrective Action Specifications:**

- Significant tracking of mud clods off-site; or
- Significant rutting or total loss of compaction and surface integrity; or
- Sediment discharge from unpaved surface that threatens to reach or has reached live water.
- Dislodged rock that leaves exposed soils; or
- Sedimentation occurring over more than 1/2 of the armoring material

### **References**

Keller, Gordon, and James Sherar, *Low-Volume Roads Engineering, Best Management Practices Field Guide*. United States Department of Agriculture (USDA), Forest Service, US Agency of International Development (USAID), 2005. <[http://ntl.bts.gov/lib/24000/24600/24650/Index\\_BMP\\_Field\\_Guide.htm](http://ntl.bts.gov/lib/24000/24600/24650/Index_BMP_Field_Guide.htm)>

## Subsoil Segregation (SubS)



### Description

Subsoil segregation during construction of well pads, pipelines, or roads involves the removal and stockpiling of all excess subsoil cut material separate from the removal and stockpiling of surface (topsoil) material. Topsoil handling shall be in accordance with the **Topsoil Conservation and Segregation** Control Measure.

### Applicability

Subsoil segregation applies to the construction of all well pads, roads, pipelines, and any other construction activity where subsoil is temporarily stockpiled.

### Limitations

- Stockpiling increases the overall area of disturbance at a site.
- Stockpiles often require revegetation or some other stabilization Control Measure.

### Construction specifications

Subsoil material horizons will be stripped after all topsoil has been stripped and stockpiled to ensure proper segregation of topsoil and subsoil materials. Subsoil material will be placed in a subsoil stockpile berm above the topsoil stockpile berm which is placed at the toe of pad slopes.

### Maintenance Specifications:

- Forming of rills; or
- Cracking around shoulder of slopes

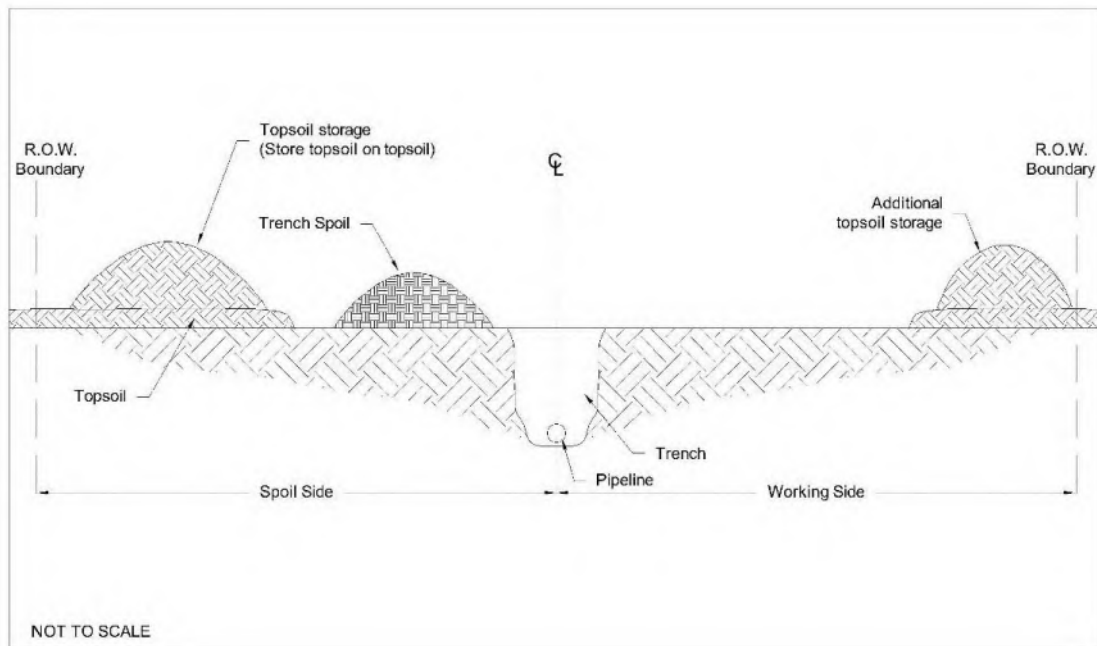
### Corrective Action Specifications:

- Mass sloughing of material; or
- Forming of gullies; or
- Inadequate separation of stockpiles (Clear mixing of topsoil and subsoil or one pile with total disregard for separation.)

### Removal/Abandonment

Stockpiles are often placed back in their original location when the site is recontoured during interim or final reclamation.

**Figure SubS-1**  
**Stockpiling for Pipeline Installation**



## References

United States Army Corps of Engineers (USACE), Engineering and Design - Handbook for the Preparation of Storm Water Pollution Prevention Plans for Construction Activities. February 1997.

United States Department of the Interior and United States Department of Agriculture. Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development "Gold Book." BLM/WO/ST-06/021+3071. Bureau of Land Management (BLM). Denver, Colorado. Fourth Edition, 2006.

## Surface Roughening (SR)



**Corrugating/Furrowing**



**Mini-Benching**



**Pocking**

### Description

Surface roughening is a temporary erosion control practice often used in conjunction with landforming and or land grading. Surface roughening involves increasing the relief of a bare soil surface using construction equipment. Slopes that are not fine graded and that are left in a roughened condition can reduce erosion. Surface roughening reduces runoff velocity, increases infiltration, reduces erosion, traps sediment, and prepares the soil for seeding and planting by giving seed an opportunity to take hold and grow. The following types of Surface roughening are discussed in this Control Measure:

- Corrugating/Furrowing
- Mini-Benching
- Pocking

### Applicability

Surface roughening is most effective for areas of 1 acre or less, and works well for the following applications:

- Any slope, but particularly fill slopes greater than 2:1
- Areas with highly erodible soils
- Soils that are frequently disturbed
- Prior to application of permanent or temporary seeding



- Adjacent to roadways as “irrigating” furrows to divert runoff away from roads

## **Limitations**

- Surface roughening is not appropriate for rocky slopes.
- Surface compaction might occur when roughening with tracked machinery.
- Surface roughening is of limited effectiveness in anything more than a gentle or shallow depth rain.
- If roughening is washed away in a heavy storm, the surface may have to be re-roughened and new seed laid.
- Some slopes may be too steep to safely use tracked equipment.
- Pocking size can be too exaggerate, preventing the establishment of vegetation.

## **Construction specifications**

To slow erosion, roughening should be done as soon as possible after grading activities have ceased (temporarily or permanently) in an area. All cut and fill slopes should be roughened wherever possible. Do not blade or scrape the final fill slope face. Excessive compacting of the soil surface should be avoided during roughening, and areas should be seeded as quickly as possible after roughening is complete.

## **Corrugating/Furrowing**

Corrugating/furrowing (Figure SR-1) uses machinery to create a series of ridges and depressions that run across the slope on the contour. Corrugating/furrowing is an ideal way to harvest/collect runoff water and use that water for a beneficial use (such as directing the water towards newly seeded areas). Groove using any appropriate implement that can be safely operated on the slope, such as disks, tillers, spring harrows, or the teeth of a front-end loader bucket. Do not make the grooves less than 3 inches deep or more than 15 inches apart. Corrugations/furrows may be used adjacent to roadways to divert runoff away from roads.

## **Mini-benching**

Benches shall be constructed on an even contour line. Benches shall be constructed approximately 2 to 3 feet deep and according to Figure SR-2.

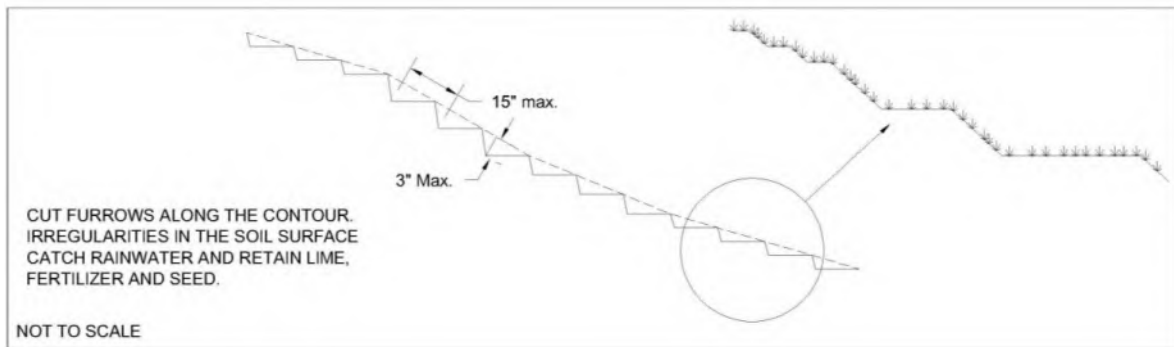
## **Pocking**

Pocking is performed with a backhoe as shown in the photo at the beginning of this section and as depicted in Figure SR-3. Pocks should be constructed with the bucket of a backhoe and shall be as close together as possible. Pocking that is too large may become a safety concern.

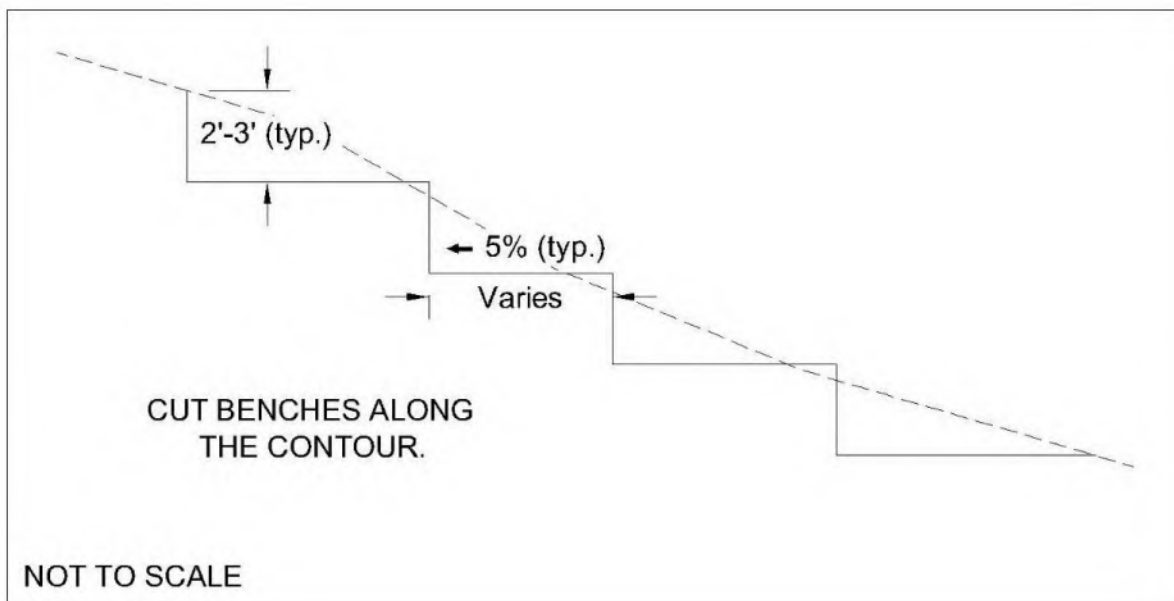
## **Maintenance considerations**

The frequency of inspections should be in accordance with the SWMP or PCSWMP. Roughening might need to be repeated after storm events. Inspections of roughened slopes will indicate where additional erosion and sediment control measures are needed. If rills appear, they should be filled, graded again, and reseeded as soon as possible. Proper dust control methods should be used.

