# PERMANENT EROSION AND SEDIMENT CONTROL DESIGN GUIDELINES

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# APPENDICES

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# LIST OF ACRONYMS

| | |
|---|---|
| AGR | Alignment and Grade Review |
| BMP | Best Management Practice |
| BOD | Biochemical Oxygen Demand |
| CalTrans | California Department of Transportation |
| CWB | Constructed Wetland Basin |
| DNRC | Department of Natural Resources and Conservation |
| REC | Rolled Erosion Control |
| EPM | Engineering Project Manager |
| HDPE | High Density Polyethylene |
| LID | Low Impact Development |
| MDEQ | Montana Department of Environmental Quality |
| MDT | Montana Department of Transportation |
| MS4 | Municipal Separate Storm Sewer System |
| NRCS | Natural Resources Conservation Service |
| PESC | Permanent Erosion and Sediment Control |
| PFR | Preliminary Field Review |
| PIH | Plan-in-Hand |
| SWMP | Storm Water Management Program |
| TMDL | Total Maximum Daily Load |
| TRM | Turf Reinforcement Mats |
| USBR | US Bureau of Reclamation |
| USDA | US Department of Agriculture |
| WQV | Water Quality Volume |

# SECTION 1.0: INTRODUCTION

The purpose of these Permanent Erosion and Sediment Control Design Guidelines is to describe procedures and methods to address the following:

1. Long-term erosion that could potentially result from highway construction.

2. Sedimentation resulting from highway-related storm water runoff.

These guidelines include procedures for evaluating the need for permanent erosion and sediment control (PESC) measures during the project development process and determining which PESC measures can practicably be incorporated into the design. The guidelines also provide design details that address specific erosion and sediment control issues and discussions of construction issues and maintenance considerations.

The primary objective of this guidance document is to provide adequate information for the selection of the appropriate PESC measures to be included in the plans package. Those PESC measures would be intended to reduce soil erosion and sediment deposition into adjacent waterways and to protect the highway facility. It is anticipated that including PESC measures in the plans will clarify the Montana Department of Transportation's (MDT's) expectations of contractors, reduce maintenance needs, improve control efficiency, facilitate efficient permitting and reduce long-term control costs.

Inclusion of PESC measures into project plans should be evaluated on a project-by-project, site-specific basis. Inclusion of PESC measures into the project plans should be coupled with proactive management of basic design considerations such as limiting the area exposed to construction, maximizing use of existing and proposed vegetative cover, minimizing sliver cuts and fills, weighing appropriateness of flat-bottomed ditches as opposed to v-ditches, and using natural topographic features to the best advantage. Proactive steps could reduce the need for PESC design measures.

Erosion is uncontrolled soil movement caused by wind or water action. The byproduct of erosion, sediment, is soil particles being transported away from their natural location by wind and water action. Erosion control measures are used to stabilize disturbed or highly erosive soils. Sediment control measures are used to trap and contain, and potentially treat, sediment caused by the erosion process.

# SECTION 2.0: EVALUATION AND DESIGN PROCESS

## 2.1 General

Incorporation of PESC measures should be considered with projects disturbing 1 acre or more, or projects having the potential to adversely affect water quality. Incorporation of PESC measures will typically be limited to projects with scopes related to rehabilitation or reconstruction and locations in proximity to sensitive resources such as impaired waterways or high quality aquatic habitat and spawning areas. PESC measures can also provide solutions for areas with a history of erosion or sedimentation problems. The PESC evaluation process will begin at the Preliminary Field Review (PFR), continue through coordination with resource agencies in permitting actions, and should be completed at the Plan-in-Hand (PIH) Review.

Site-specific factors must be taken into consideration early in the design and evaluation process. As a result, site-specific information should be gathered as early as possible in the design process.

Appendix A of this manual includes detailed information on each PESC method as well as a decision matrix to aid in the selection of appropriate measures. Appendix B of this manual provides sample plan sheets displaying how PESC measures should be shown in the plans.

## 2.2 Preliminary Field Review

For rehabilitation and reconstruction projects, the following location information can be obtained at, or prior to, the PFR:

A. General
- Soil characteristics,
- Vegetative cover,
- Topography near roadway, and
- Climate and typical weather conditions.

B. Sediment Control
- Locations of any waterways near the project,
- Presence of impaired waterways adjacent to the project. (An impaired waterway is a waterway that does not meet water quality standards for one or more reasons. See http://www.cwaic.mt.gov/ to determine if an impaired waterway exists on or near the project.)
- Stream and river crossings, and
- Areas of heavy sanding.

C. Permanent Erosion Control – the following areas should be identified on the as-built plans and/or reviewed in the field:
- Cut-to-fill transitions,
- Cut slopes,
- Fill slopes steeper than 3:1,
- Ditches with long grades in cut (>1500 ft or 460 m),
- Steep embankment slopes behind guardrail,
- Bridge ends,
- Intercepting drainages in back slope,
- Existing culverts, and
- Evidence of existing erosion.

D. When possible the following information associated with erosion and sediment control should also be discussed at the PFR:
- What potential control measures can be used?
- Will additional soils or geotechnical information be needed?
- Will an additional, or more detailed, field survey be required? (This information is most critical for rehabilitation projects where the amount of field survey is typically limited.)
- Will right-of-way or construction permits be necessary?
- What type of regulatory requirements will apply?

A discussion of the above information should be included in the PFR report. The Road Designer will coordinate with the District Hydraulics Engineer and the Reclamation Specialist within the Environmental Services Bureau to determine the appropriate treatment for various types of erosion.

## 2.3 Alignment and Grade Review

When a project involves modifications to the roadway alignment, the majority of the site-specific information discussed in Section 2.2 may not be available until the Alignment and Grade Review (AGR) stage of design. Additionally, for projects with or without modifications to the alignment, considerably more information is available at the AGR than the PFR. That additional information, especially cross-sections and major drainage structures, will allow more detailed identification and evaluation of sites that would benefit from PESC measures and sites where design could be optimized for issues such as elimination of sliver cuts and fills. Document in the AGR report all efforts to minimize: soil erosion, the amount of soil exposed during construction activity, disturbance of steep slopes, and soil compaction.

At the AGR stage of development, sufficient information is provided to make preliminary recommendations of site-specific measures. Maintenance access to the PESC measures can also be assessed at this time. If an on-site review will not be held for the project, designers should request that Environmental Services Bureau personnel review the project to determine the appropriateness or need for sediment and/or erosion control measures.

## 2.4 Plan-in-Hand

A complete set of plans that includes the various PESC measures should be distributed for the PIH review. Since all of the information concerning PESC measures should be available and the plans package should be essentially complete at this stage of project development, the most in-depth review should occur at this time. The following information contained in the PIH plans should be evaluated and reviewed in the field:

A. **Assess Locations of PESC Measures.** Are the appropriate PESC measures shown at the correct locations? The reviewer should compare what is shown in the plans to the recommendations that were previously provided to the designer and evaluate whether additional PESC measures are needed. This task will involve a review of the plan and profile sheets, cross-sections and summaries.

B. **Assess Constructability.** Can the PESC measures be constructed within the normal contractor operation? The reviewer should evaluate whether the sequence of work for the construction of the PESC measures will have to be specified or if specialized equipment will be needed.

C. **Special Provisions.** Do the special provisions adequately describe the work, materials, equipment, and process required to construct the PESC measures?

D. **Accessibility.** Is adequate access provided to the PESC measures that will require long-term maintenance? PESC measures should be designed and constructed to allow maintenance personnel to access these measures for long-term maintenance activities. Maintenance personnel will likely use heavy equipment such as skid steers, backhoes, and loaders to perform ongoing maintenance activities of these PESC measures, particularly sediment control measures. It is essential that these PESC measures are accessible.

E. **Minor Drainage.** The plans should be reviewed for the elimination of drainage culverts and the concentration of flows to new locations. The existing drainage patterns should be maintained by replacing culverts as close as possible to the existing culverts or at least within the same drainage basin. In cases where the existing culverts cannot be replaced, the design should include provisions to handle the increased flows downstream at the roadway and approach crossings and to properly reduce the energy and erosion potential at the outlet. Additionally, adequate PESC measures should be shown on the plans at cut-to-fill transitions, where drainages intercept back slopes, on long ditch grades, and along guardrail sections. (See Section A11.0: Maintenance of Existing Drainage for additional information.)

G. **Avoidance.** Avoidance of ground disturbance should be considered throughout all phases of the design process. Preservation of ground in a stable, vegetated condition lessens the amount of ground exposed to erosional forces. Protection of ground on the perimeter of the project area reduces run-on from adjacent lands and surface flow through unprotected soils.

Avoidance has additional benefits in reducing right-of-way needs, utility relocations, clearing/grubbing costs, reclamation costs and long-term noxious weed control.

Simple measures such as eliminating sliver cuts and fills, limiting backslope grading to 3:1 or flatter slopes, constructing V-ditches to reduce sliver cuts and establishing strict construction limits, all provide immediate and long-term benefits.

H. **Slope Rounding.** Slope rounding (not to be confused with contour grading) is a grading technique at the tops and sides of cuts and transitions to facilitate plant establishment and minimize soil erosion. Rounding of cut slopes also is an important element in achieving operational, environmental and visual functions. While engineered slopes define grades to meet engineering requirements, slope rounding should be designed so that the constructed slope blends smoothly into the surrounding landscape. Use on cut slopes and transitions prior to the application of temporary soil stabilization or permanent seeding. Some limitations can include potential increase in design and construction costs, and increased right-of-way requirements.

## 2.5 Final Plan Review

The final plan review is an opportunity to review the completed plans. This review should be a relatively minor activity unless substantial changes were made to the PESC measures at the PIH. Coordinate with the Environmental Services Bureau to ensure permit conditions are incorporated appropriately into the plans.

# SECTION 3.0: CONSTRUCTION

An appropriately developed and detailed plan will help the contractor understand MDT's expectations in regard to the work required and will assist the Engineering Project Manager in assuring that erosion and sediment control is adequately provided.

The complexity of the plans and the types, locations and quantities of various erosion and sediment control measures will be dependent upon the scale and scope of the project and the natural and man-made resources requiring protection.

The special provisions, plan sheets, and/or appropriate tables must contain adequate details for construction and inspection of the PESC measure, and should include any or all of the following:

- Specific locations, sizes and lengths of each required erosion and sediment control measure;
- Material, dimensional, and installation details for erosion and sediment control practices and facilities;
- Timing or scheduling necessary for appropriate installation, especially when a measure is intended for both temporary control during construction and permanent control following construction;
- Site preparation requirements, such as grading, compaction, or subgrade needs; and
- Details of alternatives for sites where alternative measures are considered practical.

Items or requirements specific to a given PESC measure will be included in the contract documents for the identified measure. See Appendix B of this manual for the minimum amount of detail that should be shown in the plans for each PESC measure.

# SECTION 4.0: MAINTENANCE

The long-term costs of operating and maintaining a PESC measure will depend on a number of factors such as frequency and duration of maintenance, equipment/materials utilized, regulatory requirements, and off-site disposal costs. The designer should evaluate these long-term costs before selecting a specific PESC measure. Regular maintenance of PESC measures is necessary to keep them functioning properly. If PESC measures are not maintained on a regular basis, they may become sources of pollutants. For example, the failure of a detention basin during a large rainfall event could discharge a measurable amount of sediment downstream. Therefore, it is important to develop and implement a schedule for monitoring and maintaining these PESC measures.

Maintenance activities may include cleaning, repairing, and replacing PESC measures, installing rolled erosion control products, reseeding areas with poor vegetative cover, and controlling noxious weeds. Maintenance frequency will be related to the type of PESC measure and site-specific conditions such as soil type, highway grade, cut/fill slopes, storm intensity/duration and traction sand application rates. MDT Maintenance personnel will be responsible for conducting the majority of the maintenance for these measures after the construction project passes final acceptance.

A detailed description of each PESC measure and, if available, associated maintenance activities, frequency, and cost are included in Appendix A.

# SECTION 5.0: REGULATORY CONSIDERATIONS

## 5.1 Municipal Separate Storm Sewer System (MS4)

The process of evaluating projects for PESC measures as discussed in this manual can help MDT meet some of the requirements of the Montana Department of Environmental Quality’s Small Municipal Separate Storm Sewer System (MS4) program. The MS4 program regulates the discharge of pollutants in stormwater originating from some of MDT’s roadways and facilities.

Discharges of pollutants in stormwater off some of MDT’s roadways and facilities are subject to the requirements of the MS4 program. The MS4 program requirements apply in urban areas within the state of Montana that have storm sewer systems that serve a population of at least 10,000 people. Areas currently required to have an MS4 permit are Billings, Missoula, Great Falls, Butte, Helena, Kalispell, and Bozeman. Cities, counties, universities, military bases, and MDT are some of the entities required to obtain permits within these areas. The MS4 program is administered by the Montana Department of Environmental Quality (MDEQ).

Each permit holder must develop, implement, and enforce a Storm Water Management Program (SWMP). The SWMP must address six “minimum control measures,” one of which is post-construction storm water management in new development and redevelopment projects. The PESC process is a designated element of the SWMP. As a result, coordination and documentation efforts are necessary for MS4 program compliance. If there are questions about the permit or to make sure the latest permit is being considered, contact the Environmental Services Bureau.