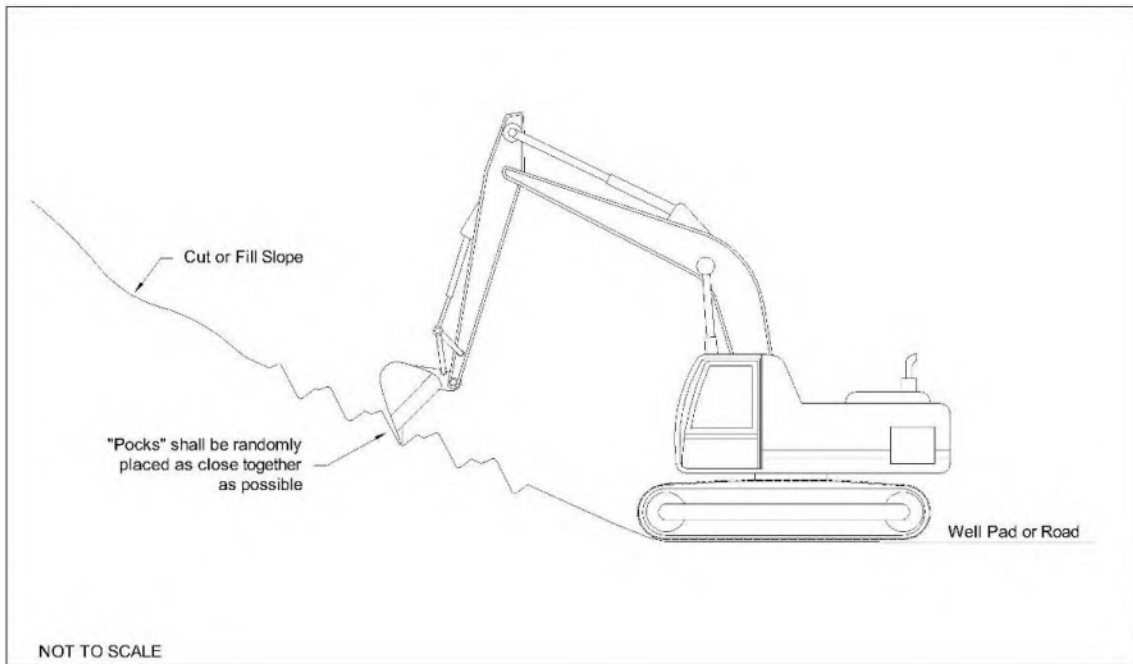
**Figure SR-1**  
**Corrugating**



**Figure SR-2**  
**Mini-benching**



**Figure SR-3**  
**Pocking**



## References

Environmental Protection Agency (EPA), National Pollutant Discharge Elimination System (NPDES). Construction Site Storm Water Runoff Control. Washington, D.C., February 2003.  
<[http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con\\_site.cfm](http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con_site.cfm)>

Horizon Environmental Services, Inc, Guidance Document Reasonable and Prudent Practices for Stabilization (RAPPS) of Oil and Gas Construction Sites. April 2004.

New York State Department of Environmental Conservation, New York Guidelines for Urban Erosion and Sediment Control. New York. Fourth Edition, 1997.

## Topsoil Conservation and Segregation (TopS)



### Description

Topsoil conservation and segregation during construction of well pads, pipelines, or roads involves the removal and stockpiling of all surface soil materials from the entire cut and fill area for later reuse during interim and final reclamation. Topsoil provides a planting and growth medium that is more desirable than deeper subsoils for use during reclamation and revegetation activities.

If there is an excess of cut material, subsoil may also be stockpiled in accordance with the Subsoil Segregation Control Measure.

### Applicability

Topsoil conservation and segregation applies to the construction of all well pads, roads, pipelines, and any other construction activity where soil is disturbed and later revegetated.

### Limitations

- Stockpiling increases the overall area of disturbance at a site.
- Stockpiles often require revegetation and also require other erosion and sediment controls during the establishment of vegetation such as diversions.
- Topsoil conservation and segregation required planning and coordination.

### Construction specifications

In accordance with the General Reclamation Surface Management Guideline.

### Maintenance Specifications:

- Forming of rills; or
- Cracking around shoulder of slopes

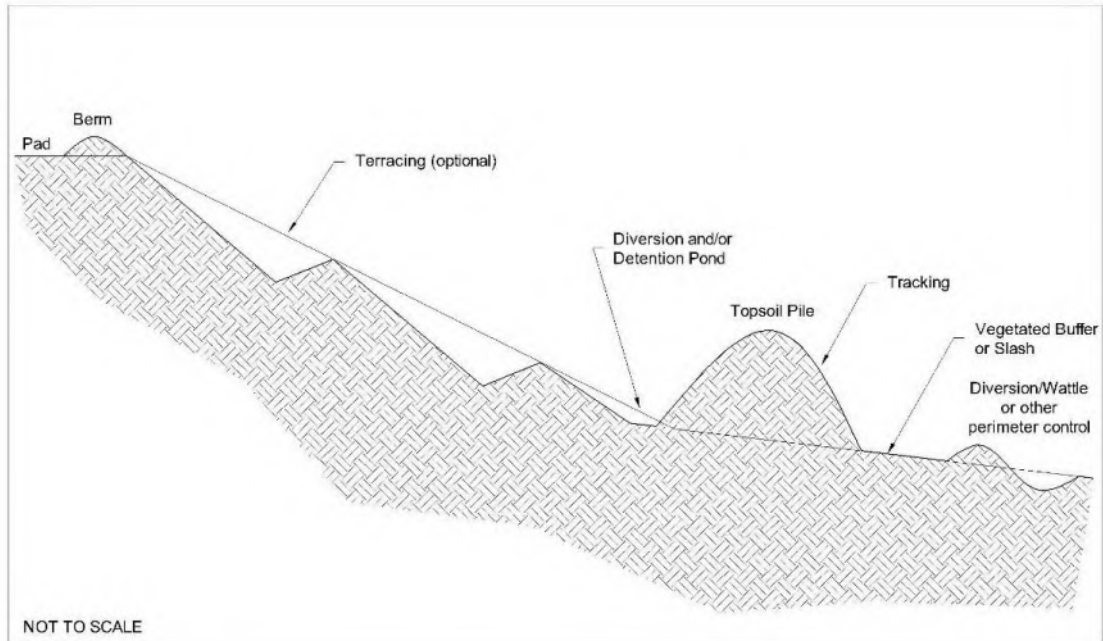
### Corrective Action Specifications:

- Mass sloughing of material; or
- Forming of gullies; or
- Inadequate separation of stockpiles (Clear mixing of topsoil and subsoil or one pile with total disregard for separation.)

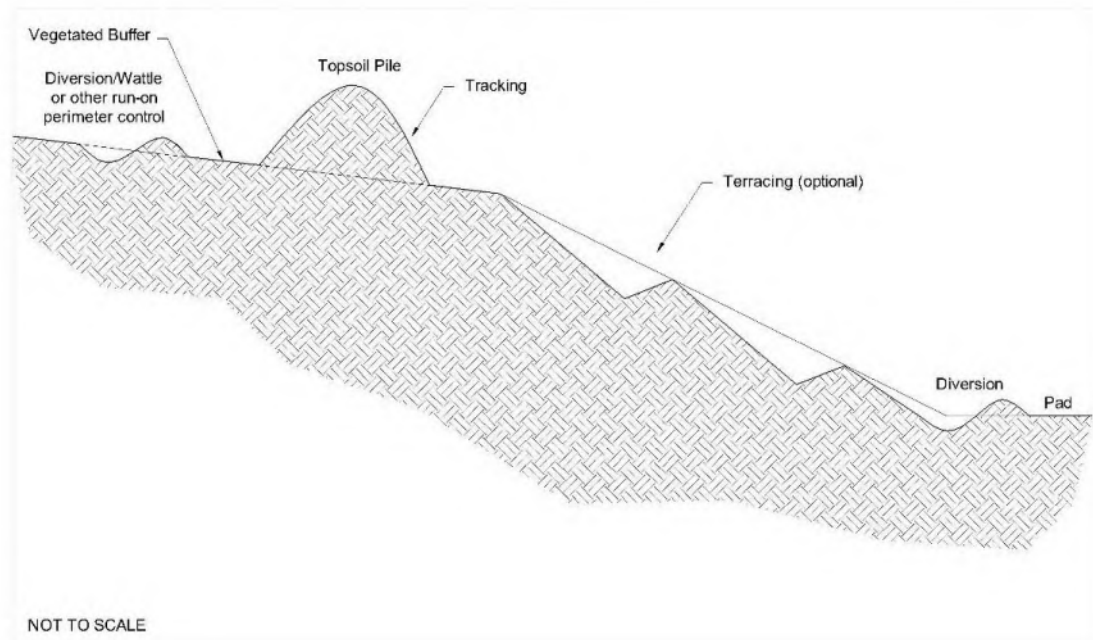
## Removal/Abandonment

Stockpiles may be removed when the site is ready for interim or final reclamation.

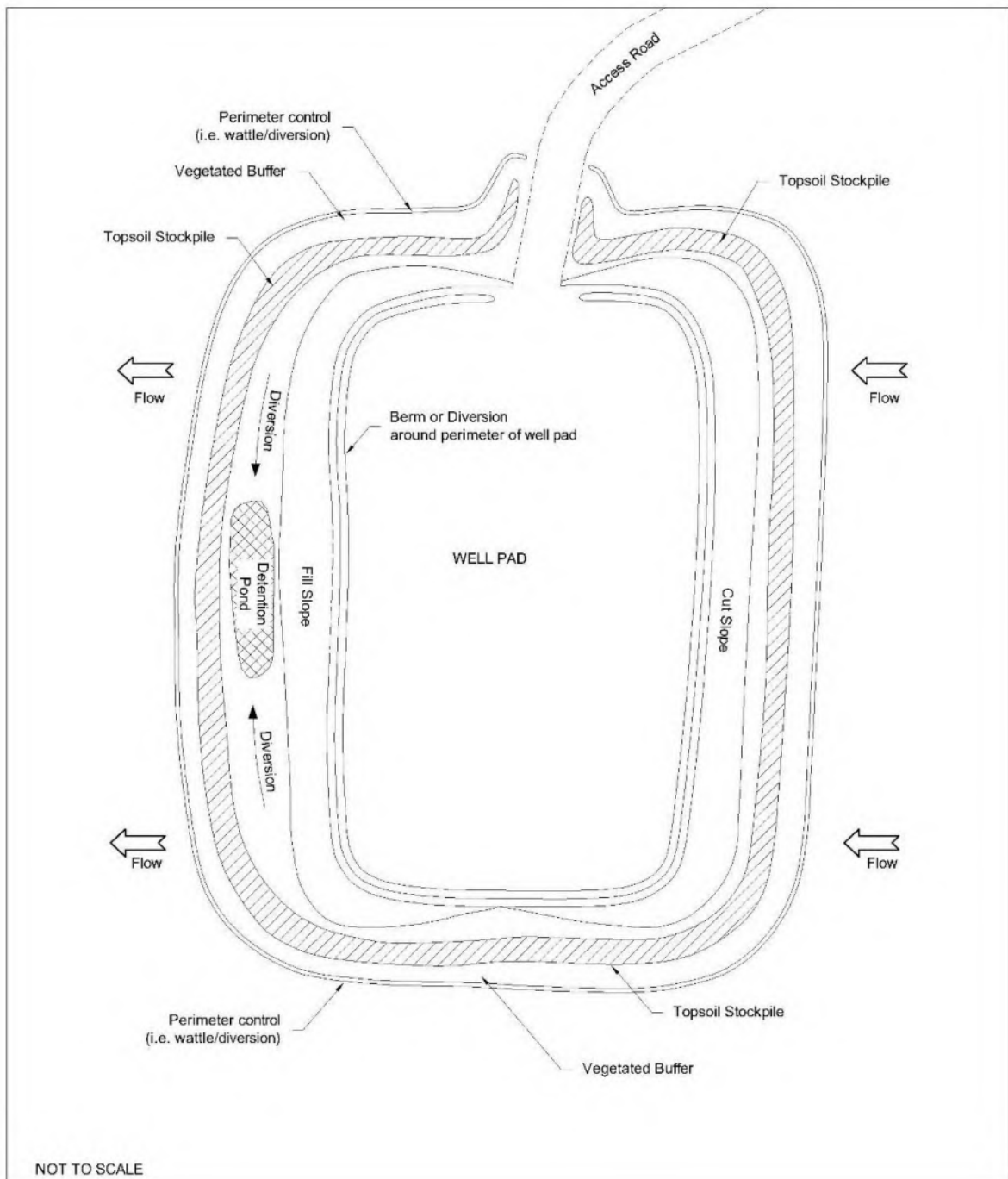
**Figure TopS-1**  
**Topsoil Stockpile – Located Below Well Pad**