Specific MS4 program requirements can vary with each permit cycle. Generally speaking, the permit will require incorporation of practicable low impact development (LID) practices with certain projects. The Environmental Services Bureau’s District Project Development Engineer, with assistance from other MDT staff as necessary, will determine if implementation of LID is “practicable” (as defined in 40 CFR 230.3(q)). Designers working in one of the seven urban areas listed above will need to coordinate with the Environmental Services Bureau’s District Project Development Engineer to determine the appropriate steps to ensure the proposed design features comply with MDT’s MS4 program requirements and that compliance efforts are documented appropriately.

## 5.2 Total Maximum Daily Load (TMDL)

Section 305(b) of the federal Clean Water Act (and related regulations) requires states to assess the condition of their waters to determine where water quality is impaired (does not fully meet standards) or threatened (is likely to violate standards in the near future). Section 303(d) requires states to develop plans, called Total Maximum Daily Loads (TMDLs), to achieve compliance with the water quality standards for impaired waterbodies. The result of this review are the **305(b)** and **303(d) Lists**, which must be submitted to the U.S. Environmental Protection Agency (EPA) every two years. Section 303(d) also requires states to prioritize and target water bodies on their list for development of water quality improvement strategies for impaired and threatened waters.

MDEQ is required to develop TMDLs for all water bodies on the 303(d) list. A TMDL is the total amount of a pollutant that a water body may receive from all sources without exceeding water quality standards. A TMDL can also be defined as a reduction in pollutant loading that results in meeting water quality standards.

Appropriate PESC measures should be considered in the early development stages of projects adjacent to listed impaired streams. MDEQ maintains the list of impaired waterways. As of the date of printing, a list of impaired waterways for Montana was available at the following website: http://www.cwaic.mt.gov/

## 5.3 Section 404 Clean Water Act Permit

Section 404 of the federal Clean Water Act requires permits for the discharge of dredge or fill material into Waters of the United States. If activities are proposed that require a Section 404 Permit, specific conditions related to the type of erosion control material allowed in or adjacent to Waters of the U.S. may apply. Environmental Services should be consulted to determine if there are any prohibitions on the type of PESC measure proposed.

# APPENDIX A: PERMANENT EROSION AND SEDIMENT CONTROL MEASURES

This appendix provides design information for permanent erosion and sediment control (PESC) measures. The following information is included in each detail and should be evaluated to select appropriate measures for the given situation.

1. Definition and Purpose
2. Appropriate Applications
3. Limitations
4. Design Considerations
5. Materials
6. Construction Considerations
7. Operation and Maintenance
8. Initial Cost and Cost per Year
9. Method of Payment

The decision matrix on the following pages is provided to assist in the selection of appropriate measures.

| Title of Measure | | Revision No. | Revision Date |
|---|---|---|---|
| **Erosion Control BMPs** | | | |
| A1.0 | Ditch Blocks | 2 | January 2018 |
| A2.0 | Check Dams | 2 | January 2018 |
| A3.0 | Lined Ditches | 2 | January 2018 |
| A4.0 | Interceptor Ditches | 2 | January 2018 |
| A5.0 | Channelizing Curb | 2 | January 2018 |
| A6.0 | Embankment Protectors | 2 | January 2018 |
| A7.0 | Drainage Chutes | 2 | January 2018 |
| A8.0 | Outlet Protection/Velocity Dissipation Devices | 2 | January 2018 |
| A9.0 | Slope Soil Stabilization | 2 | January 2018 |
| A10.0 | Streambank Stabilization | 2 | January 2018 |
| A11.0 | Maintenance of Existing Drainage | 1 | January 2018 |
| **Sediment Control BMPs** | | | |
| A12.0 | Detention Basins | 2 | January 2018 |
| A13.0 | Retention Basins | 2 | January 2018 |

## Guidelines for Minor Drainage and Erosion Control

| Roadway Feature | Application | Reference | Comments |
|---|---|---|---|
| Cut-to-Fill Transitions | Embankment Protector | Section A6.0 | |
| | Drainage Chute | Section A7.0 | |
| Intercepting Drainages in Back Slope | Embankment Protector | Section A6.0 | |
| | Drainage Chute | Section A7.0 | |
| | Interceptor Ditch | Section A4.0 | |
| Steep Fill or Cut Slopes | Slope Soil Stabilization | Section A9.0 | |
| Steep Embankment Slopes Behind Guardrail | Slope Soil Stabilization | Section A9.0 | |
| | Embankment Protector or Drainage Chute w/Channelizing Curb | Sections A6.0, A7.0, and A5.0. | |
| | Leave Curbing in Place When Replacing Guardrail | | Plan-in-Hand team to evaluate if curbing should be removed. |
| Long or Steep Ditch Grades | Check Dams | Section A2.0 | |
| | Lined Ditch | Section A3.0 | |
| | Ditch Block and Culvert to Divert Flows | Section A1.0 | Use to maintain existing drainage patterns. |
| Elimination of Existing Culverts | Maintain Existing Drainage | Section A11.0 | |
| High Velocities at Culvert Outlets | Outlet Protection and Velocity Dissipation Devices | Section A8.0 | |
| Direct Discharge to TMDL Streams [303(d)] | Vegetated Buffer | MDT BMP Manual | |
| | Preserve Existing Vegetation | | |
| | Retention Basins | Section A13.0 | |
| | | | |
| | Detention Basin | Section A12.0 | |
| Erosion Along Stream Banks near Bridge Crossings or Roadway Embankments | Stream Bank Stabilization | Section A10.0 | Type of measure is often function of permit conditions. |
| | Riprap Bank Protection | Det. Dwg. 613-16 | |
| Bridge Ends | Divert Flows Before the Bridge End | | Diverted flows should flow through a vegetation strip before entering a stream. |
| | Embankment Protector or Drainage Chute w/Channelizing Curb | Sections A6.0, A7.0, and A5.0. | Provide outlet protection and vegetation strip before flows enter a stream. |
| | Detention Basin | Section A12.0 | |

| Roadway Feature | Application | Reference | Comments |
|---|---|---|---|
| Sanding Material Collection on Mountain Passes | Ditch Blocks / Gravel Check Dams | Sections A1.0 and A2.0 | |
| | Channelizing Curbs | Section A5.0 | |
| | Detention Basins | Section A12.0 | |
| | Vegetated Buffer | MDT BMP Manual | |
| Large Paved Parking Areas at Rest Stops or Weigh Stations | Detention Basin | Section A12.0 | |
| | Retention Basin | Section A13.0 | |
| | | | |

# A1.0: DITCH BLOCKS

## A1.1 Definition and Purpose

A ditch block is a barrier placed across a natural or man-made channel or drainage ditch to divert flows into a cross drain.

## A1.2 Appropriate Applications

Ditch blocks are typically installed in the following locations:

- In roadside ditches in cut sections to divert water from the ditch to a cross drain that accesses a natural drainage.
- In roadside ditches in cut sections to divert water from the ditch to a cross drain that discharges to the roadside ditch on the other side of the roadway. When used in this case the ditch block essentially acts as a check structure to reduce the volume and velocity of flow in the ditch.
- Near a cross drain in a natural drainage to ensure that the flow does not overtop the drainage divide.

## A1.3 Limitations

Severe erosion may result when a ditch block fails by overtopping, typically due to a lack of established vegetation.

## A1.4 Design Guidelines and Considerations

- Ditch blocks should have sufficient height to divert all of the designed flow to the cross drain. The height should be a minimum of one foot below the finished roadway shoulder and preferably no higher than the top of the subgrade.
- The cross slopes of the ditch block should be no steeper than 6:1 and 10:1 slopes are desirable when the ditch block is adjacent to a high speed facility (45 mph, 70 kph or greater).
- See MDT Detailed Drawing 203-20 for ditch block details.
- The ditch block height and the capacity of the cross drain need to coincide to ensure that runoff is not forced onto the roadway.
- Erosion protection (rolled erosion control products (REC), riprap, etc.) is necessary on the upstream bank particularly for sites that experience higher flows and velocities. Riprap may be needed on the downstream bank if overtopping is anticipated for more frequent storm events or if the failure of the ditch block will result in damage to property or adverse environmental impacts.
- An approach may be used as a ditch block when installed in conjunction with a cross drain. The approach landing must be a 3% downgrade so the approach can be overtopped without overtopping the mainline when used in this application.

- The Hydraulics Section may provide the design requirements for ditch blocks in unique situations, such as high flows and velocities, or where overtopping of the roadway is a concern. The details provided may include ditch block spacing, height requirements and emergency spillways.

## A1.5 Materials

Normally a ditch block is a standard grading item (unclassified excavation or embankment-in-place). The ditch block is incorporated into the roadside revegetation work, and at a minimum includes topsoil and seeding. Rolled erosion control products (REC) and/or riprap with geotextile can be used in special situations.

## A1.6 Construction Considerations

Ordinary placement and compaction in accordance with the Standard Specifications.

## A1.7 Operation and Maintenance

- Inspect ditch blocks annually and after each major storm event. Repair damage as necessary.
- If a ditch block is a chronic maintenance problem, contact district engineering staff. A designed solution may be needed.

## A1.8 Initial Cost and Cost per Year

| | |
|---|---|
| Initial Cost: | Low |
| Cost per Year: | Low |

## A1.9 Method of Payment

Included in additional excavation or roadway quantities (unclassified excavation or embankment-in-place).

Rolled erosion control products (REC) are paid for by area, square yards (meters).

Riprap is paid for by the cubic yard (meter).

# A2.0: CHECK DAMS

## A2.1 Definition and Purpose

Check dams are structures (generally porous) placed across a natural or man-made channel, swale, or drainage ditch that work to reduce scour and channel erosion by reducing the velocity of concentrated storm water flows to non-erosive flow velocities and by encouraging sediment dropout. A series of check dams functions as a large sediment filter that gradually improves water quality as the sediment load is removed from the runoff. Check dams are generally considered temporary sediment control; however, check dams are designed for long-term functionality.

Check dam options include:

- Option 1 - Gravel
- Option 2 - Vegetated Earth
- Option 3 - Inverted

## A2.2 Appropriate Applications/Selection Criteria

- Use check dams when sediment is expected on steeper ditch grades (4-7%) and ditches with long grades in cuts greater than 1500 ft (460 m).
- When using check dams in combination, always consider the specific site conditions (ditch grade, soil conditions, drainage area, precipitation, etc.) and project experiences, and give consideration to the effects and reach of the impounded water and sediment.
- Where long cuts are present and sediment is anticipated, concentrate the spacing of the check dams at the end of the ditch.

## A2.3 Limitations

- Do not use in already vegetated areas unless erosion is expected, as installation may damage vegetation.
- Promotes sediment trapping which can be re-suspended during subsequent storms or removal of the check dam; therefore, may require maintenance following high velocity flows and may require repair or replacement.
- May be difficult to seed around.

## A2.4 Design Guidelines and Considerations

### A2.4.1 General

- Rolled erosion control products (REC) may be used with vegetated earth berms to maximize the check dam performance. Rolled erosion control products (REC) prevent undermining of the check dams and encourage the earliest vegetative growth.

- Install the first check dam approximately 15 ft (5 m) from the outfall device and at regular intervals based on slope gradient and soil type.
- Recommended spacing for check dams given various ditch slopes is as follows:

| | |
|---|---|
| 1%-3%: | place check dams at approximately 300 ft (90 m) spacing |
| 3%-4%: | place check dams at approximately 200 ft (60 m) spacing |
| > 4%: | place check dams at approximately 100 ft (30 m) spacing |

  Check dam spacing may be adjusted on a project-by-project basis during project development. See the MDT BMP Manual for additional details.
- The approach face of the check dam slope within the clear zone is 10:1. The outlet face on the check dam, if within the opposing traffic clear zone, is also 10:1

## A2.5 Materials

Gravel berm check dams should be constructed of crushed aggregate course (CAC). Vegetated earth berm check dams should be constructed of compacted soil then topsoiled and seeded. Inverted check dams should be constructed of drain aggregate.

## A2.6 Construction Considerations

- Install the check dam perpendicular to the direction of flow.
- Gravel may be placed by hand or by mechanical method to achieve complete ditch or swale coverage.
- Vegetated earth berm check dams should be compacted, topsoiled, and seeded.
- Space the check dams as indicated above. Check dam spacing may be adjusted on a project-by-project basis during project development.

## A2.7 Operation and Maintenance

***During construction***
- Inspect check dams after each significant storm event [0.5 inch (13 mm) in one hour], or, according to permit requirements if there is an active storm water permit.
- Remove sediment from behind the dam when it accumulates to one-half the original check dam height.
- Remove accumulated sediment and dispose of properly, or seed accumulated sediment to stabilize, whichever is most practical for the situation.

***After Construction***
- Inspect for erosion along the edges of the check dams and immediately repair as required.

## A2.8 Initial Cost and Cost per Year

Initial Cost: Moderate
Cost per Year: Low

## A2.9 Method of Payment

Gravel and inverted check dams will be paid by the cubic yard (meter) of the appropriate gravel bid item on the project. Vegetated earth check dams will be paid as additional excavation (unclassified excavation or embankment-in-place).

# A3.0 LINED DITCHES

## A3.1 Definition and Purpose

Lined ditches are utilized to convey surface water in areas that are susceptible to erosion and discharge this surface water to a stabilized watercourse, drainage pipe, or channel. Ditches may be lined with asphalt, riprap, or rolled erosion control products (REC). Riprap-lined ditches may be grouted in place for high flow velocities and steep grades.

Lined ditches are ideal for collecting and dispersing surface water in a controlled manner. Well-designed ditches provide an opportunity for sediments and other pollutants to be removed from runoff water before it enters surface waters or groundwater. Efficient removal of runoff from the roadway will help preserve the roadbed and banks. In addition, a stable ditch will not become an erosion problem itself.