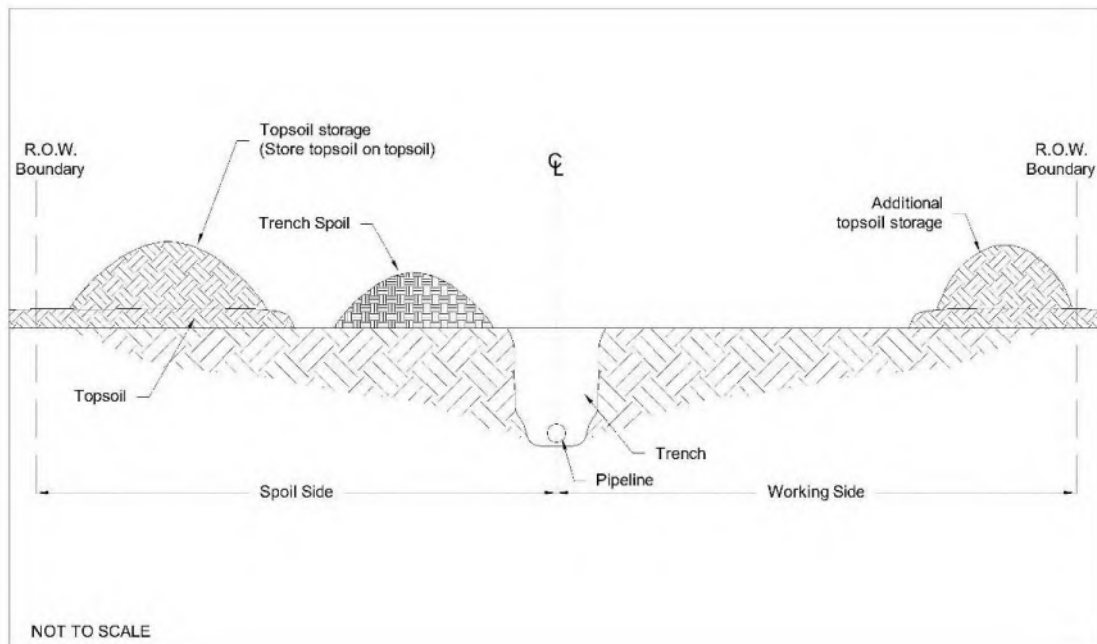
**Figure TopS-2**  
**Topsoil Stockpile – Located above Well Pad**



**Figure TopS-3**  
**Topsoil Stockpile – Plan View**



**Figure TopS-4**  
**Topsoil Stockpile for Pipeline Installation**



## References

United States Army Corps of Engineers (USACE), Engineering and Design - Handbook for the Preparation of Storm Water Pollution Prevention Plans for Construction Activities. February 1997.

United States Department of the Interior and United States Department of Agriculture. Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development "Gold Book." BLM/WO/ST-06/021+3071. Bureau of Land Management (BLM). Denver, Colorado. Fourth Edition, 2006.

## Berm (B)/Working Surface Perimeter Berm



### Description

A berm is a ridge of compacted soil located at the top or base of a sloping disturbed area. The purpose of a berm is to serve as a sediment barrier. A berm may also be referred to as a working surface perimeter berm (these terms can be used interchangeably, as the design specifications are the same). Berms should be constructed to minimize velocity and prevent erosion to the extent possible. Berms may be constructed from either excavated topsoil or subsoil.

### Applicability

Berms are usually appropriate for smaller drainage basins or basins with minimal runoff, but with modifications they can be capable of servicing larger areas. If properly designed, constructed, and implemented berms can be permanent Control Measure features. Key factors to check are the soils potential for erosion, the predicted velocities along the berm, and the capacity of the channel formed by the berm. Berms are applicable for the following:

- At the perimeter of a well pad (particularly the outer edge) to ensure that runoff remains on the pad and is diverted to a well pad detention pond or sediment trap, if available. See the **Detention Pond (DP)** and **Sediment Trap (ST)** Control Measure.
- Along the outside shoulder of an in-sloped road to ensure that runoff from the roadway drains inward and to protect the fill slope from continual disturbances during road blading and maintenance. See the **Land Grading (LG)** Control Measure.
- Upslope of cut or fill slopes to divert flows away from disturbed areas.
- As a toe berm down-slope of cut or fill slopes to divert on-site runoff to a stabilized outlet or sediment trapping device, although diversions are more commonly used for this application. See the **Diversion (D)** Control Measure.
- On well-pads for secondary containment.
- As a windrow lip along pipelines and roadways.

### Limitations

- Berms may erode if not properly compacted and stabilized. Berms will also have erosion issues if the velocities of the conveyed/diverted flows are too high. This happens when the flowline at the toe of the berm is too steep (i.e., the berm is not constructed along the contours, but across them).



Berms which are adjacent to or that convey concentrated flows may require additional erosion control measures.

- If a berm crosses a vehicle roadway or entrance, its effectiveness can be reduced. Thus, wherever possible, berms should be designed to avoid crossing vehicle pathways.
- Berms should not be placed across concentrated flow pathways (ditches, swales, streams, etc.). The discharge end of the berm may require a sediment trap or outlet protection.

## Design criteria

The design storm should match the application, the risks associated with failure, and the design life of the facility. Typically, permanent applications would be designed at a minimum of the 25-year 24-hour storm. Runoff calculations should take into account the increased runoff potential of disturbed areas and subsurface soils. The design should consider the erosive potential of site-specific soils. If the potential for erosion is high then engineering controls (i.e., additional Control Measures) should be implemented to limit erosion and minimize any potential downstream impacts.

## Construction specifications

1. Prior to berm construction, remove all trees, brush, stumps, and other objects in the path of the berm and till the base of the berm before laying the fill. The depth of removal will vary, but in general at a minimum it will be to the bottom of the topsoil layer. Fill may consist of topsoil or subsoil excavated during the construction of nearby roads or well pads. If fill material is excavated adjacent to the berm, follow the specification for the **Diversion (D)** Control Measure.
2. Construct the berm according to Figure B-1 for the appropriate application. For points where vehicles will cross the berm, the side slope should be no steeper than 3:1 and the mound may be surfaced with gravel. This will prolong the life of the berm and increase effectiveness at the point of vehicle crossing. For well pad perimeter installation the pad side of the berm should be sloped at 1.5:1 to help prevent vehicles from backing over the edge of the pad.
3. Berm material shall be compacted, unless topsoil berm, to minimize erosion and increase effectiveness. The compactive effort required is dependent upon many things including, but not limited to the expected design life of the berm, the soils used to construct the berm, the moisture content of the soils, the equipment available, and if vegetation is to be established on the berm. The minimum compactive effort shall be tracking with equipment.
4. Berms should have positive drainage to a stabilized outlet so that runoff does not collect in ponds on the upslope side of the berm, but instead flows along the berm until it reaches a stabilized outlet. Field location should be adjusted as needed. Stabilized outlet may be a well-vegetated area, a well pad detention pond, or a sediment control such as wattles or a sediment trap where sediment can settle out of the runoff before being discharged off-site.
5. If the expected life span of the berm is greater than 15 days, it is recommended that the berm be stabilized with compaction, hydromulch, seeded or apply tackifier immediately after construction. Stabilization is required where concentrated flows are expected.
6. Berms should be constructed and fully stabilized prior to commencement of major upslope land disturbance. This will maximize the effectiveness of the structure as a stormwater control device.

## Maintenance Specifications:

- Initial signs of erosion or loss of compaction on or along the berm resulting in berm height less than 1/3 the install height; or
- Occurrence of sediment buildup behind the berm up to 1/2 the overall height of the berm
- Occurrence of scouring/undercutting

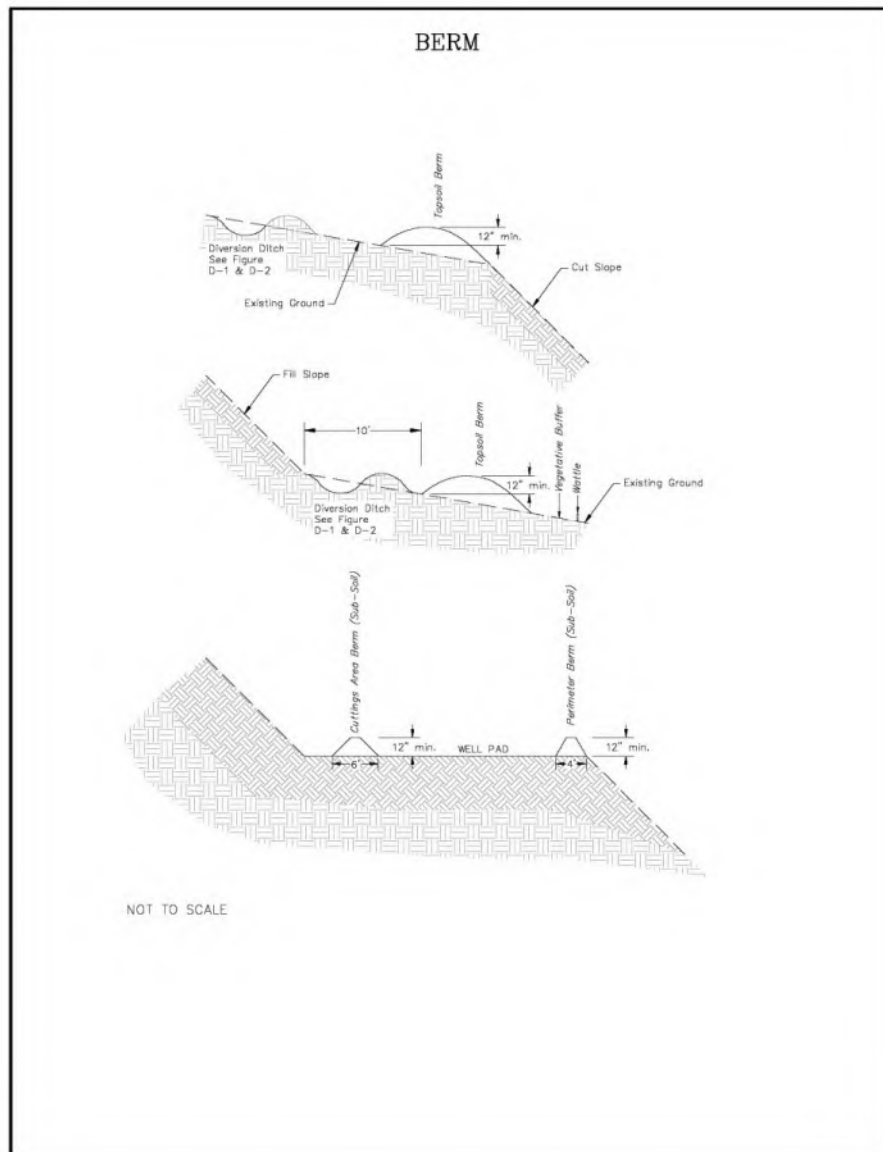
## Corrective Action Specifications:

- Breach which allows for bypass of the berm; or
- Occurrence of sediment buildup behind the berm greater than 1/2 the overall height of the berm; or
- Inadequate control measure; or
- Improper installation

## Removal/Abandonment

Berms should remain in place and in good condition until all upslope disturbed areas are permanently stabilized. There is no need to formally remove the berm on completion of stabilization until interim or final reclamation.

**Figure B-1**  
**Berm Installation**



## References

Environmental Protection Agency (EPA), National Pollutant Discharge Elimination System (NPDES).  
Construction Site Storm Water Runoff Control. Washington, D.C., February 2003.  
<[http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con\\_site.cfm](http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con_site.cfm)>

New York State Department of Environmental Conservation, New York Guidelines for Urban Erosion and  
Sediment Control. New York. Fourth Edition, 1997.

## Roadside Ditches (RSD)



### Description

Roadside ditches (also called bar ditches) are channels constructed parallel to roads. The ditches convey concentrated runoff of surface water from roads and surrounding areas to a stabilized outlet.

### Applicability

- Roadside ditches should be designed to handle flows and used for all roads built on sloping topography with either an insloped or a crowned design.

### Limitations

- If roadside ditches are not installed correctly, they may become a source of erosion.
- Roadside ditches do not necessarily filter sediment from runoff.

### Construction specifications

1. Roadside ditches should be constructed with no projections of roots, stumps, rocks, or similar debris.
2. Excavate ditches alongside to a width and depth that can handle expected flows according to Figure RSD-1.
3. All ditches shall have uninterrupted positive grade to a terminal Control Measure. Slope ditch so that water velocities do not cause excessive erosion, but no less than 0.5%. If steep slopes and high velocities exist, use velocity control measure to slow runoff and catch sediment.
4. To control erosion and collect sediment, the aggregate used to line the roadside ditch and construct aggregate check dams should be the same material as used to surface the roadway. The aggregate should be clean-screened.
5. All ditches shall convey runoff to a sediment trapping device such as a sediment trap (see **Sediment Trap (ST)** Control Measure) or an undisturbed, well vegetated, and stabilized area at non-erosive velocity. Ditches may also be periodically relieved by culverts or continuously relieved by furrows constructed for that purpose (as described in the **Surface Roughening (SR)** Control Measure).

### Maintenance Specifications:

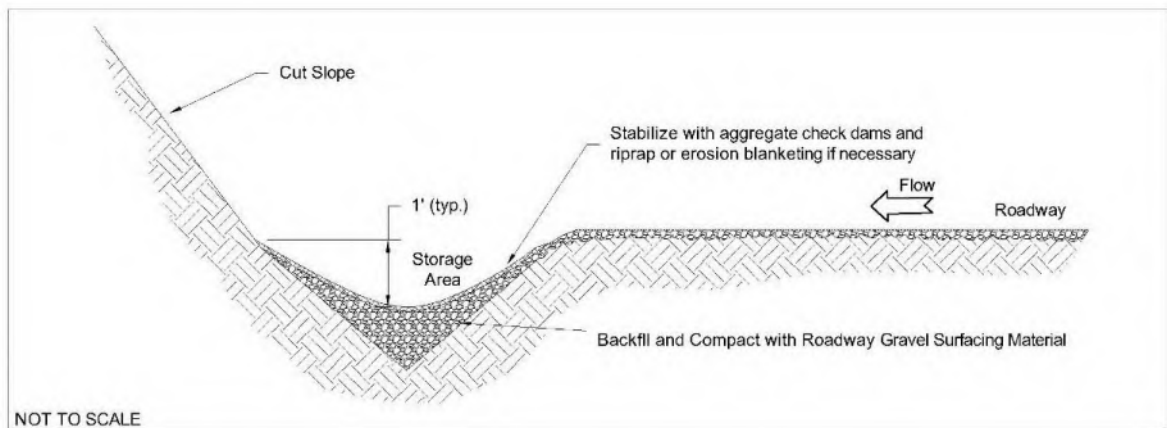
- Initial signs of erosion or scouring in or along the roadside ditch resulting in loss of structure more than 1/3 of the install depth; or

- Occurrence of sediment buildup within the roadside ditch greater than 2/3 the overall height

### Corrective Action Specifications:

- Breach in roadside ditch which allows for bypass; or
- Inadequate control measure; or
- Improper installation

**Figure RSD-1  
Roadside Ditch Installation**



### References

- Horizon Environmental Services, Inc, Guidance Document Reasonable and Prudent Practices for Stabilization (RAPPS) of Oil and Gas Construction Sites. April 2004.
- Keller, Gordon, and James Sherar, Low-Volume Roads Engineering, Best Management Practices Field Guide. United States Department of Agriculture (USDA), Forest Service, US Agency of International Development (USAID), 2005. <[http://ntl.bts.gov/lib/24000/24600/24650/Index\\_BMP\\_Field\\_Guide.htm](http://ntl.bts.gov/lib/24000/24600/24650/Index_BMP_Field_Guide.htm)>
- United States Department of the Interior and United States Department of Agriculture. Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development "Gold Book". BLM/WO/ST-06/021+3071. Bureau of Land Management (BLM). Denver, Colorado. Fourth Edition, 2006.

## Sediment Trap (ST) / Stormwater Collection Basin (SCB)



### Description

Sediment traps/Stormwater Collection Basins are typically small to medium sized ponding areas that retain or detain flows with the primary purpose of water quality improvement via sedimentation. They are usually installed in natural ground along a controlled water conveyance or other point of discharge from a disturbed area. Sediment traps/Stormwater Collection Basins are typically formed by excavating below grade and occasionally also formed by constructing an earthen embankment with a stabilized spillway to slow the release of runoff.

### Applicability

Sediment traps/Stormwater Collection Basins are generally temporary control measures used at the outlets of stormwater diversion structures (such as water bars or wing ditches), channels, slope drains, construction site entrance wash racks, or any other runoff conveyance that discharges waters containing erosion sediment and debris. Traps are common along pipelines or roadways and may be located in series to allow for backup control in case one trap fails.

Sediment traps/Stormwater Collection Basins can be used in the following applications:

- Used as a temporary storage area during dewatering activities.
- Placed on stormwater conveyance and diversion outlets including, but not limited to: culverts, wing ditches, water bars, slope drains, and construction entrance wash stations.
- Water and sediment storage area on well pads, at the base of well pads, and/or down-slope of other large disturbed areas.
- Used as a storage area for snow until melting conditions occur.

### Limitations

- Regular maintenance is required to remove sediment. Traps should be located near roads or where they are accessible to remove sediment.
- Sediment traps do not typically remove fine particles such as silts and clays.

Never construct a sediment trap on a live flowing stream, natural drainage ways, or in wetlands.

## Design criteria

### Location

The location of Sediment traps/Stormwater Collection Basins will be determined by the natural terrain, drainage pattern of the runoff, and the accessibility for maintenance. Sediment traps should not be located in areas where their failure due to stormwater runoff excess can lead to further erosive damage of the landscape. Alternative diversion pathways should be designed to accommodate these potential overflows. Sediment traps/Stormwater Collection Basins locations should also allow for easy maintenance access for the periodic removal of accumulated sediment.

### Storage capacity

A Sediment traps/Stormwater Collection Basins should be designed to maximize surface area for infiltration and sediment settling. This will increase the effectiveness of the trap and decrease the likelihood of backup during and after periods of high runoff intensity.

Sediment traps/Stormwater Collection Basins shall be sized to accommodate site runoff volumes resulting from the 2-year 24-hour precipitation event as provided by regional NOAA Precipitation Atlases (see Diversion Ditches DD BMP section) and calculated from the Rational Method. From the table below, the sediment trap volume has been estimated by multiplying its tributary disturbed area in acres by the runoff volume for the appropriate runoff coefficient and adding 15% for sediment accumulation. From these calculations, minimum sediment trap volumes have been calculated for the given tributary acreage.

**Runoff Volume Estimates Using the Rational Method  
for Northwest Colorado**

<b>Runoff Coefficient</b>	<b>Tributary Area (Acres)</b>	<b>2-year 24-hour Rainfall Intensity<sup>(1)</sup> (Inches/hour)</b>	<b>Peak Flow<sup>(2)</sup> (cfs)</b>	<b>Estimated Runoff Volume<sup>(3)</sup> (ft.<sup>3</sup>)</b>
0.3	1	0.05	0.015	1296
0.4	1	0.05	0.02	1728
0.5	1	0.05	0.025	2160
0.6	1	0.05	0.03	2592
0.7	1	0.05	0.035	3024

(1) NOAA Atlas 2, Vol III reports the 2-yr 24-hr precipitation for Northwest Colorado to be 1.2 inches .

(2) Peak Flow using Rational Method:  $Q = C \times I \times A$

where C = runoff coefficient; I = rainfall in inches/hour; A = tributary area in acres

(3) Runoff Volume = Peak flow in cfs x Storm Duration in seconds

### Minimum Trap Volumes

0.25 ac.  
(373 ft.<sup>3</sup>)

0.5 ac  
(745 ft.<sup>3</sup>)

0.75 ac.  
(1118 ft.<sup>3</sup>)

1.0 ac.  
(1490 ft.<sup>3</sup>)

The following formula may be used, as a reference, to estimate the volume of a sediment trap.  
 $\text{Volume (ft}^3\text{)} = 0.4 \times \text{surface area (ft}^2\text{)} \times \text{maximum pool depth (ft)}$ . The table below also serves as a volume calculator for various sediment trap dimensions.