## A3.2 Appropriate Applications

Lined ditches may be utilized in the following areas/situations:

- Areas that are susceptible to erosion where vegetation is difficult to establish,
- Steep grades/high flow velocities,
- Below steep grades where runoff begins to concentrate,
- At the top of slopes to divert run-on from adjacent or undisturbed slopes, and

Lining ditches with riprap and rolled erosion control products (REC) should be considered before concrete and asphalt since they decrease flow velocities and allow infiltration (thus decreasing the erosion potential). In addition, rolled erosion control products (REC) promote vegetation growth. Concrete and asphalt-lined ditches may be appropriate for ditches located within the clear zone and on heavily sanded mountain passes.

## A3.3 Limitations

- Sediment-laden runoff should be discharged into a sediment trapping facility and/or treated in the ditch via check dams.
- Asphalt-lined ditches do not provide any energy dissipation; therefore, these ditches may have considerable erosion at the outlets if they are not properly protected.
- Under the 2012 Nationwide 404 Permits, erosion control materials, including all rolled erosion control (REC) products, used in or adjacent to Waters of the U.S. must be natural and biodegradable. In addition, materials that include synthetic or UV

stabilized mesh are not allowed. Environmental Services should be contacted to determine if other materials would be allowed under an individual 404 permit.

## A3.4 Design Considerations

- Do not use on ditches where vegetation is already established.
- Lined ditches should be considered for slopes steeper than 2%, and/or areas that are susceptible to erosion and difficult to establish vegetation (see soil condition definitions below).

Use the Ditch Liner Product Selection Table below to specify the appropriate rolled erosion control product (REC) or contact the District Hydraulics Engineer to discuss alternate lining materials.

The following are the typical soil conditions encountered on a project. Soil conditions can be determined through site visits (for example, during the PFR), information regarding past erosion issues, from the District Hydraulics Engineer, or Geotechnical Section.

- Non-Erosive Soil Condition – a non-erosive soil condition or a condition with very low probability of erosion will occur: in areas where blasting is required to form the ditch, or in geographical areas of adequate topsoil and quick revegetation. Ditch lining is typically not required for sites with non-erosive soil conditions.
- Erosive Soil Condition – an erosive soil condition is described as an in-situ material consisting of fine grained soils and poor to moderate vegetative qualities. Use the table below for selecting the appropriate ditch liner for sites with erosive soil conditions.
- Highly-Erosive Soil Condition – a highly erosive soil condition is described as an in-situ material consisting of almost no gravels and providing poor vegetative qualities. Use the table below for selecting the appropriate ditch liner for sites with highly-erosive soil conditions.

Select the ditch liner according to the following ditch slopes and soil conditions:

## Ditch Liner Product Selection

| Ditch Slope | Erosive Soil Condition ($D_{75}$ = 0.10 to 0.60 in.) | Highly-Erosive Soil Condition ($D_{75} \leq 0.09$ in.) |
|---|---|---|
| <2% | | ** |
| 2-4% | High Performance Blanket | High Performance Blanket |
| 4-6% | High Performance Blanket | Natural Fiber TRM |
| 6-8% | High Performance Blanket | Natural Fiber TRM |
| 8-12% | Natural Fiber TRM | Synthetic TRM |
| >12% | NA* | NA* |

*Contact District Hydraulics Engineer for ditch liner recommendation

** Lining of ditches less than 2% may be necessary in extremely erosive soil conditions.

- In very steep areas where established vegetation is present other types of biodegradable, non-typical ditch lining may be used in place of non-biodegradable materials such as synthetic TRM. Non-typical ditch lining may consist of multiple layers of biodegradable REC products such as short-term blankets and long-term blankets (i.e. coir blanket).
- In areas were vegetation is very sparse a rigid liner may be used. Consult the MDT Reclamation Specialist or district Hydraulics Engineer when designing lining for roadside ditches that do not have good vegetative qualities.
- In a constructed ditch, do not design intermittent lining installations unless the ditch is interrupted by another erosion control feature.
- Within the clear zone, use traversable ditch sections meeting the requirements of the roadside safety section of the MDT Road Design Manual.
- Provide energy dissipation measures such as check dams to reduce flow velocity and to prevent erosion at the ditch outlet.
- Contact the District Hydraulics Engineer to determine if a lined ditch outlet settling basin is recommended to prevent erosion at the end of the lined ditch section. The settling basin consists of riprap placed over turf reinforcement mat (TRM) to allow roots to establish in the riprap.

## A3.5 Materials

The materials utilized for lining ditches include asphalt, concrete, cobble, riprap, or rolled erosion control products (REC).

Rolled erosion control products (REC) that are commonly used by MDT are described in section 713.12 of the Standard Specifications. These products consist of two major categories: erosion control blankets and permanent turf reinforcement mats (TRM). Erosion control blankets can be classified as short term, long term, or high performance. Permanent turf reinforcement mats (TRM) are typically constructed with either a synthetic fiber matrix or a natural fiber matrix.

Multiple layers of biodegradable REC products such as short-term blankets and long-term blankets (i.e. coir blanket) may be substituted for TRM if vegetation is expected to establish. Rigid liner materials including asphalt, concrete, cobble, and riprap may be used when vegetation cannot effectively establish using REC products.

Under the 2012 Nationwide 404 Permits, erosion control materials, including all rolled erosion control products (REC), used in or adjacent to Waters of the U.S. must be natural and biodegradable. In addition, materials that include synthetic or UV stabilized mesh are not allowed. Environmental Services should be contacted to determine if other materials would be allowed under an individual 404 permit.

## A3.6 Construction Considerations

- Remove all vegetation, roots, and rocks and construct the ditch according to the design plans and specifications.
- If using rolled erosion control products (REC) for ditch lining, seed the soil with the permanent seed blend (Area 2) defined in the contract seeding special provision prior to REC installation.
- Install the ditch liner according to the design plans and specifications. Install all rolled erosion control products (REC) according to the Detailed Drawings and manufacturer's recommendations.
- Place outlet protection before, or in conjunction with, the construction of the ditch so that it is in place when the ditch begins to operate.

## A3.7 Operation and Maintenance

- Inspect ditch linings, embankments, beds, and outlets of ditches for erosion and accumulation of debris/sediment after major storm events. Remove debris/sediment, replace lost riprap, and repair ditches, linings, and embankments as necessary.
- Regrade/reshape ditches for improving flow capacity, as necessary. Repair/replace liners immediately following grading activities.

## A3.8 Initial Cost and Cost per Year

Construction and maintenance costs for ditches are dependent on a number of factors such as:

- Type (concrete, asphalt, riprap, rolled erosion control products (REC)),
- Size (length, width, and depth), and
- Location (mountainous or prairie terrain).

Construction costs are low to medium and maintenance costs are low.

## A3.9 Method of Payment

Plant mix lined ditches are paid by the linear foot (linear meter).

For riprap lined ditches, the riprap is paid by the cubic yard (meter) and the underlying geotextile is paid by the square yard (square meter).

For ditches lined with rolled erosion control products (REC), the liner is paid by the square yard (square meter).

Typically, the grading work for lined ditches is included in mainline grading quantities.

# A4.0: INTERCEPTOR DITCHES

## A4.1 Definition and Purpose

Interceptor ditches are designed ditches utilized to intercept, divert, and convey surface water away from steep slopes (including cut and fill slopes) and discharge this surface water into a stabilized watercourse, drainage pipe, or channel. These ditches reduce the volume of water that is discharged into the roadside drainage system and protect slopes from excessive runoff and erosion. Interceptor ditches are ideal for collecting and dispersing surface water in a controlled manner.

## A4.2 Appropriate Applications

Interceptor ditches may be utilized in areas where surface water is causing (or has the potential to cause) erosion on a steep slope. Berms may be used in combination with interceptor ditches in areas where runoff is hard to control or when constructed on a slope. Interceptor ditches should discharge into a stable area for collecting sediment. Interceptor ditches may be lined in areas that are susceptible to erosion and/or where it is difficult to establish vegetation.

## A4.3 Limitations

Interceptor ditches are not suitable as sediment trapping devices. Sediment-laden runoff should be discharged into a sediment trapping facility and/or treated in the ditch via check dams.

Interceptor ditches should not be placed adjacent to steep cut or fill slopes in regions with soils susceptible to failure. Consult with the Geotechnical Section to determine the location of the interceptor ditch as well as to identify slope or soil stability concerns and recommendations.

## A4.4 Design Considerations

- The Hydraulics Section will determine if an interceptor ditch needs to be designed. If a designed ditch is required, the Road Designer will coordinate the design, quantities summary, details, and special provisions with Hydraulics. The Geotechnical Section should be consulted to determine if an interceptor ditch is detrimental to the cut-slope.
- Design and grade ditch and bank side slopes at a maximum 2H:1V ratio.
- Provide energy dissipation measures as necessary to prevent erosion at the ditch outlet.
- Interceptor ditches may be lined with asphalt, riprap, or rolled erosion control products (REC) for grades steeper than 2%, and/or areas that are susceptible to erosion or difficult to establish vegetation. See Section A3.0 – Lined Ditches, for liner selection criteria.

## A4.5 Materials

Typically, no specialized materials are needed to construct interceptor ditches. If the ditch will be constructed in an area that is susceptible to erosion, then the designer should consider lining the ditch (see Section A3.0 - Lined Ditches). The designer should consult with Hydraulics on the need for installing outlet protection for the ditch (see Section A8.0 – Outlet Protection/Velocity Dissipation Devices).

## A4.6 Construction Considerations

- Remove all vegetation, roots, and rocks, and construct the ditch according to the design plans and specifications.
- Place outlet protection before, or in conjunction with, the construction of the ditch so that it is in place when the ditch begins to operate.

## A4.7 Operation and Maintenance

- Inspect embankments, beds, and outlets of ditches for erosion and accumulation of debris/sediment after major storm events. Remove debris/sediment, replace lost riprap, and repair ditches, linings, and embankments as necessary.
- Regrade/reshape ditches for improving flow capacity as necessary. Reseed immediately following grading activities.

## A4.8 Initial Cost and Cost per Year

Operation and maintenance costs for ditches are dependent on a number of factors such as:

- Size (length, width, and depth),
- Location (mountainous or prairie terrain), and
- Liners installed (if applicable).

Initial Cost: Low
Cost per Year: Low

## A4.9 Method of Payment

Payment for unlined interceptor ditches will be included in mainline or additional grading quantities. If interceptor ditches require lining, see section A3.9 for payment of lined ditches.

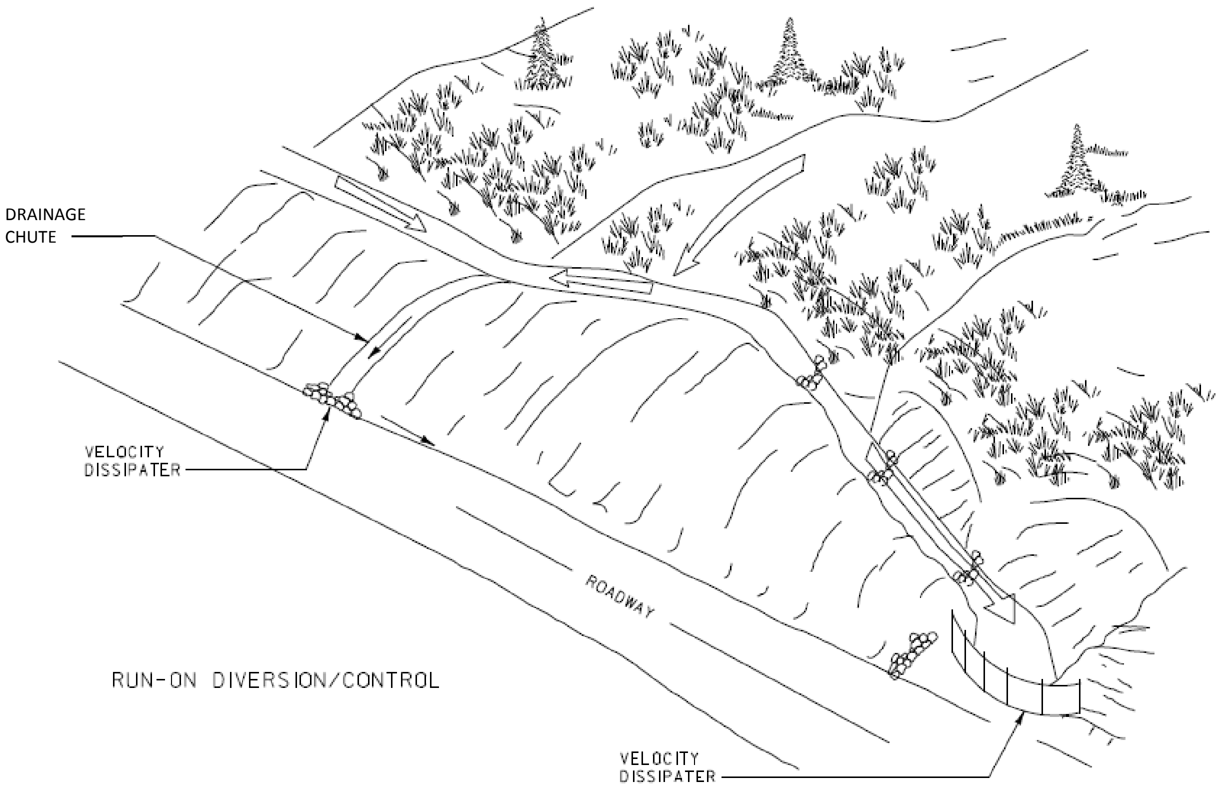



**Figure A4-1: Interceptor Ditch**

# A5.0 CHANNELIZING CURBS

## A5.1 Definition and Purpose

A channelizing curb is any curb that intercepts surface runoff and directs it to a specific outfall such as a drainage chute or embankment protector.