SEDIMENT TRAP DIMENSIONS  
 CAERUS OIL AND GAS  
 PICEANCE BASIN, COLORADO

Sediment Trap Dimensions			
Length (Ft)	Width (Ft)	Depth (Ft)	Cubic Feet (Ft <sup>3</sup> )
5	5	4	100
5	5	6	150
5	5	8	200
10	10	4	400
10	10	6	600
10	10	8	800
15	15	4	900
15	15	6	1350
15	15	8	1800
20	20	4	1600
20	20	6	2400
20	20	8	3200
25	25	4	2500
25	25	6	3750
30	30	4	3600
30	30	6	5400

Sediment traps can be configured as diversion ditches using the runoff volume estimates above. Based on tributary drainage area, various ditch configurations and sizes are provided in the sizing tables below to accommodate corresponding runoff volumes.



## Sediment Trap Volume Computations (ft.<sup>3</sup>)

**2 ft. Wide Bottom Ditch with 1:1 Sideslopes**

	Depth (in.)						
Length (ft.)	12	18	24	30	36	42	48
10	30	53	80	113	150	193	240
15	45	79	120	169	225	289	360
20	60	105	160	225	300	385	480
25	75	131	200	281	375	481	600
30	90	158	240	338	450	578	720
35	105	184	280	394	525	674	840
40	120	210	320	450	600	770	960
50	150	263	400	563	750	963	1200
60	180	315	480	675	900	1155	1440
70	210	368	560	788	1050	1348	1680
80	240	420	640	900	1200	1540	1920
90	270	473	720	1013	1350	1733	2160
100	300	525	800	1125	1500	1925	2400
110	330	578	880	1238	1650	2118	2640
120	360	630	960	1350	1800	2310	2880
130	390	683	1040	1463	1950	2503	3120
140	420	735	1120	1575	2100	2695	3360
150	450	788	1200	1688	2250	2888	3600
160	480	840	1280	1800	2400	3080	3840
170	510	893	1360	1913	2550	3273	4080
180	540	945	1440	2025	2700	3465	4320
190	570	998	1520	2138	2850	3658	4560
200	600	1050	1600	2250	3000	3850	4800

**3 ft. Wide Bottom Ditch with 1:1 Sideslopes**

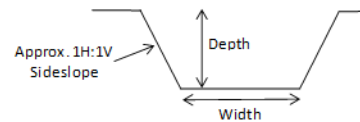
	Depth (in.)						
Length (ft.)	12	18	24	30	36	42	48
10	40	68	100	138	180	228	280
15	60	101	150	206	270	341	420
20	80	135	200	275	360	455	560
25	100	169	250	344	450	569	700
30	120	203	300	413	540	683	840
35	140	236	350	481	630	796	980
40	160	270	400	550	720	910	1120
50	200	338	500	688	900	1138	1400
60	240	405	600	825	1080	1365	1680
70	280	473	700	963	1260	1593	1960
80	320	540	800	1100	1440	1820	2240
90	360	608	900	1238	1620	2048	2520
100	400	675	1000	1375	1800	2275	2800
110	440	743	1100	1513	1980	2503	3080
120	480	810	1200	1650	2160	2730	3360
130	520	878	1300	1788	2340	2958	3640
140	560	945	1400	1925	2520	3185	3920
150	600	1013	1500	2063	2700	3413	4200
160	640	1080	1600	2200	2880	3640	4480
170	680	1148	1700	2338	3060	3868	4760
180	720	1215	1800	2475	3240	4095	5040
190	760	1283	1900	2613	3420	4323	5320
200	800	1350	2000	2750	3600	4550	5600

**4 ft. Wide Bottom Ditch with 1:1 Sideslopes**

	Depth (in.)						
Length (ft.)	12	18	24	30	36	42	48
10	50	83	120	163	210	263	320
15	75	124	180	244	315	394	480
20	100	165	240	325	420	525	640
25	125	206	300	406	525	656	800
30	150	248	360	488	630	788	960
35	175	289	420	569	735	919	1120
40	200	330	480	650	840	1050	1280
50	250	413	600	813	1050	1313	1600
60	300	495	720	975	1260	1575	1920
70	350	578	840	1138	1470	1838	2240
80	400	660	960	1300	1680	2100	2560
90	450	743	1080	1463	1890	2363	2880
100	500	825	1200	1625	2100	2625	3200
110	550	908	1320	1788	2310	2888	3520
120	600	990	1440	1950	2520	3150	3840
130	650	1073	1560	2113	2730	3413	4160
140	700	1155	1680	2275	2940	3675	4480
150	750	1238	1800	2438	3150	3938	4800
160	800	1320	1920	2600	3360	4200	5120
170	850	1403	2040	2763	3570	4463	5440
180	900	1485	2160	2925	3780	4725	5760
190	950	1568	2280	3088	3990	4988	6080
200	1000	1650	2400	3250	4200	5250	6400

**Applicability:** Sediment traps constructed with track hoe equipment.

### Sediment Trap Configuration:



### Instructions:

1. Select the appropriate bottom width table.
  2. Select the tributary drainage area flowing into the sediment trap.
- The acreages are coded by color with minimum trap volumes (ft.<sup>3</sup>) provided below:

0.25 ac. (373 ft. <sup>3</sup> )	0.5 ac. (745 ft. <sup>3</sup> )	0.75 ac. (1118 ft. <sup>3</sup> )	1.0 ac. (1490 ft. <sup>3</sup> )
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3. Select any of the corresponding depths and length that fit the color code.

**Example:** Tributary area to the sediment trap is approximately 0.75 acres  
Given: My equipment can dig a 3ft. wide ditch.

**Answer:** Use the 3 ft. Wide Bottom Ditch table above & select a yellow box. You can select any of the yellow corresponding depths and lengths. There are several choices. If select 1260 then your sediment trap should be at least 36 inches deep and 70 ft. long or choice 1148 and use 18 inches deep and 170ft. length.

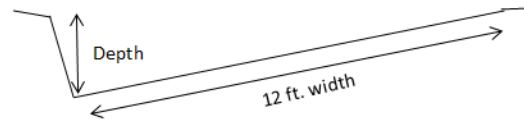
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### Diversion Ditch As Sediment Trap - Volume Computations

Sediment Trap Volumes			
Ditch Length (ft.)	(ft. <sup>3</sup> ) Depth (in.)		
	12	18	24
10	60	90	120
15	90	135	180
20	120	180	240
25	150	225	300
30	180	270	360
35	210	315	420
40	240	360	480
50	300	450	600
60	360	540	720
70	420	630	840
80	480	720	960
90	540	810	1080
100	600	900	1200
110	660	990	1320
120	720	1080	1440
130	780	1170	1560
140	840	1260	1680
150	900	1350	1800
160	960	1440	1920
170	1020	1530	2040
180	1080	1620	2160
190	1140	1710	2280
200	1200	1800	2400
210	1260	1890	2520
220	1320	1980	2640
230	1380	2070	2760
240	1440	2160	2880
240	1440	2160	2880
260	1560	2340	3120
270	1620	2430	3240
280	1680	2520	3360
290	1740	2610	3480
300	1800	2700	3600

**Applicability: Sediment traps constructed with motor grader equipment.**  
(With Standard 12 ft. Wide Motor Grader Blade)

#### Sediment Trap Cross-Section Configuration:



#### Instructions:

1. Select the tributary drainage area flowing into the sediment trap.  
The acreages are coded by color with minimum trap volumes (ft.<sup>3</sup>) provided below:

0.25 ac.	0.5 ac	0.75 ac.	1.0 ac.
(373 ft. <sup>3</sup> )	(745 ft. <sup>3</sup> )	(1118 ft. <sup>3</sup> )	(1490 ft. <sup>3</sup> )

2. Select the corresponding depths and lengths that fit the color code.

Example: Tributary area to the sediment trap is approximately 0.50 acres  
Given: Motor Grader to cut a depth of 18 inches.

Answer: From the Table, select the green box in the 18 inch column.  
Move to the left of that green box and you will see the  
corresponding ditch length is 90 ft. The sediment trap ditch should  
be a minimum of 90 ft. long and 18 inches deep.

## Construction specifications

See Figure ST-1 for installation details and Table 1 for a listing of dimensions associated with different volumes.

- If possible, Sediment traps/Stormwater Collection Basins, along with other perimeter controls, shall be installed before any land disturbance takes place in the drainage area.
- Traps should be located above the floodplain, where possible. If there are space constraints, several small sediment traps may be constructed in series.
- Area under embankment shall be cleared, grubbed, and stripped of any vegetation and root mat. The pool area shall be cleared.
- The fill material for the embankment shall be free of roots and other woody vegetation as well as over-sized stones, rocks, organic material, or other objectionable material. The embankment shall be compacted by traversing with equipment while it is being constructed. Seeding of the embankment should be performed as soon as possible after construction of the sediment trap. Erosion control blanketing may also be used to cover the embankment in combination with seeding or during time periods when seeding is ineffective.
- The spillway may consist of a stone section in the embankment formed by a combination coarse aggregate/riprap to provide for filtering/detention capability. See Figure ST-1 for spillway installation details.

A spillway or slope drain may be utilized to drain the sediment trap. Slope drain pipe diameter sizes may be determined using the slope drain sizing table below. Should a spillway be desired, the spillway shall be compacted and lined with coarse angular aggregate/riprap, or local adequately sized rock to provide for filtering/detention capability and to prevent erosion of the spillway. The spillway may alternately be constructed with a small section of pipe or may consist of a level spreader, where the entire embankment is constructed at a uniform elevation. The spillway weir for each sediment trap should be at least four feet long for a 1-acre drainage area and increase by 2 feet for each additional drainage acre added, up to a maximum drainage area of 5 acres.

See Figure ST-1 for installation details.

1. If possible, sediment traps, along with other perimeter controls, shall be installed before any land disturbance takes place in the drainage area.
2. Traps should be located above the floodplain, where possible. If there are space constraints, several small Sediment traps/Stormwater Collection Basins may be constructed in series.
3. Area under embankment shall be cleared, grubbed, and stripped of any vegetation and root mat. The pool area shall be cleared.
4. The fill material for the embankment shall be free of roots and other woody vegetation as well as over-sized stones, rocks, organic material or other objectionable material. The embankment shall be compacted by traversing with equipment while it is being constructed. Seeding of the embankment should be performed as soon as possible after construction of the Sediment Trap/Stormwater Collection Basin. Mulching may also be used to cover the embankment in combination with seeding or during time periods when seeding is ineffective.
5. Potential options for dewatering of the Sediment Trap/Stormwater Collection Basin are:
  - a. **Spillway** - Dewatering may be achieved through a defined spillway located at least 6-inches lower than the berm of the Sediment Trap/Stormwater Collection Basin. The spillway shall be stabilized

with armoring to support the establishment of vegetation. The spillway shall be discharge into a sediment trapping device or into a well-stabilized area.

- b. **Level spreader** – Dewatering may be achieved through a level spreader, which may extend around as much as half of the Sediment Trap/Stormwater Collection Basin. A level spreader is a device used to prevent erosion and to improve infiltration by spreading concentrated storm water runoff evenly over the ground at a level contour as shallow flow instead of through channels. This reduces flow speed and increases infiltration. The level spreader may consist of compacted earth, which will be vegetated on completion of construction. However, if erosion is noted during inspections it may be necessary to install aggregate, mulching, or wattles along the length of the level spreader.
- c. **Filter Berm** – The entire Detention Pond/Sediment Trap/Stormwater Collection Basin berm fill cross-section may be constructed of coarse angular native rock or import material. Due to its internal void space, the Filter Berm provides a permeable media for slow-release of stormwater following sediment deposition in the pond/trap/berm. Filter Berms are typically constructed at natural grade and disperse stormwater at their down-stream toe of slope to an existing vegetation buffer. Filter Berms are constructed with a level top line and typically do not need a defined spillway. Filter Berms are considered for dewatering applications with perhaps high influent rates and where maximum perimeter dispersal to the surrounding vegetation community is desired.