## A5.2 Appropriate Applications

Channelizing curbs are used to divert potential sheet runoff over slopes that are susceptible to erosion, due to their steepness or lack of vegetation. Channelizing curbs have often been considered as a temporary measure until vegetation is established on a slope. However, before a curb is removed, the slope should be evaluated to ensure that the vegetation is sufficient to prevent erosion.

Channelizing curbs can also be used to divert runoff from a sensitive watercourse.

## A5.3 Limitations

- Severe erosion may occur if the spacing or capacity of the outfalls is inadequate.
- When used in conjunction with guardrail, maximum curb height is 4”.
- The Hydraulics Section should evaluate the spread width of the flow contained by the curb if the embankment protector spacing exceeds the calculated spacing. A safety issue for vehicles can occur if the spread width of the flow encroaches on the travel lane.

## A5.4 Design Guidelines and Considerations

- The dimensions of channelized curbs should be in accordance with Detailed Drawing 609-05 unless special conditions exist.
- Channelized curbs must be used in conjunction with other PESC BMPs.
- The primary design consideration is the spacing of the outfalls as described in the drainage facilities section of the Road Design Manual.
- The outfall sites must be evaluated to determine if additional erosion control measures are needed at the outfall.
- Curb materials and construction practices need to comply with MDT Standard Specifications and special project conditions.
- See Detail Drawing 603-28 for channelizing curb in conjunction with embankment protectors.

## A5.5 Materials

Concrete.

## A5.6 Construction Considerations

Construct channelized curbs in accordance with the Standard Specifications and Detailed Drawings.

## A5.7 Operation and Maintenance

The maintenance of channelizing curbs is minimal unless they are damaged by vehicle or snowplow impacts. Channelized curbs should be inspected annually.

## A5.8 Initial Cost and Cost per Year

| | |
|---|---|
| Initial Cost: | Low |
| Cost per Year: | Low |

## A5.9 Method of Payment

Channelized curbs are measured and paid by the linear foot (linear meter) of new curb.

# A6.0 EMBANKMENT PROTECTORS

## A6.1 Definition and Purpose

An embankment protector is a type of drainage chute consisting of a pipe extending down a slope to a designed outfall. It is used to intercept and direct surface runoff into a stabilized watercourse, trapping device or stabilized area.

## A6.2 Appropriate Applications

Embankment protectors are typically used in conjunction with channelized curbs, at bridge ends and in cut-to-fill transitions.

They can also be used on back slopes where the height of the drop, the steepness of the slope or the volume of surface runoff exceeds the capability of other types of drainage chutes.

The installation of embankment protectors is not necessary for bridges that have rail configurations without curbs.

## A6.3 Limitations

Severe erosion may result when the inlet is overtopped or as the result of piping or pipe separation.

Where embankment protectors are used on back slopes, energy dissipation/erosion protection at the outfall in the roadside ditch should consist of some type of hard armoring. This may consist of riprap, paving a section of ditch or installing a concrete dissipater. Riprap should not be used in the roadside ditch if it is within the clear zone.

## A6.4 Design Considerations

An embankment protector with channelized curb should be designed in accordance with the criteria provided in the drainage facilities section of the Road Design Manual.

Where embankment protectors are used in cut-to-fill transitions, the pipe size is determined through hydraulic analysis. The designer should have the Hydraulics Section evaluate the capacity of the embankment protector.

The outfall of the embankment protector should be evaluated to determine which energy dissipation or erosion control measures are needed. A riprap apron sized according to hydraulic practice is generally sufficient.

- Securely anchor and stabilize pipe and appurtenances into soil.
- Check to ensure that pipe connections are watertight.
- Use standard flared end sections at the inlet and outlet for pipes 12 inches (300 mm) in diameter or greater.
- Embankment protector materials and construction practices need to comply with MDT Standard Specifications, MDT Detailed Drawing 603-28 and special project conditions.
- In areas of heavy sanding, provide sediment traps to collect the sanding material upstream of the embankment protector inlet.

## A6.5 Materials

Embankment protectors are typically constructed with corrugated metal pipe. Optional pipe materials and coatings may be considered depending on soil conditions.

## A6.6 Construction Considerations

Embankment protectors should be constructed in accordance with the Detailed Drawings and Standard Specifications.

## A6.7 Operation and Maintenance

- Inspect after each major storm, but at least once per year.
- Inspect outlet for erosion and downstream scour. If eroded, repair damage and install additional energy dissipation measures. If downstream scour is occurring, it may be necessary to reduce flows being discharged into the outfall area unless other preventative measures are implemented.
- Inspect embankment protector inlet for accumulations of debris and sediment.
- Inspect the embankment protector for distortion, leakage or pipe separation.
- Remove built-up sediment from entrances and outlets as required. Flush pipe if necessary; capture and settle out sediment from discharge.

## A6.8 Initial Cost and Cost per Year

| | |
|---|---|
| Initial Cost: | Moderate |
| Cost per Year: | Low |

## A6.9 Method of Payment

Embankment protectors are paid by the linear foot (linear meter). This includes any preparatory work at the inlet. Any measures installed at the embankment protector outlet will be paid separately under the appropriate item for the specific measure.

# A7.0 DRAINAGE CHUTES

## A7.1 Definition and Purpose

A drainage chute is a measure used to intercept and direct surface runoff or groundwater into a stabilized watercourse, trapping device or stabilized area. Drainage chutes are often used to intercept and direct surface flow into a confined drainage feature to protect cut or fill slopes.

## A7.2 Appropriate Applications

- Drainage chutes are typically used on back slopes where surface runoff is concentrated due to natural or man-made features. These features may consist of minor drainages intercepted by the back slope or at the outfalls of furrow ditches constructed on the top of the back slope.
- Drainage chutes can be used in cut-to-fill transitions. (If the volume of runoff or the slope steepness limits the use of a drainage chute in these locations, utilize embankment protectors to protect the cut-to-fill transition.)
- Drainage chutes can be used in conjunction with a channelized curb. The type of drainage chute is usually limited to riprap or grouted riprap chutes due to the height of drop typically associated with channelized curbs.

## A7.3 Limitations

Severe erosion may result when drainage chutes fail by overtopping or piping. Limitations to the height of drop and slope depend on the type of material used for the drainage chute.

Under the 2012 Nationwide 404 Permits, erosion control materials, including all rolled erosion control (REC) products, used in or adjacent to Waters of the U.S. must be natural and biodegradable. In addition, materials that include synthetic or UV stabilized mesh are not allowed. Environmental Services should be contacted to determine if other materials would be allowed under an individual 404 permit.

## A7.4 Design Considerations

Utilize outlet protection/velocity dissipation devices at the drainage chute outfall. Where drainage chutes outfall into roadside ditches, the outlet protection may have to extend up the inslope of the roadway. In areas of higher flows where drainage chutes are intercepting furrow ditches, consider regrading the furrow ditches and providing additional drainage chutes.

- Channelization on top of the slope to direct flow to the drainage chute is essential. Direct surface runoff to drainage chutes by using furrow ditches, berms or other dikes as shown on Detailed Drawing 613-18.

- Drainage chute materials need to comply with MDT Standard Specifications or special project conditions.

- Where an approach is installed in cut sections, the roadside ditches for the approach will act as drain chutes. Therefore, the ditches should be evaluated and designed using drainage chute criteria.

Drainage chutes include grouted riprap, riprap, and turf reinforcement mat drainage chutes. The use of culverts for drainage chutes is discussed in Section A6.0 Embankment Protectors. Recommended design parameters for various drainage chutes are summarized below. See Detail Drawing 613-18 for additional details. Contact the District Hydraulics Engineer to determine the proper drainage chute type.

### A7.4.1 Grouted Riprap Drainage Chute

- Maximum drop = 30 ft (9 m)
- Maximum slope = 1.5:1*

*For slopes steeper than 1.5:1, a culvert is generally more cost-effective (see Section A6.0 Embankment Protectors).

### A7.4.2 Riprap Drainage Chute

- Maximum drop = 30 ft (9 m)
- Maximum slope = 3:1

### A7.4.3 Turf Reinforcement Mat (TRM)

- Maximum drop = 20 ft (6 m)
- Maximum slope = 4:1 (Maximum slope for turf reinforcement mat. (TRM) is determined ultimately by the soil stability and manufacturer’s maximum permissible velocity)

## A7.5 Materials

Grouted riprap, riprap, or turf reinforcement mat (TRM) can be used depending on the type of slope drain selected.

Turf reinforcement mat (TRM) commonly used by MDT are described in section 713.12 of the Standard Specifications. Typical turf reinforcement mat (TRM) types include Fully Synthetic TRM and Natural Fiber TRM.

Under the 2012 Nationwide 404 Permits, erosion control materials, including all rolled erosion control (REC) products, used in or adjacent to Waters of the U.S. must be natural and biodegradable. In addition, materials that include synthetic or UV stabilized mesh are not allowed. Environmental Services should be contacted to determine if other materials would be allowed under an individual 404 permit.

## A7.6 Construction Considerations

When installing slope drains:

- Install drainage chutes perpendicular to slope contours.
- Ensure drainage chute drains properly with the proper depth depression on the chute cross section.
- Use geotextiles in conjunction with riprap slope drains. Input from the Geotechnical Section may be necessary.
- Compact soil around and under entrance and outlet, and along the length of the slope drain.
- Protect area around inlet with geosynthetic liner meeting MDT Standard Specifications. Protect outlet with riprap or other energy dissipation devices. For high-energy discharges, reinforce riprap with concrete or use reinforced concrete device.

## A7.7 Operation and Maintenance

- Inspect after each major storm, but at least once per year.
- Inspect outlet for erosion and downstream scour. If eroded, repair damage and install additional energy dissipation measures. If downstream scour is occurring, it may be necessary to reduce flows being discharged into the ditch unless other preventative measures are implemented.
- Inspect slope drainage for accumulations of debris and sediment.
- Remove built-up sediment from entrances and outlets as required. Flush drains if necessary; capture and settle out sediment from discharge.
- Make sure water is not ponding at inappropriate areas (for example, inlet of slope drain, roadside ditch, etc.).

## A7.8 Initial Cost and Cost per Year

| | |
|---|---|
| Initial Cost: | Moderate |
| Cost per Year: | Low |

## A7.9 Method of Payment

- Grouted riprap drainage chutes are measured and paid by the square yard (square meter) of grouted riprap.
- Riprap drainage chutes are measured and paid by the cubic yard (cubic meter).
- Turf reinforcement mat (TRM) is measured and paid by the square yard (square meter).

# A8.0: OUTLET PROTECTION/VELOCITY DISSIPATION DEVICES

## A8.1 Definition and Purpose

Outlet protection for culverts, storm drains, or even steep ditches and flumes is essential to preventing major erosion and damage to downstream ditches and drainage structures. Outlet protection can be a ditch lining or a structure or flow barrier. Outlet protection is designed to lower excessive flow velocities from pipes and culverts, prevent scour, and dissipate energy. Effective outlet protection must begin with efficient storm drainage system design that uses adequately sized pipes, culverts, ditches, and channels placed at the most efficient slopes and grades.

## A8.2 Appropriate Applications

Outlet protection is needed wherever discharge velocities and energies are sufficient to erode the immediate downstream reach. These devices may be used at the following locations:

- Outlets of pipes, drains, culverts, conduits, diversion ditches, swales, or channels.
- Outlets located at the bottom of mild to steep slopes.
- Discharge outlets that carry continuous flows of water.
- Outlets subject to short, intense flows of water, such as flash floods.
- Points where lined conveyances discharge to unlined conveyances.
- Outlets of other PESC measures including embankment protectors and drainage chutes.

## A8.3 Limitations

- Riprap outlet protection can occupy a large area, which may require additional easements.
- Loose rock may be washed away during high flows.
- Grouted riprap and concrete structures may break up in areas of freeze and thaw. Weepholes and adequately drained foundations are necessary for these types of outlet protection.
- Sediment caught in the rock outlet protection device may be difficult to remove without removing the rocks.

## A8.4 Design Considerations

The MDT Hydraulics Section typically designs permanent outlet protection and velocity dissipation devices for cross culverts and storm drains. Outlet protection is also required with the installation of other permanent erosion control devices including embankment protectors, drainage chutes, interceptor ditches and detention basin outlets.

- A rock apron is the most common type of energy dissipater. Other types of devices include stilling basins, impact barriers, and baffle chutes. Coordinate with the Hydraulics Section for design of these types of outlet protection and velocity dissipation devices.
- Rock outlet protection is effective at limiting erosion when the rock is sized and placed appropriately. Increase rock size for high velocity flows. Use sound, durable, angular rock.
- When designing the outlet protection, consider flow depth, roughness, gradient, side slopes, discharge rate, and velocity. The discharge pipe size governs the rock depth and outlet protection length.
- For proper operation of apron:
  - Align apron with receiving stream and keep it straight throughout its length. If a curve is needed to fit site conditions, place the curve in the upper section of the apron.
  - If the apron riprap is large in size, protect underlying filter fabric with a gravel blanket.
- Outlets on slopes steeper than 10% will need additional protection.
- Where lump sum payments are used for structural devices provide quantities for information purposes.

## A8.5 Materials

The type of material will depend on the measure selected (ditch lining, flow barrier, structure).

## A8.6 Construction Considerations

Refer to Section 613 of the Standard Specifications and to the MDT BMP Manual.

## A8.7 Operation and Maintenance

- Inspect outlet protection on a regular basis for erosion, sedimentation, scour or undercutting.
- Repair or replace riprap, geotextile or concrete structures as necessary to handle design flows.
- Remove trash, debris, grass, sediment or burrowing animals as needed.

## A8.8 Initial Cost and Cost per Year

Initial Cost: High
Cost per Year: Low

## A8.9 Method of Payment

- Cubic yards (cubic meters) for riprap.
- Lump sum for structural devices.

# A9.0 SLOPE SOIL STABILIZATION

## A9.1 Definition and Purpose

Slope soil stabilization is the use of one or more methods to stabilize the soil of a portion of a slope that is often unaddressed. Steep slopes, exposure of unweathered parent material (bedrock), lack of moisture infiltration capacity, and difficulty in reestablishing a cover of vegetation, create an environment that produces large amounts of sediment movement into roadside ditches. This sediment can move with flowing water off-site and increases maintenance costs by clogging culverts and contributing to saturated road bases. Slope soil stabilization is intended to retain sediment on the slope, as opposed to trying to contain the eroded material once it reaches the ditch section.

## A9.2 Appropriate Applications

For most situations, treating the lower 1/3 of the slope should act as an effective filtering zone to reduce the amount of sediment from reaching a ditch section. These measures would also serve to prevent headcutting from erosion originating near the slope toe. Use one of the following methods individually, or in combination, to stabilize the lower portion of large cut slopes.

- Rock veneer, with seeding,
- Erosion control blanket, with seeding,
- Topsoil treatment, with seeding.

Use is restricted to large cuts where any of the above measures is cost-prohibitive to treat the entire slope.

This BMP does not eliminate the MDT standard seeding protocol for the entire slope. It is meant to supplement standard seeding by incorporating practices that either foster vegetation establishment or act as a barrier to sediment transport into the ditch.

## A9.3 Limitations

Any of the methods involving seeding should only be specified on slopes capable of supporting plant growth. An assessment of whether soil conditions are capable of supporting plant growth should be made by the MDT Reclamation Specialist prior to the plan-in-hand. If the slopes in the general area from the original road construction appear likely to support plant growth, then the selection of one of the seeding treatments is a viable option.

If the slope faces exposed after grading will be composed of hard bedrock, little plant growth can be expected, as well as limited sediment generation from weathering. No treatment is necessary in such cases.

Rock veneer is appropriate in areas where the finished slope is composed of highly erodible material, but plant growth is not expected due to contributing factors such as high salt levels, excessive steepness and/or extreme clay or fine silt content.

Rock veneer may also be appropriate around exposed seepage zones where piping erodes soil particles. Seepage zones are most prevalent where a water-bearing zone lies atop a salt-rich layer of clay (shale).

With any of the treatments, a hard point in the slope must be constructed along, and parallel to, the top edge of the BMP. The hard point is necessary to prevent undercutting of the installation, whether rock or one of the seeding methods. The hard point will be constructed of a trenched-in piece of turf reinforcement mat.

## A9.4 Design Considerations

The use of this BMP will be contingent upon the location and size of large cuts that are constructed at 2:1 or steeper slopes. The MDT Reclamation Specialist may decide that none of the specialized treatments is necessary or practical given the size and number of cut slopes. Regardless of selected treatment, the BMP is not to extend higher than about 20 ft (6 m) vertical elevation up the slope from the ditch bottom. It may be necessary to leave the bottom 5 ft (1.5 m) of the slope untreated if the rock veneer is used in order to eliminate a hazard in the recovery zone.

The MDT Reclamation Specialist will recommend appropriate BMP slope method(s) to be incorporated into the design once the construction limits are established and an assessment is made of the appropriateness of slope soil stabilization. The default treatment will always be topsoiling/erosion control blanket and seeding of the lower third of the slope [or maximum 20 ft (6 m) high].

The remaining upper portions of the slope will be seeded according to the “Area 2” instructions in the seeding special provision.

Following coordination with the MDT Reclamation Specialist, the designer will calculate the quantity of each designated method, summarize the methods by stationing and list them separately in the schedule of items for bidding purposes. A summary frame will be provided in the set of plans detailing the location and size of each of the methods.

## A9.5 Materials

The materials will depend on the measure that is selected.

## A9.6 Construction Considerations

### A9.6.1 Rock Veneer, with Seeding

Grade the treated area of the slope to a smooth, even surface. Broadcast seed (wet or dry) the area with the “Area 2” seed mixture and rates. Following seeding, install a natural fiber permanent turf reinforcement mat (TRM) meeting MDT Standard Specification 713.12.

Cover the TRM with a single layer of Class I riprap, meeting MDT Standard Specification 701.06.2. Place the riprap in a manner that limits blanket ripping or dislodgement. Rocks must not be dropped from a distance greater than 1-2 ft (0.3-0.6 m) from the soil surface.

### A9.6.3 Erosion Control Blanket, with Seeding

Grade the treated area of the slope to a smooth, non-compacted surface. Broadcast seed (wet or dry) the area with the “Area 2” seed mixture and rates. Lightly rake the seeded area to incorporate the seed into the upper ½ inch of soil. Following seed incorporation, install a long term erosion control blanket meeting MDT Standard Specification 713.12. Only use blankets constructed with 100% non-synthetic, biodegradable netting and stitching. Turf reinforcement mats (TRM) may be used on slopes steeper than 3:1 with limited growth potential.

### A9.6.4 Topsoiling and Erosion Control Blanket, with Seeding

Prepare the area to be treated by first scarifying it with a chisel plow or disk. Following scarification, place a 2 inch (50 mm) layer of salvaged or furnished topsoil over the treated area. Broadcast seed (wet or dry) the area with the “Area 2” seed mixture and rates. Lightly rake the seeded area to incorporate the seed into the upper ½ inch of soil. Following seed incorporation, install an erosion control blanket meeting MDT Standard Specification 713.12. Only use blankets constructed with 100% non-synthetic, biodegradable netting and stitching.

## A9.7 Operation and Maintenance

Maintenance of the ditches is restricted to avoid damaging the slope soil stabilization BMPs.

## A9.8 Initial Cost and Cost per Year

| | |
|---|---|
| Initial Cost: | Moderate |
| Cost per Year: | Low |

## A9.9 Method of Payment

The slope soil stabilization rolled erosion control products (REC) are typically measured and paid for by the square yard (square meter). Riprap is typically measured and paid by the cubic yard (cubic meter) when utilized.

# A10.0: STREAMBANK STABILIZATION

## A10.1 Definition and Purpose

Streambank erosion is the loss of soils along streams and rivers predominantly due to the force of flowing water. The seepage of groundwater and the overland flow of surface water runoff also contribute to the erosion of streambanks. The purpose of this control measure is to protect streambanks from the erosive forces of flowing water through use of designed vegetative and/or structural measures.

Bioengineered methods integrate plant materials and landform modifications in order to stabilize slopes and streambanks. Bioengineered techniques utilize natural elements such as trees, shrubs, rocks and native vegetation to stabilize banks.

Structural measures incorporate the use of stone or fractured rock riprap. Riprap can be utilized either fully or partially in support of bioengineered streambank stabilization designs. Stone or rock provides the needed weight for erosion protection as well as providing needed foundation for other design elements.

## A10.2 Appropriate Applications

Streambank stabilization is applicable where continued erosion of a stream channel bank would be detrimental to a highway, bridge, or other public infrastructure.

## A10.3 Limitations

These control measures may require special permitting from resource agencies such as the Montana Departments of Environmental Quality; Fish, Wildlife and Parks; the Environmental Protection Agency; and the U.S. Army Corps of Engineers.

## A10.4 Design Considerations

Since each reach of channel requiring protection is unique, measures for streambank protection should be designed according to specific site conditions. The Hydraulics Section will coordinate with the Environmental Services Bureau to determine the appropriate design.

Designs are developed according to the following principles:

- Protective measures are compatible with other channel modifications planned or being carried out in adjacent channel reaches.
- Streambank protection extends between stabilized or controlled points along the stream.
- Channel alignments are not changed without a complete evaluation of the anticipated effect on the rest of the stream channel, especially downstream.

- Special attention is given to maintaining and improving habitat for fish and wildlife.
- All requirements of state law and all permit requirements of local, state, and federal agencies are met.
- All methods are designed for structural stability and erosion resistance.

Stream channel erosion problems vary widely in type and scale and no one measure works in all cases.

## A10.5 Materials

Materials will vary depending on the specific stabilization measure used.

## A10.6 Construction Considerations

Access to the construction site should be evaluated and if in-water work is anticipated additional permitting may be required.

## A10.7 Operation and Maintenance

Monitor stabilized streambank sections after spring runoff and make any needed repairs immediately to prevent further damage.

## A10.8 Initial Cost and Cost per Year

| | |
|---|---|
| Initial Cost: | Moderate |
| Cost per Year: | Moderate |

## A10.9 Method of Payment

The measurement and payment of streambank stabilization measures varies.

# A11.0: MAINTENANCE OF EXISTING DRAINAGE

## A11.1 Definition and Purpose

The purpose of maintaining the existing drainage patterns is to ensure that a new roadway configuration does not result in concentration of runoff or obstruction of minor drainages. The failure to do so can result in water trapped next to the roadway and can potentially impact the hydrology of a drainage. Alteration in site runoff characteristics can cause an increase in the volume and frequency of runoff flows (discharge) and velocities that cause flooding, accelerated erosion, and reduced groundwater recharge, and contribute to degradation of water quality and the ecological integrity of streams.

## A11.2 Appropriate Applications

Impacts to the existing drainages most often occur as the result of projects that involve changes to the horizontal or vertical alignment. The locations of minimum sized [24 inch (600 mm)] culverts are often overlooked and new grades may result in new low spots where water may be trapped.

Roadway widening may also impact roadside drainage. Many older sections of roads were constructed using side borrow which resulted in substantial roadside ditches. New wider roadway templates often fill these ditches leaving no clear drainage path.

## A11.3 Limitations

Maintaining the existing drainage patterns may not always be practical, but should always be considered as part of the design process.

## A11.4 Design Considerations

Whenever a project involves adjustments to the horizontal or vertical alignment or includes major widening, the following items should be considered:

- Review as-built plans and conduct on-site reviews to determine the location of minimum sized culverts.
- Perpetuate minor drainage crossings unless it is impractical to do so.
- If a crossing must be eliminated, direct the flow to the nearest natural drainage. Determine if the drainage can accommodate the additional flow.
- Since the elimination of the minor drainage crossing will often result in additional flow in the roadside ditch, evaluate the need for erosion control measures in the ditch to prevent erosion that would result from the increased flow.
- Where new grades result in new low spots where runoff would otherwise be trapped, grade the ditch to drain. This may require a ditch profile that is independent of the roadway profile.

- Where new templates fill in existing roadside ditches, drain ditches may be needed at the toe of the fill to promote positive drainage to a natural drainage course. As in cut sections, these ditches may require a ditch profile that is independent of the roadway profile.
- In cases where the flow pattern is changed from the original situation, evaluate the effects of the additional flow on the existing features such as drainages and wetlands to ensure that it does not result in adverse impacts.
- When filling in existing drainage ditches is unavoidable, careful evaluation of new drainage patterns is required. In no instance is it acceptable to block an existing drainage route with fill material without providing an alternative drainage pattern.

## A11.5 Materials

This section is not applicable.

## A11.6 Construction Considerations

This section is not applicable.

## A11.7 Operation and Maintenance

This section is not applicable.

## A11.8 Initial Cost and Cost per Year

This section is not applicable.

## A11.9 Method of Payment

This section is not applicable.

# A12.0: DETENTION BASINS

## A12.1 Definition and Purpose

Detention basins are permanent dams or basins that can be used to reduce peak storm water runoff rates and enhance storm water runoff quality.

Detention basins can be designed to drain and/or infiltrate completely (dry pond) or to maintain a permanent pool (wet pond). Ponds will be sized with enough volume to temporarily detain larger flows long enough to reduce the peak flow rate to an acceptable level. The typical water quality component of the basins is detaining sediment-laden runoff long enough to allow most of the large sediment particles to settle out before the water is released.

### A12.1.1 Dry Detention Basins

A dry detention basin is a storm water storage basin that drains completely within a certain amount of time depending on the outlet structure design. Dry basins receive storm water runoff and detains enough volume so that the captured water is released at an acceptable rate. In some cases, the outlet structure may be designed to hold a smaller volume of the water for an extended period of time (24 to 48 hours) to allow the sediment to settle out. Dry detention basins can be incorporated in underground chambers, athletic fields, or other open spaces and relatively easy to fit into a site.

### A12.1.2 Wet Ponds

A wet pond has a permanent pool of water that is replaced with storm water, in part or in total, during storm water runoff events. The influent water mixes with the permanent pool water as it rises above the permanent pool level. The wet pond is designed so that the surcharge captured volume above the permanent pool is detained long enough to provide an acceptable level peak flow reduction and sedimentation. Wet ponds require a dry-weather base flow to maintain the permanent pool.

## A12.2 Appropriate Applications

Detention basins can be used to enhance storm water runoff quality and reduce peak storm water runoff rates and therefore, are effective in meeting the requirements of the Storm Water Management Program under the MS4 permit.

## A12.3 Limitations

- Safety concerns such as clear zone issues.
- Fencing may be required based on water depth and the risk of unauthorized access.
- Maintenance and sediment removal needs.
- Floating and trapped debris can lead to aesthetic issues.
- Aquatic plant growth can be a factor in clogging outlet controls.
- The permanent pool can attract water fowl, which can be an issue near airports.