### **Maintenance Specifications:**

- Signs of visible erosion, on or around control measure; or
- Occurrence of sediment buildup within the trap greater than 2/3 the overall height or amount that would result in ultimate failure or bypass of Control Measure; or
- Inlet/outlet erosion control(s) and/or velocity dissipation controls show signs of erosion or sedimentation altering functionality

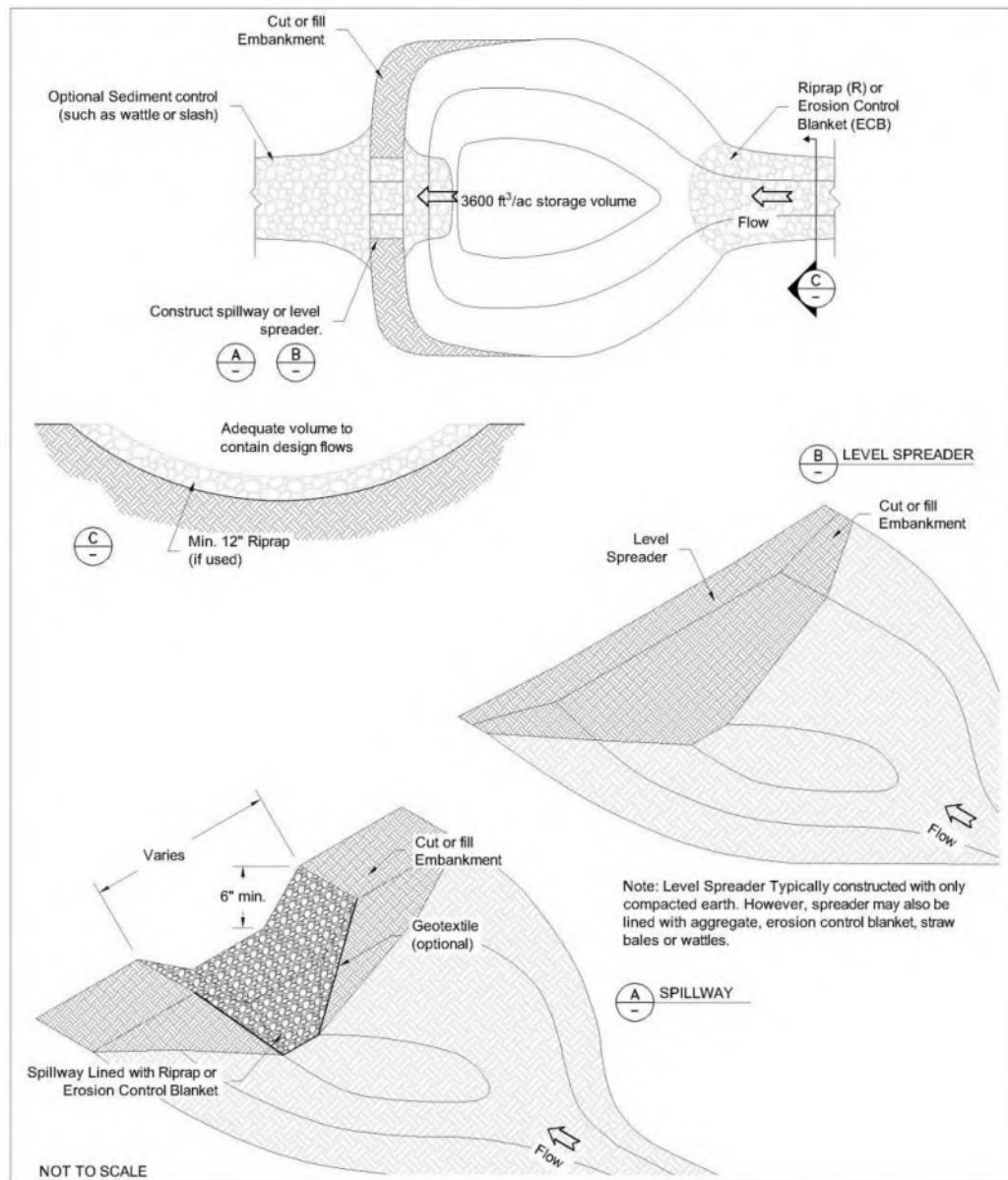
### **Corrective Action Specifications:**

- Sediment Trap/Stormwater Collection Basin has a breach or failure resulting in an unintended release of water; or
- Traps are not placed in the appropriate locations to collect the anticipated amount of precipitation; or
- Traps are more than 2/3 full of sediment.

### **Removal/Abandonment**

After the contributing area has been properly stabilized, the Sediment Trap/Stormwater Collection Basin may remain in place (if the trap itself is also fully stabilized), or the Sediment Trap/Stormwater Collection Basin may be removed, and the newly disturbed area shall be stabilized.

**Figure ST-1**  
**Sediment Trap/Stormwater Collection Basin Installation**



## References

Colorado Department of Transportation (CDOT), Erosion Control and Stormwater Quality Guide. 2002.  
<http://www.dot.state.co.us/environmental/envWaterQual/wqms4.asp>

Environmental Protection Agency (EPA), National Pollutant Discharge Elimination System (NPDES).  
 Construction Site Storm Water Runoff Control. Washington, D.C., February 2003.  
[http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con\\_site.cfm](http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con_site.cfm)

Horizon Environmental Services, Inc, Guidance Document Reasonable and Prudent Practices for Stabilization (RAPPS) of Oil and Gas Construction Sites. April 2004.



# Hydrologic Soil Group—Rio Blanco County Area, Colorado (Northeast)



# Hydrologic Soil Group—Rio Blanco County Area, Colorado (Northeast)

## MAP LEGEND

### Area of Interest (AOI)









 Area of Interest (AOI)

### Soils

#### Soil Rating Polygons

 A  
 A/D  
 B  
 B/D  
 C  
 C/D  
 D  
 Not rated or not available

#### Soil Rating Lines

 A  
 A/D  
 B  
 B/D  
 C  
 C/D  
 D  
 Not rated or not available

#### Soil Rating Points

 A  
 A/D  
 B  
 B/D

 C  
 C/D  
 D  
 Not rated or not available


### Water Features

 Streams and Canals

### Transportation

 Rails  
 Interstate Highways  
 US Routes  
 Major Roads  
 Local Roads

### Background

 Aerial Photography

## MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service  
 Web Soil Survey URL:  
 Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Rio Blanco County Area, Colorado  
 Survey Area Data: Version 17, Sep 6, 2022

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jun 24, 2020—Jul 8, 2020

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

## Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
70	Redcreek-Rentsac complex, 5 to 30 percent slopes	D	0.4	100.0%
<b>Totals for Area of Interest</b>			<b>0.4</b>	<b>100.0%</b>

## Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

## Rating Options

*Aggregation Method:* Dominant Condition



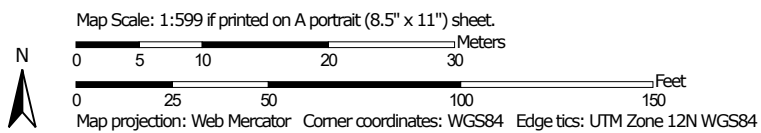
*Component Percent Cutoff: None Specified*

*Tie-break Rule: Higher*

# Hydrologic Soil Group—Rio Blanco County Area, Colorado (Northwest)



Soil Map may not be valid at this scale.



**Natural Resources  
Conservation Service**

Web Soil Survey  
National Cooperative Soil Survey

12/5/2022  
Page 1 of 4

# Hydrologic Soil Group—Rio Blanco County Area, Colorado (Northwest)

## MAP LEGEND

### Area of Interest (AOI)

 Area of Interest (AOI)

### Soils

#### Soil Rating Polygons

 A  
 A/D  
 B  
 B/D  
 C  
 C/D  
 D  
 Not rated or not available

#### Soil Rating Lines


 A  
 A/D  
 B  
 B/D  
 C  
 C/D  
 D  
 Not rated or not available

#### Soil Rating Points






 A  
 A/D  
 B  
 B/D

 C  
 C/D  
 D  
 Not rated or not available

### Water Features

 Streams and Canals

### Transportation

 Rails  
 Interstate Highways  
 US Routes  
 Major Roads  
 Local Roads

### Background

 Aerial Photography

## MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service  
 Web Soil Survey URL:  
 Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Rio Blanco County Area, Colorado  
 Survey Area Data: Version 17, Sep 6, 2022

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jun 24, 2020—Jul 8, 2020

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

## Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
70	Redcreek-Rentsac complex, 5 to 30 percent slopes	D	0.0	3.0%
73	Rentsac channery loam, 5 to 50 percent slopes	D	0.4	97.0%
<b>Totals for Area of Interest</b>			<b>0.4</b>	<b>100.0%</b>

## Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

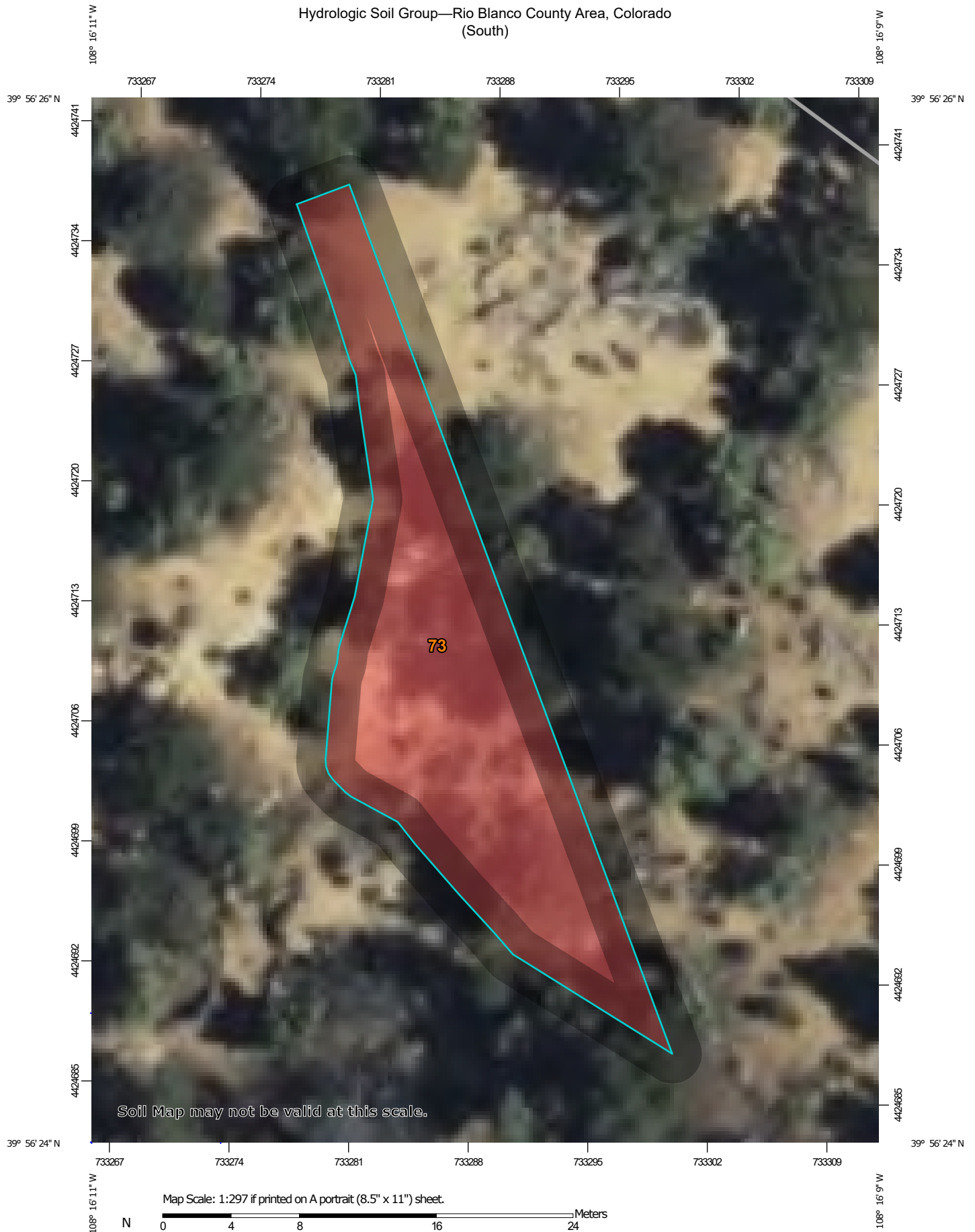
## Rating Options

*Aggregation Method:* Dominant Condition

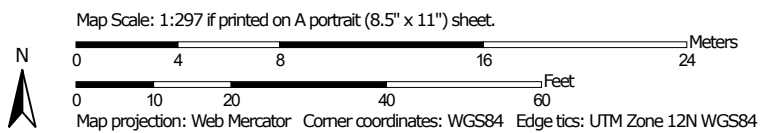
*Component Percent Cutoff:* None Specified

*Tie-break Rule:* Higher

# Hydrologic Soil Group—Rio Blanco County Area, Colorado (South)




Soil Map may not be valid at this scale.



# Hydrologic Soil Group—Rio Blanco County Area, Colorado (South)

## MAP LEGEND

### Area of Interest (AOI)









 Area of Interest (AOI)

### Soils

#### Soil Rating Polygons





 A  
 A/D  
 B  
 B/D  
 C  
 C/D  
 D  
 Not rated or not available

#### Soil Rating Lines


 A  
 A/D  
 B  
 B/D  
 C  
 C/D  
 D  
 Not rated or not available

#### Soil Rating Points






 A  
 A/D  
 B  
 B/D

 C  
 C/D  
 D  
 Not rated or not available


### Water Features

 Streams and Canals

### Transportation

 Rails  
 Interstate Highways  
 US Routes  
 Major Roads  
 Local Roads

### Background

 Aerial Photography

## MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service  
 Web Soil Survey URL:  
 Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

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Soil Survey Area: Rio Blanco County Area, Colorado  
 Survey Area Data: Version 17, Sep 6, 2022

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jun 24, 2020—Jul 8, 2020

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.



## Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
73	Rentsac channery loam, 5 to 50 percent slopes	D	0.1	100.0%
<b>Totals for Area of Interest</b>			<b>0.1</b>	<b>100.0%</b>

## Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

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Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

## Rating Options

*Aggregation Method:* Dominant Condition

*Component Percent Cutoff:* None Specified



*Tie-break Rule:* Higher

\*\*\*\*\*

Project Description - 2 Yr SCS Type II 24-Hour Storm Distribution (1.13 inches)

\*\*\*\*\*

File Name ..... 2 YEAR.SPF

\*\*\*\*\*

Analysis Options

\*\*\*\*\*

Flow Units ..... cfs

Subbasin Hydrograph Method. SCS TR-55

Time of Concentration..... SCS TR-55

Link Routing Method ..... Kinematic Wave

Storage Node Exfiltration.. Constant rate, free surface area

Starting Date ..... OCT-19-2022 00:00:00

Ending Date ..... OCT-20-2022 00:00:00

Report Time Step ..... 00:05:00

\*\*\*\*\*

Element Count

\*\*\*\*\*

Number of rain gages ..... 1

Number of subbasins ..... 3

Number of nodes ..... 6

Number of links ..... 3

\*\*\*\*\*

Raingage Summary

\*\*\*\*\*

Gage	Data	Data	Recording
ID	Source	Type	Interval
			min

Rain Gage-01	2 YEAR 24 HR	INTENSITY	6.00
--------------	--------------	-----------	------

\*\*\*\*\*

Subbasin Summary

\*\*\*\*\*

Subbasin	Total	Peak Rate
ID	Area	Factor
	ft <sup>2</sup>	

NORTHEAST	18088.57	484.00
-----------	----------	--------

NORTHWEST	16008.46	484.00
-----------	----------	--------

SOUTHBASIN	3895.86	484.00
------------	---------	--------

\*\*\*\*\*

Node Summary

\*\*\*\*\*

Node ID	Element Type	Invert Elevation ft	Maximum Elev. ft	Ponded Area ft <sup>2</sup>	External Inflow
-----					
Out-01	OUTFALL	0.00	0.00	0.00	
Out-02	OUTFALL	0.00	0.00	0.00	
Out-03	OUTFALL	0.00	0.00	0.00	
NORTHEASTPOND	STORAGE	0.00	6.00	0.00	
NORTHWESTPOND	STORAGE	0.00	6.00	0.00	
SOUTHPOND	STORAGE	0.00	6.00	0.00	

\*\*\*\*\*

Link Summary

\*\*\*\*\*

Link ID	From Node	To Node	Element Type	Length ft	Slope %	Manning's Roughness
-----						
Link-01	NORTHWESTPOND	Out-01	DIRECT	212.4	0.0005	0.0150
Link-02	NORTHEASTPOND	Out-02	DIRECT	148.6	0.0007	0.0150
Link-03	SOUTHPOND	Out-03	DIRECT	221.4	0.0005	0.0150

\*\*\*\*\*

Cross Section Summary

\*\*\*\*\*

Link ID	Shape	Depth/ Diameter ft	Width ft	No. of Barrels	Cross Sectional Area ft <sup>2</sup>	Full Flow Hydraulic Radius ft	Design Flow Capacity cfs
-----							
Link-01	DUMMY	0.00	0.00	1	0.00	0.00	0.00
Link-02	DUMMY	0.00	0.00	1	0.00	0.00	0.00
Link-03	DUMMY	0.00	0.00	1	0.00	0.00	0.00

\*\*\*\*\*

Runoff Quantity Continuity

\*\*\*\*\*

	Volume acre-ft	Depth inches
-----		
Total Precipitation .....	0.083	1.144
Surface Runoff .....	0.003	0.044
Continuity Error (%) .....	-0.000	

***** Flow Routing Continuity *****	Volume acre-ft -----	Volume Mgallons -----
External Inflow .....	0.000	0.000
External Outflow .....	0.000	0.000
Initial Stored Volume ....	0.000	0.000
Final Stored Volume .....	0.032	0.010
Continuity Error (%) .....	0.000	

\*\*\*\*\*  
Composite Curve Number Computations Report  
\*\*\*\*\*

-----  
Subbasin NORTHEAST  
-----

Soil/Surface Description	Area (ft <sup>2</sup> )	Soil Group	CN
-----	-----	-----	-----
Gravel roads	18088.57	D	91.00
Composite Area & Weighted CN	18088.57		91.00

-----  
Subbasin NORTHWEST  
-----

Soil/Surface Description	Area (ft <sup>2</sup> )	Soil Group	CN
-----	-----	-----	-----
Gravel roads	16008.45	D	91.00
Composite Area & Weighted CN	16008.45		91.00

-----  
Subbasin SOUTHBASIN  
-----

Soil/Surface Description	Area (ft <sup>2</sup> )	Soil Group	CN
-----	-----	-----	-----
Gravel roads	3895.86	D	91.00
Composite Area & Weighted CN	3895.86		91.00

\*\*\*\*\*  
SCS TR-55 Time of Concentration Computations Report  
\*\*\*\*\*

Sheet Flow Equation

-----

$$T_c = (0.007 * ((n * L_f)^{0.8})) / ((P^{0.5}) * (S_f^{0.4}))$$

Where:

$T_c$  = Time of Concentration (hrs)

$n$  = Manning's Roughness

$L_f$  = Flow Length (ft)

$P$  = 2 yr, 24 hr Rainfall (inches)

$S_f$  = Slope (ft/ft)

Shallow Concentrated Flow Equation

-----

$$V = 16.1345 * (S_f^{0.5}) \text{ (unpaved surface)}$$

$$V = 20.3282 * (S_f^{0.5}) \text{ (paved surface)}$$

$$V = 15.0 * (S_f^{0.5}) \text{ (grassed waterway surface)}$$

$$V = 10.0 * (S_f^{0.5}) \text{ (nearly bare \& untilled surface)}$$

$$V = 9.0 * (S_f^{0.5}) \text{ (cultivated straight rows surface)}$$

$$V = 7.0 * (S_f^{0.5}) \text{ (short grass pasture surface)}$$

$$V = 5.0 * (S_f^{0.5}) \text{ (woodland surface)}$$

$$V = 2.5 * (S_f^{0.5}) \text{ (forest w/heavy litter surface)}$$

$$T_c = (L_f / V) / (3600 \text{ sec/hr})$$

Where:

$T_c$  = Time of Concentration (hrs)

$L_f$  = Flow Length (ft)

$V$  = Velocity (ft/sec)

$S_f$  = Slope (ft/ft)

Channel Flow Equation

-----

$$V = (1.49 * (R^{2/3}) * (S_f^{0.5})) / n$$

$$R = A_q / W_p$$

$$T_c = (L_f / V) / (3600 \text{ sec/hr})$$

Where:

$T_c$  = Time of Concentration (hrs)

$L_f$  = Flow Length (ft)

$R$  = Hydraulic Radius (ft)

$A_q$  = Flow Area (ft<sup>2</sup>)

$W_p$  = Wetted Perimeter (ft)

$V$  = Velocity (ft/sec)

$S_f$  = Slope (ft/ft)

$n$  = Manning's Roughness

-----  
Subbasin NORTHEAST  
-----

Sheet Flow Computations  
-----

	Subarea A	Subarea B	Subarea C
Manning's Roughness:	0.01	0.00	0.00
Flow Length (ft):	10.00	0.00	0.00
Slope (%):	9.40	0.00	0.00
2 yr, 24 hr Rainfall (in):	1.13	0.00	0.00
Velocity (ft/sec):	0.75	0.00	0.00
Computed Flow Time (minutes):	0.22	0.00	0.00

Shallow Concentrated Flow Computations  
-----

	Subarea A	Subarea B	Subarea C
Flow Length (ft):	432.00	0.00	0.00
Slope (%):	9.40	0.00	0.00
Surface Type:	Unpaved	Unpaved	Unpaved
Velocity (ft/sec):	4.95	0.00	0.00
Computed Flow Time (minutes):	1.45	0.00	0.00