## A12.4 Design Considerations

- Detention basins are designed by the Hydraulics Section. The Road Designer will review locations and ensure that the design details are included in the plans.
- Avoid placing these structures in environmentally sensitive areas such as perennial or intermittent streams and wetlands.
- The embankment slopes for open basins should be flatter than 3H:1V slope for safety and ease of maintenance.

Existing and potential future downstream development should be considered, when designing the pond outlet. The provisions for removal of accumulated sediment will need to be included.

## A12.5 Materials

Materials required will vary with site-specific conditions.

## A12.6 Construction Considerations

Unclassified excavation can be used for the construction of dry basins and muck excavation may be necessary for the construction of wet ponds. If the basin is constructed early in the project construction process, construction-related sediment may need to be removed before project completion.

## A12.7 Operation and Maintenance

Basins should be inspected annually. Remove sediment as necessary to ensure proper function.

## A12.8 Initial Cost and Cost per Year

| | |
|---|---|
| Initial Cost: | High |
| Cost per Year: | Moderate |

## A12.9 Method of Payment

Materials required for construction will be paid at appropriate unit prices.

# A13.0: RETENTION BASINS

## A13.1 Definition and Purpose

A retention basin is a shallow impoundment that captures and stores storm water until it can infiltrate into the soil. In addition to controlling peak runoff, the soil acts as a natural filter to remove pollutants from the storm water before it eventually reaches the water table.

## A13.2 Appropriate Applications

Retention basins are used where outfalls are not available, such as developed areas and urban interchanges. Depending on the site conditions, retention basins can serve small to medium sized drainage areas.

## A13.3 Limitations

Site-specific conditions will play an important role in deciding if a retention basin is the appropriate PESC measure. Soil conditions, groundwater, and available space for the anticipated amount of water retention are the primary factors. A porous soil type and a predicted groundwater elevation below the basin are necessary.

## A13.4 Design Considerations

Retention basins are typically designed by the Hydraulics Section. The Road Designer will review locations and ensure that the design details are included in the plans.

Appropriate soil properties are critical for long-term successful performance. Hydraulics will coordinate with Geotech to assess the in-situ soil conditions.

Minimum design volume should be no less than the two year storm event from the entire contributing watershed.

Additional storage or overflow paths for larger storm events (up to the 100 year) must also be provided for.

The basin should be sized to infiltrate the entire two year storm event within 72 hours.

A retention basin may be constructed in any shape to meet right-of-way restrictions. The basin floor should be as flat as possible with no noticeable depressions. Side slopes should be no more than 3:1 (H:V) to allow for mowing and other necessary maintenance.

Maximize basin floor surface area and reduce depth to optimize infiltration, as appropriate with consideration to right-of-way needs.

Established vegetation can maintain and possibly improve infiltration, prevent erosion, and remove soluble nutrients in the storm water. Vegetation on the basin bottom and sides must be capable of surviving up to 72 hours under water.

## A13.5 Materials

Consult the MDT Reclamation Specialist for specific seeding/planting guidelines.

## A13.6 Construction Considerations

Without precautions, sediments from the construction site can clog the basin, preventing post-project infiltration. Preferably, the basin would not be put into use until after the work site and the area draining to the basin are stabilized.

Prior to any site construction, rope off the infiltration area to prevent entrance by unwanted equipment.

To prevent soil compaction, build the basin without driving heavy equipment over the infiltration surface.

## A13.7 Operation and Maintenance

Maintenance and inspection are essential for the long-term successful operation of this PESC measure. Goals of inspections and maintenance should be to ensure that water infiltrates into the subsurface within 72 hours or less and that vegetation remains healthy. Recommended operation and maintenance guidelines include:

- Remove accumulated trash and debris in the basin.
- Inspect for standing water at the end of the wet season.
- Trim vegetation at the beginning and end of the wet season.
- Remove accumulated sediment.
- If erosion is occurring within the basin, revegetate immediately and stabilize with erosion control mulch or mat until vegetation cover is established.

## A13.8 Initial Cost and Cost per Year

Initial Cost: Moderate
Cost per Year: Low

## A13.9 Method of Payment

Materials required for construction will be paid at appropriate unit prices.

## Sample Summary Frame
## (Embankment in Place)

| ADDITIONAL GRADING | | | | | |
|---|---|---|---|---|---|
| STATION | | cubic yards | | | REMARKS |
| | | INCL. IN GRADING | | ADD. EMB. IN PLACE | |
| FROM | TO | EXC. | EMB. IN PLACE | | |
| 134+20 | | | 25 | | DITCH BLOCK LT. |
| SUBTOTAL | | | 25 | | |

DITCH BLOCK SUMMARY ENTRY

## Sample Summary Frame
## (Unclassified Excavation)

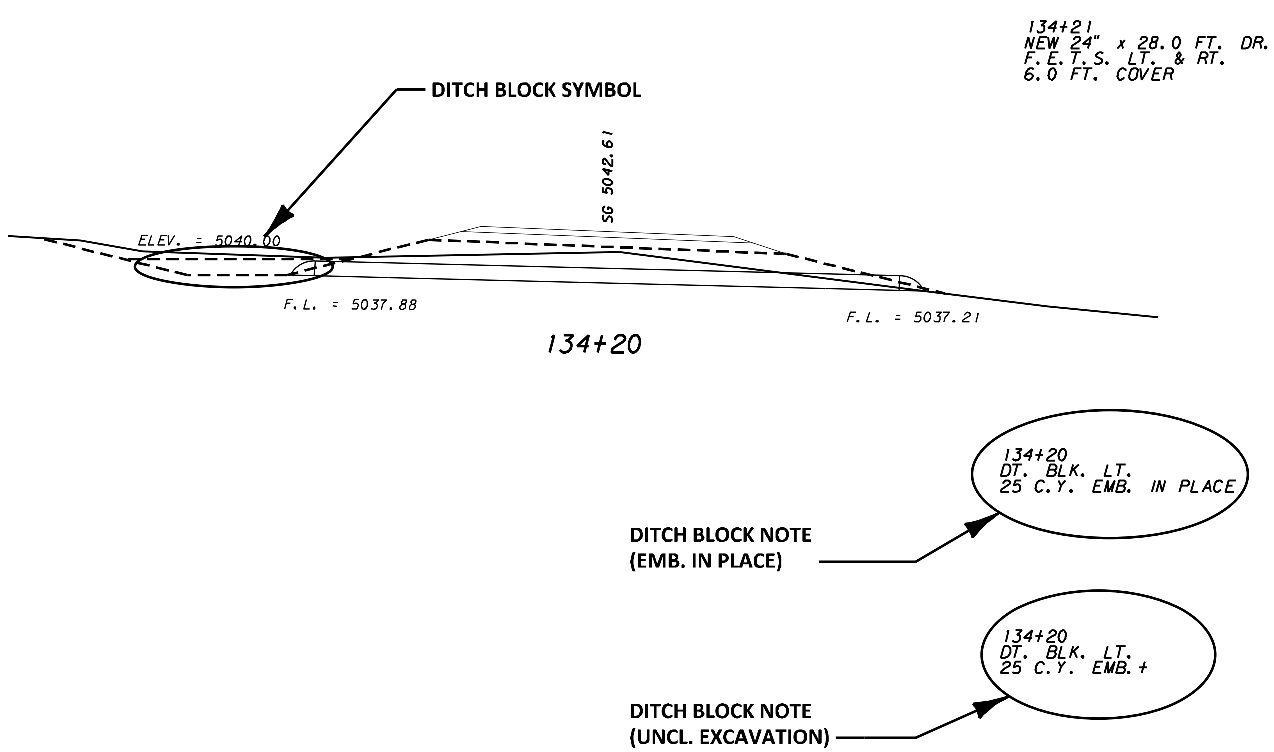
| ADDITIONAL GRADING | | | | | |
|---|---|---|---|---|---|
| STATION | | cubic yards | | | REMARKS |
| | | INCL. IN ROADWAY | | ADD. UNCL. EXC. | |
| FROM | TO | UNCL. EXC. | EMB.+ | | |
| 134+20 | | | 25 | | DITCH BLOCK LT. |
| SUBTOTAL | | | 25 | | |

DITCH BLOCK SUMMARY ENTRY

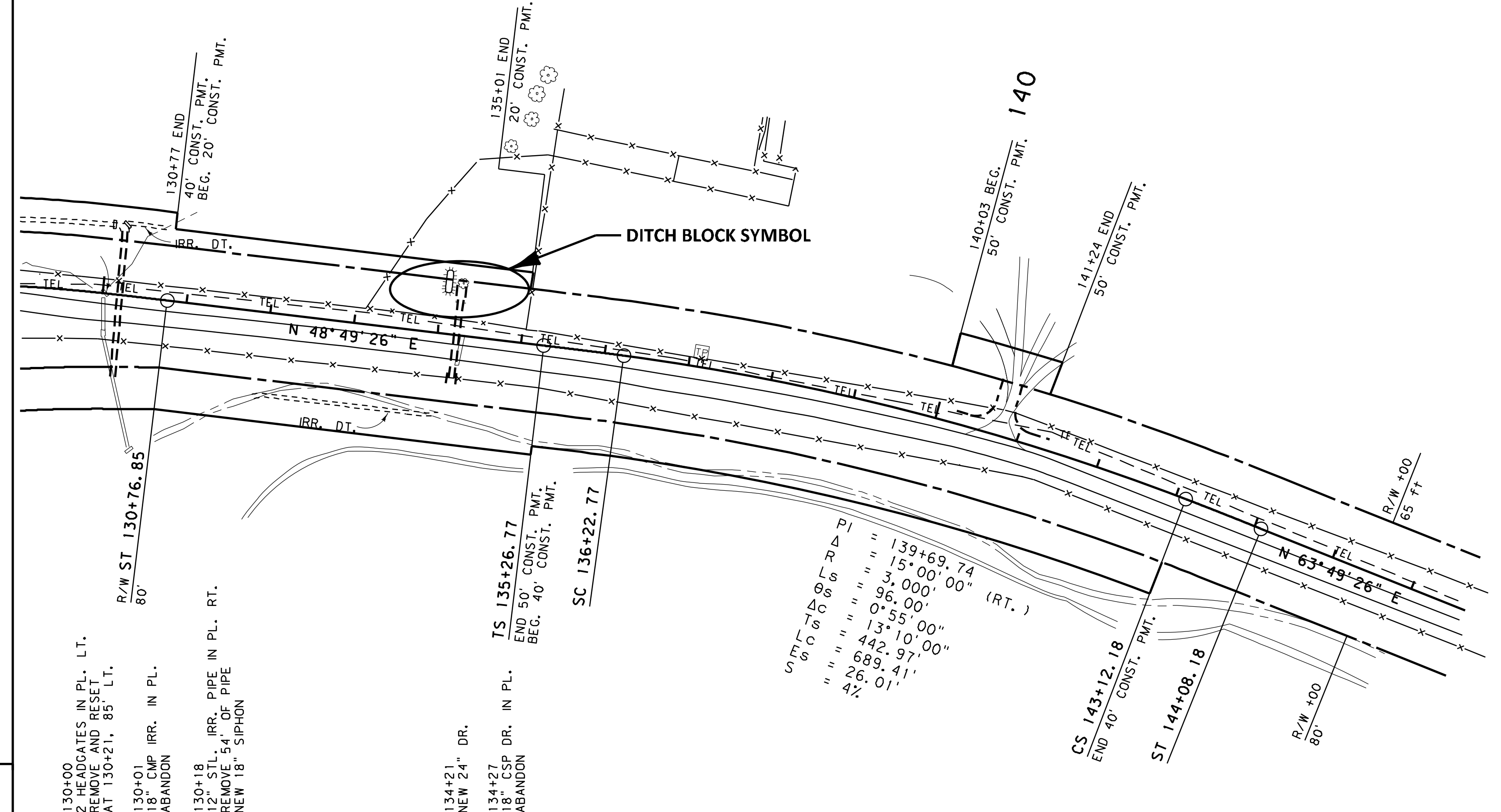
Ditch Block Reminders:

1. See Detail Drawing 203-20 for additional ditch block details.

## Sample Cross Section




## Sample Plan and Profile



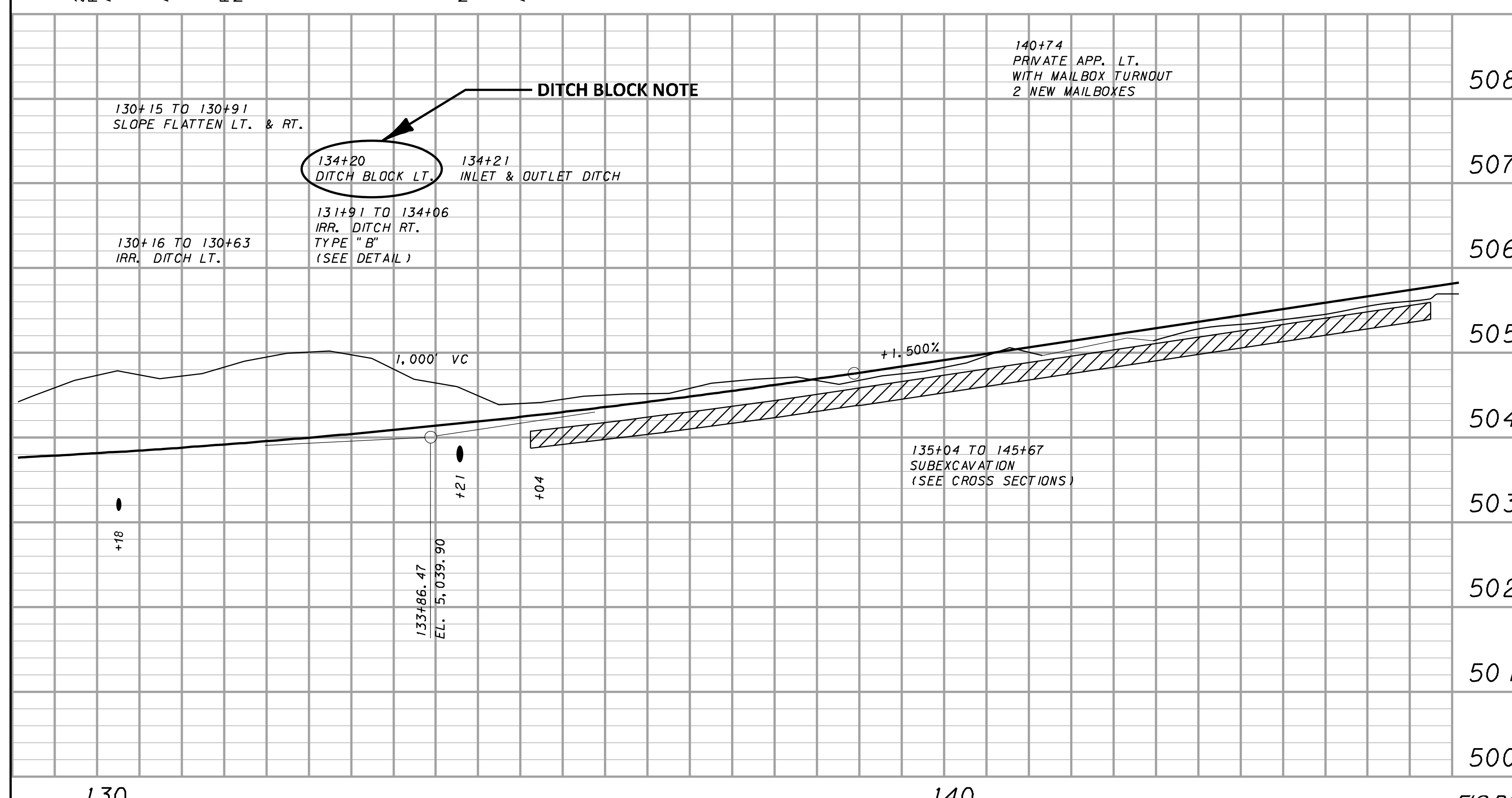




FIG B1-1

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3 / 2 / 1 | MDT MONTANA DEPARTMENT OF TRANSPORTATION | ...\Dgn\PESCMANRDB01001.dgn / 9/25/2017 / 8:51:13 AM u2373 | DESIGNED BY DESIGNER NAME DATE / REVIEWED BY SUPERVISOR NAME DATE / CHECKED BY CHECKER NAME DATE | ROAD PLANS / COUNTY NAME(S) | MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET | DITCH BLOCK SAMPLES / CSF = 0.9999999 / UPN NUMBER 12345678 | PROJECT NO. / SHEET 999 OF 999 |

## Sample Summary Frame

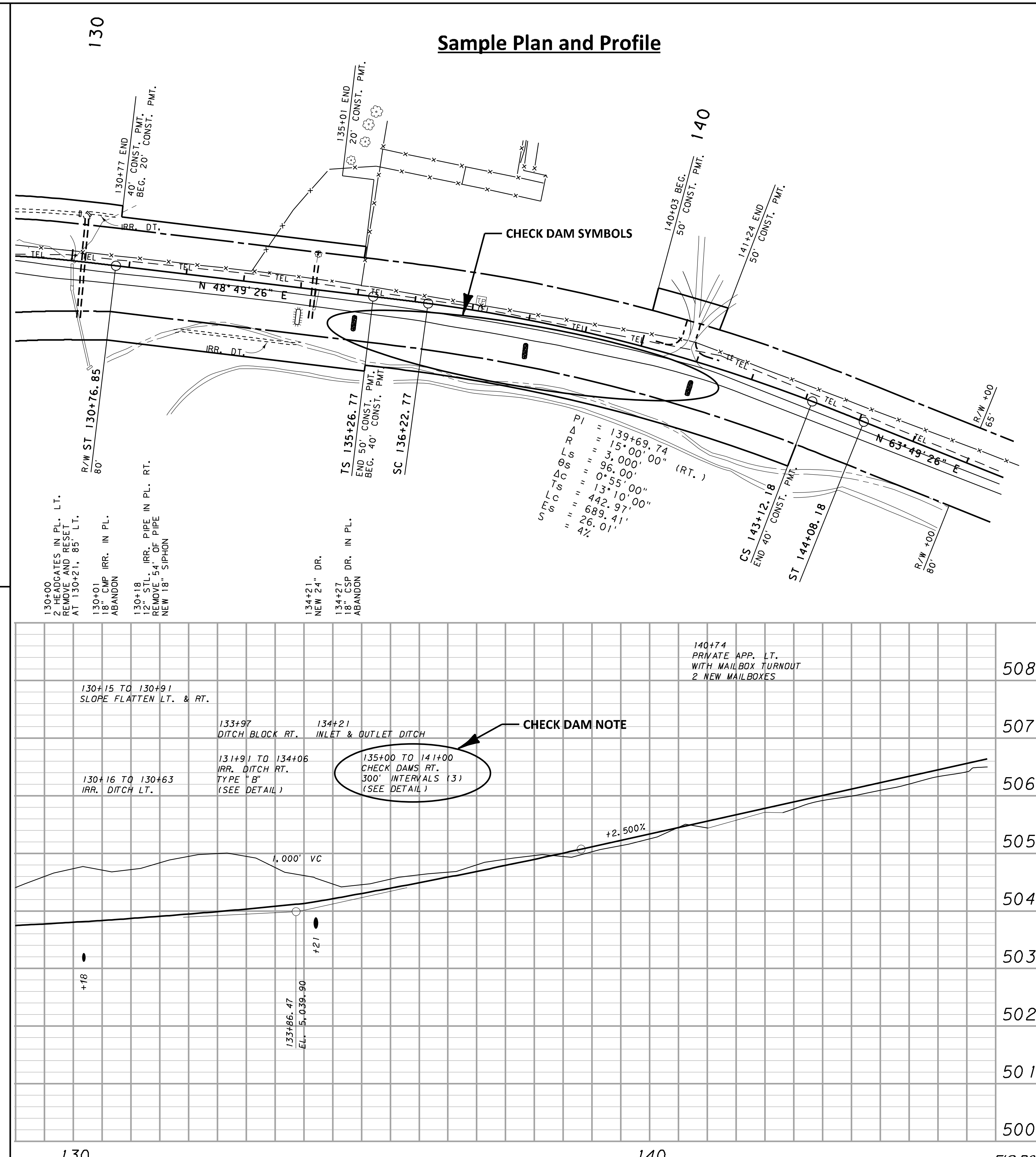
| CHECK DAMS | | | | |
|---|---|---|---|---|
| STATION | | AGGREGATE cubic yards | | REMARKS |
| | | CR. BASE COURSE TY.B GR.3 | | |
| FROM | TO | | | |
| 135+00 | 141+00 | 6 | | GRAVEL CHECK DAMS RT., 300 FT. INTERVALS (3) - SEE DETAIL |
| TOTAL | | 6 | | |

CHECK DAM SUMMARY ENTRY

*Check Dam Reminders:*

1. *See Section A2 for additional check dam information.*
2. *Vary items as necessary in summary frame for vegetated earth berm, gravel, or inverted check dams.*

## Sample Plan and Profile




## Sample Cross Section

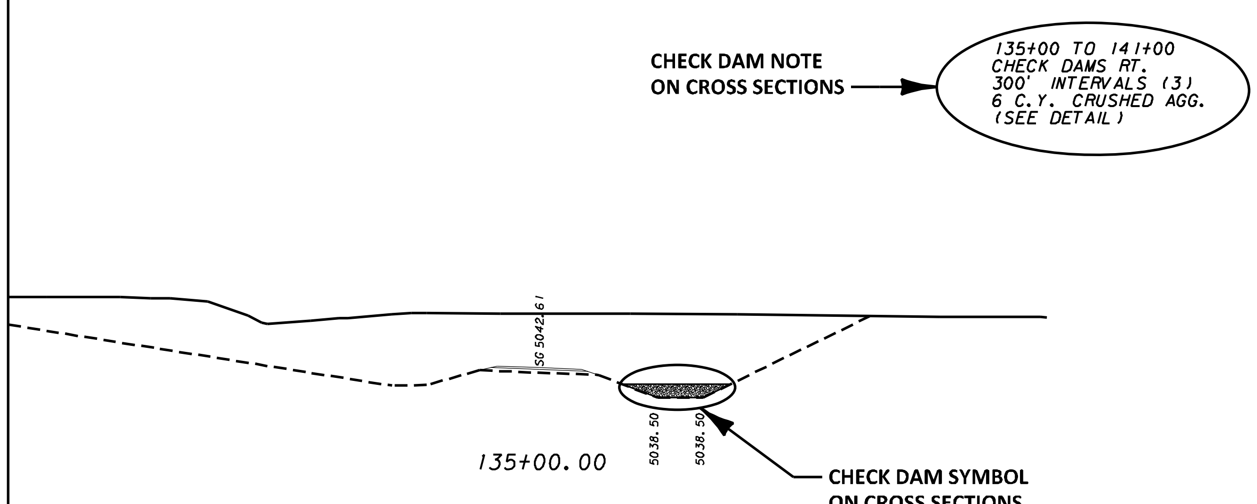
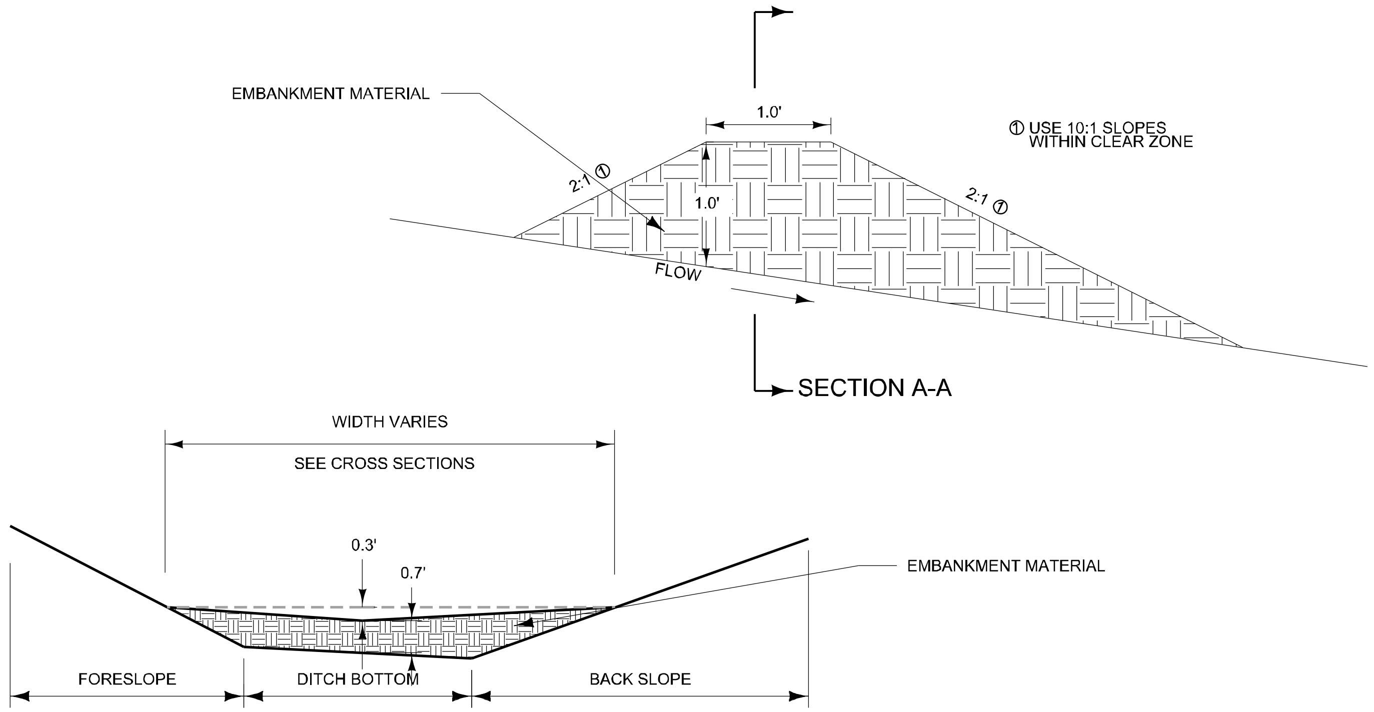