=====  
Total TOC (minutes): 1.68  
=====

-----  
Subbasin NORTHWEST  
-----

Sheet Flow Computations  
-----

	Subarea A	Subarea B	Subarea C
Manning's Roughness:	0.01	0.00	0.00
Flow Length (ft):	10.00	0.00	0.00
Slope (%):	20.00	0.00	0.00
2 yr, 24 hr Rainfall (in):	1.13	0.00	0.00
Velocity (ft/sec):	1.01	0.00	0.00
Computed Flow Time (minutes):	0.16	0.00	0.00

Shallow Concentrated Flow Computations  
-----

	Subarea A	Subarea B	Subarea C
Flow Length (ft):	240.00	0.00	0.00
Slope (%):	20.00	0.00	0.00
Surface Type:	Unpaved	Unpaved	Unpaved
Velocity (ft/sec):	7.22	0.00	0.00
Computed Flow Time (minutes):	0.55	0.00	0.00

=====  
Total TOC (minutes): 0.72  
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Subbasin SOUTHBASIN  
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Sheet Flow Computations  
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	Subarea A	Subarea B	Subarea C
Manning's Roughness:	0.01	0.00	0.00
Flow Length (ft):	10.00	0.00	0.00
Slope (%):	20.00	0.00	0.00
2 yr, 24 hr Rainfall (in):	1.13	0.00	0.00
Velocity (ft/sec):	1.01	0.00	0.00
Computed Flow Time (minutes):	0.16	0.00	0.00

Shallow Concentrated Flow Computations  
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	Subarea A	Subarea B	Subarea C
Flow Length (ft):	107.00	0.00	0.00
Slope (%):	20.00	0.00	0.00
Surface Type:	Unpaved	Unpaved	Unpaved
Velocity (ft/sec):	7.22	0.00	0.00
Computed Flow Time (minutes):	0.25	0.00	0.00

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Total TOC (minutes): 0.41  
=====

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Subbasin Runoff Summary  
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Subbasin ID	Total Precip in	Total Runoff in	Peak Runoff cfs	Weighted Curve Number	Time of Concentration days hh:mm:ss
NORTHEAST	1.13	0.45	0.26	91.000	0 00:10:00
NORTHWEST	1.13	0.45	0.23	91.000	0 00:10:00
SOUTHBASIN	1.13	0.41	0.06	91.000	0 00:10:00

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Node Depth Summary  
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Node ID	Average Depth Attained ft	Maximum Depth Attained ft	Maximum HGL Attained ft	Time of Max Occurrence		Total Flooded Volume acre-in	Total Time Flooded minutes	Retention Time hh:mm:ss
				days	hh:mm			
Out-01	0.00	0.00	0.00	0	00:00	0	0	0:00:00
Out-02	0.00	0.00	0.00	0	00:00	0	0	0:00:00
Out-03	0.00	0.00	0.00	0	00:00	0	0	0:00:00
NORTHEASTPOND	0.03	0.07	0.07	1	00:00	0	0	0:00:00
NORTHWESTPOND	0.02	0.06	0.06	1	00:00	0	0	0:00:00
SOUTHPOND	0.01	0.01	0.01	0	20:16	0	0	0:00:00

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Node Flow Summary  
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Node ID	Element Type	Maximum Lateral Inflow cfs	Peak Inflow cfs	Time of Peak Inflow Occurrence		Maximum Flooding Overflow cfs	Time of Peak Flooding Occurrence	
				days	hh:mm		days	hh:mm
Out-01	OUTFALL	0.00	0.00	0	00:00	0.00		
Out-02	OUTFALL	0.00	0.00	0	00:00	0.00		
Out-03	OUTFALL	0.00	0.00	0	00:00	0.00		
NORTHEASTPOND	STORAGE	0.26	0.26	0	12:05	0.00		
NORTHWESTPOND	STORAGE	0.23	0.23	0	12:05	0.00		
SOUTHPOND	STORAGE	0.06	0.06	0	12:05	0.00		

\*\*\*\*\*  
Storage Node Summary  
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Storage Node ID	Maximum Ponded Volume 1000 ft <sup>3</sup>	Maximum Ponded Volume (%)	Time of Max Ponded Volume		Average Ponded Volume 1000 ft <sup>3</sup>	Average Ponded Volume (%)	Maximum Storage Node Outflow cfs	Maximum Exfiltration Rate cfm	Time of Max. Exfiltration Rate hh:mm:ss	Total Exfiltrated Volume 1000 ft <sup>3</sup>
			days	hh:mm						
NORTHEASTPOND	0.675	0	1	00:00	0.277	0	0.00	0.00	0:00:00	0.000
NORTHWESTPOND	0.598	0	1	00:00	0.244	0	0.00	0.00	0:00:00	0.000
SOUTHPOND	0.131	0	0	20:00	0.058	0	0.00	0.00	0:00:00	0.000



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Outfall Loading Summary

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Outfall Node ID	Flow Frequency (%)	Average Flow cfs	Peak Inflow cfs
Out-01	0.00	0.00	0.00
Out-02	0.00	0.00	0.00
Out-03	0.00	0.00	0.00
System	0.00	0.00	0.00

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Link Flow Summary

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Link ID	Element Type	Time of Peak Flow Occurrence days hh:mm	Maximum Velocity Attained ft/sec	Length Factor	Peak Flow during Analysis cfs	Design Flow Capacity cfs	Ratio of Maximum /Design Flow	Ratio of Maximum Flow Depth	Total Time Surcharged minutes	Reported Condition
Link-01	DIRECT	0 00:00			0.00					
Link-02	DIRECT	0 00:00			0.00					
Link-03	DIRECT	0 00:00			0.00					

## Wattles (W)



### Description

A wattle (also called a fiber roll) consists of straw, or other similar materials bound into a tight tubular roll. Excelsior log (aspen fiber) is the preferred wattle. When wattles are placed at the toe and on the face of slopes, they intercept runoff, reduce its flow velocity, release the runoff as sheet flow, and provide removal of sediment from the runoff. By interrupting the length of a slope, fiber rolls can also reduce erosion.

### Applicability

Wattles may be suitable:

- As slope breakers along the toe, top, face, and at grade breaks of exposed and erodible slopes to shorten slope length, reduce runoff velocity, and spread runoff as sheet flow
- At the end of a downward slope where it transitions to a steeper slope
- Along the perimeter of a project in an undisturbed area
- At the overflow locations of sediment traps
- As check dams in unlined ditches
- Around temporary stockpiles

### Limitations

- When used in disturbed areas, wattles are not effective unless trenched.
- Difficult to move once saturated.

- If not properly staked and trenched in, wattles could be transported by high flows.
- Wattles have a very limited sediment capture zone.
- Wattles should not be used on slopes subject to creep, slumping, or landslide.
- Wattles should not be used where periodic road or surface maintenance activities are expected.

## **Construction specifications**

The Caerus Environmental Coordinator or Construction Coordinator should be contacted prior to installation. The performance-oriented specification for wattles is that sediment is not observed on the down gradient side of the wattle row. If sediment is observed on the down gradient side of the wattle, the wattle should be maintained or re-installed.

In areas prone to cattle grazing, utilizing an Excelsior wattle is recommended. See Figure W-1 for wattles used to control erosion along slopes.

1. Locate wattles on level contours spaced as follows:
  - a. Slope inclination of 4:1 or flatter: Fiber rolls should be placed at a maximum interval of 20 ft.
  - b. Slope inclination between 4:1 and 2:1: Fiber Rolls should be placed at a maximum interval of 15 ft. (a closer spacing is more effective).
  - c. Slope inclination 2:1 or greater: Fiber Rolls should be placed at a maximum interval of 10 ft. (a closer spacing is more effective).
2. Turn the ends of the wattles up slope to prevent runoff from going around the roll.
3. If wattles are used in a disturbed area, stake wattles into a 2 to 4 in. deep trench with a width equal to the diameter of the wattle. Cast soil material upgradient of the wattles. Drive stake at the end of each wattle and spaced 4 ft maximum on center.

If wattles are part of a layered Control Measure system (3 or more) or if a vegetated buffer (see Vegetated Buffer (VB)Control Measure) is used and the wattle is placed on undisturbed earth, the wattles may be installed without trenching.

## **Maintenance Specifications:**

- Buildup of debris; or
- Sedimentation occurring over more than  $\frac{1}{2}$  the height of the wattle; or
- Occurrence of scouring

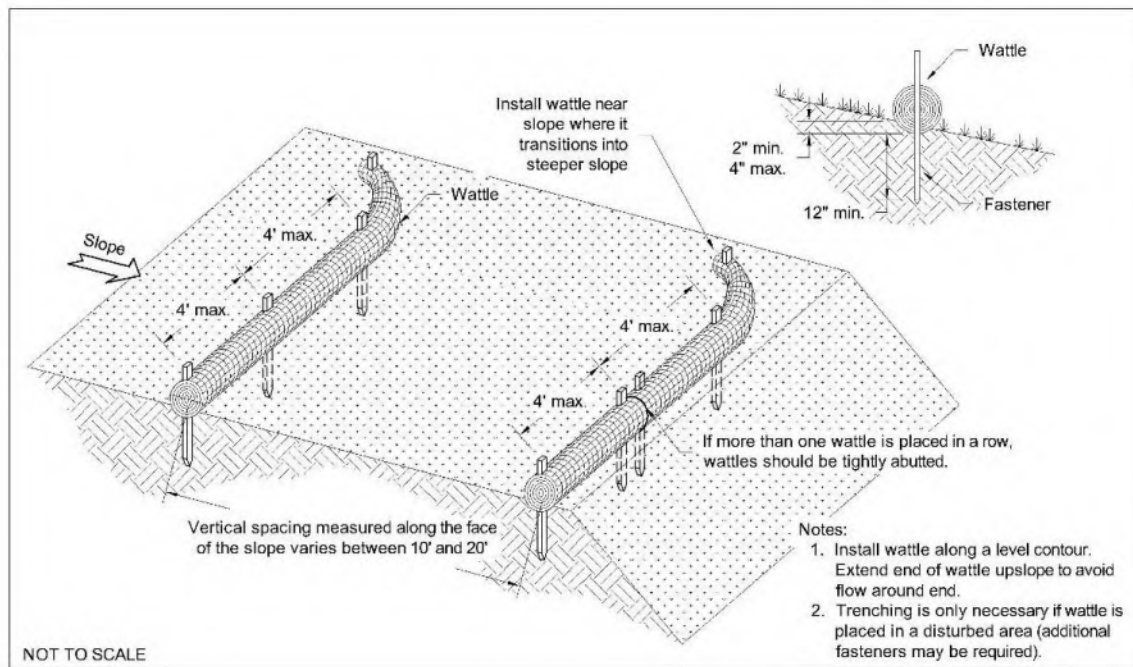
## **Corrective Action Specifications:**

- Sedimentation occurring over more than  $\frac{2}{3}$  of the berm material; or
- Need for continuation or additional wattles above or below pre-installed wattle; or
- Improper installation

## Removal/Abandonment

Wattles are typically left to rot in place. However, if wattles are removed, collect and dispose of sediment accumulation, and fill and compact holes, trenches, depressions or any other ground disturbance to blend with adjacent ground.

**Figure W-1**  
**Wattle Installation**



## References

California Stormwater Quality Association, Stormwater Best Management Practice (BMP) Handbook – Construction. January 2003. <<http://www.cabmphandbooks.com/Construction.asp>>