FIG B2-1

## VEGETATED EARTH CHECK DAM

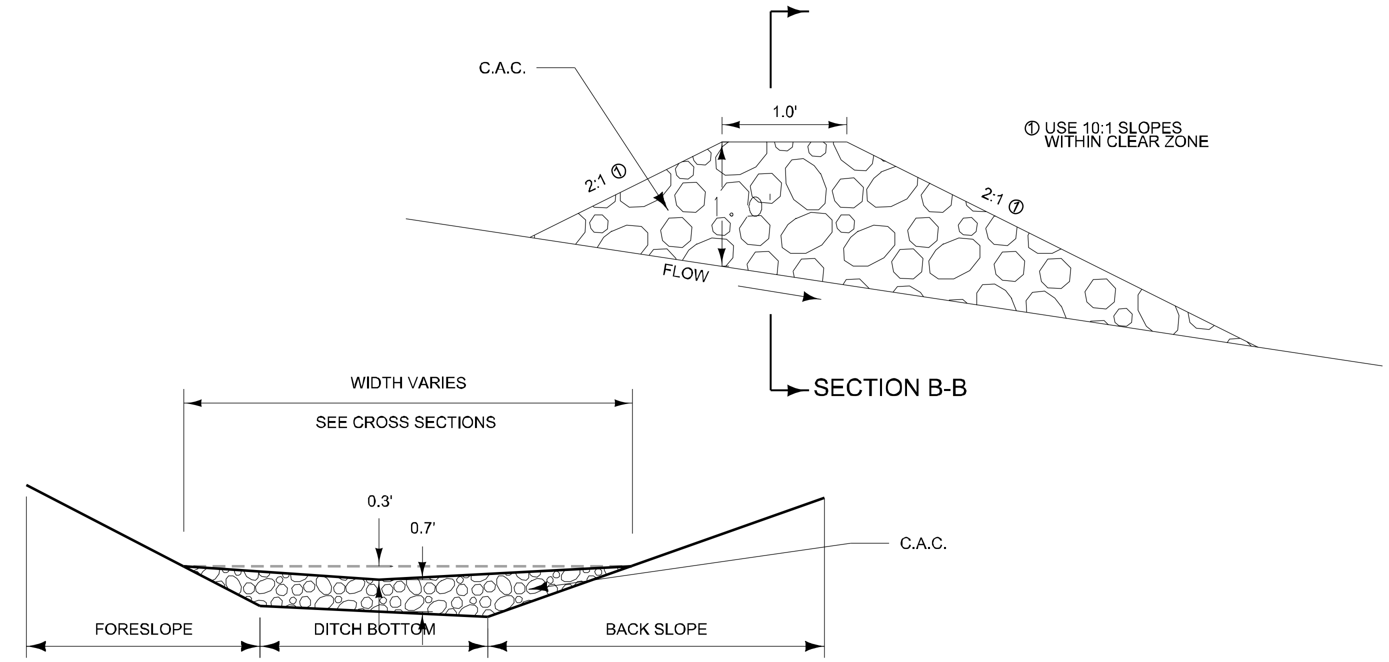
DRAWING NOT TO SCALE




SECTION A-A

## GRAVEL CHECK DAM

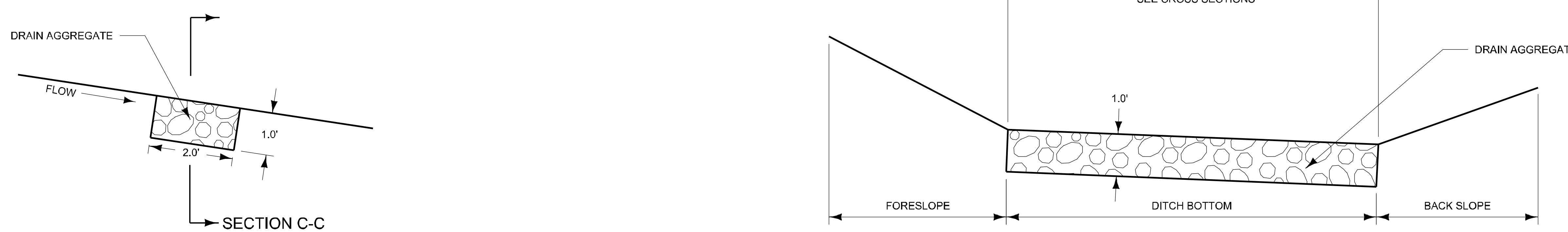
DRAWING NOT TO SCALE




SECTION B-B

## INVERTED CHECK DAM

DRAWING NOT TO SCALE




SECTION C-C

FIG. B2-2

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3 / 2 / 1 | MDT MONTANA DEPARTMENT OF TRANSPORTATION | ...\Dgn\PESCMANRDB02002.dgn<br>9/25/2017<br>8:52:18 AM u2373 | DESIGNED BY DESIGNER NAME DATE<br>REVIEWED BY SUPERVISOR NAME DATE<br>CHECKED BY CHECKER NAME DATE | ROAD PLANS<br>COUNTY NAME(S) | *MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET* | **SAMPLE LINED DITCH DETAILS**<br>CSF = 0.9999999 UPN NUMBER 12345678 | PROJECT NO.<br>SHEET 999 OF 999 |

## Sample Summary Frames

| PLANT MIX LINED DITCH * | | | | | |
|---|---|---|---|---|---|
| STATION | | linear feet | tons | | REMARKS |
| | | PL. MIX LINED DITCH | PL. MIX SURF. GR. S | ASPHALT CEMENT PG 64-28 | |
| FROM | TO | | | | |
| 123+65 | 128+75 | 510.0 | 12 | 4 | LT. |
| 134+20 | 142+75 | 855.0 | 24 | 8 | RT. |
| TOTAL | | 1365.0 | # 36 | # 12 | |

* SEE DETAIL SHEET
\# FOR INFORMATION ONLY

PLANT MIX LINED DITCH SUMMARY FRAME

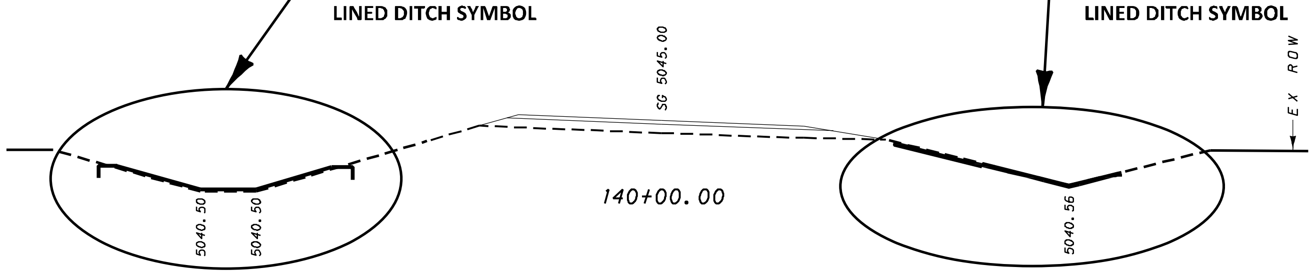
| ROLLED EROSION CONTROL | | | | |
|---|---|---|---|---|
| STATION | | square yards | | REMARKS |
| | | TURF REINFORCEMENT MAT - SYNTHETIC | HIGH PERFORMANCE BLANKET | |
| FROM | TO | | | |
| 135+27 | 140+50 | 698 | | DITCH LT. - SEE DETAIL |
| TOTAL | | 698 | | |

ROLLED EROSION CONTROL SUMMARY FRAME

*Lined Ditch Reminders:*

1. *Use Random Riprap frame as shown in the sample plans of the Road Design Manual for riprap lined ditches.*
2. *See the Road Design Manual sample plans for other applicable notes.*
3. *See Detail Drawing 610-05 for rolled erosion control lined ditches.*
4. *See Section A3 of the Permanent Erosion and Sediment Control Manual for additional information on lined ditches.*

## Sample Cross Section




EXAMPLE LINED DITCH NOTES

134+20 TO 142+75
855 L.F. PL. MIX LINED DITCH RT.
SEE DETAIL

135+27 TO 140+50
698 S.Y. TURF REINFORCEMENT
MAT-SYNTHETIC LT. SEE DETAILED
DRAWING OR PLAN DETAIL

## Sample Plan and Profile

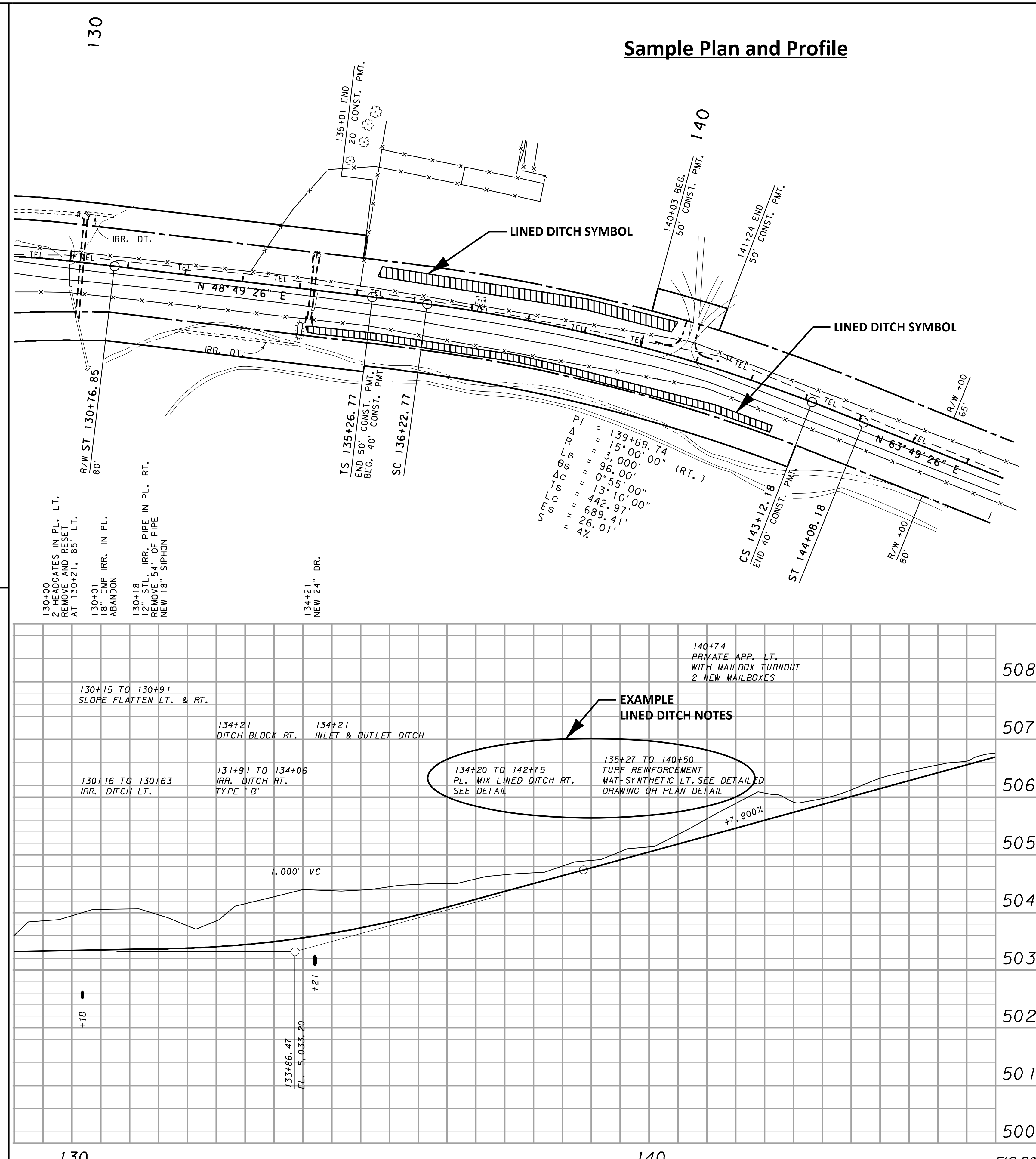
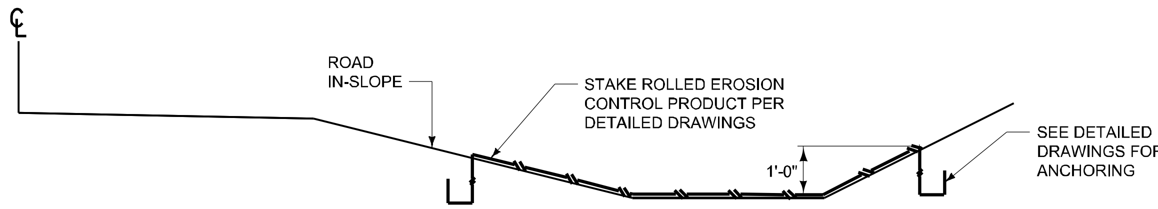
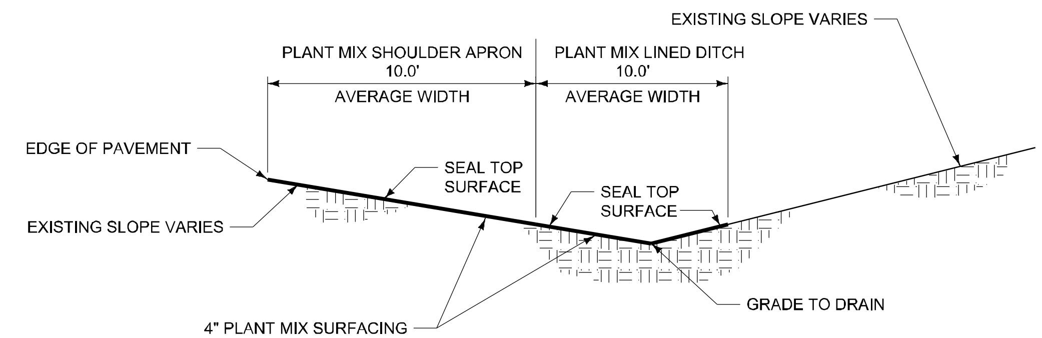



*FIG B3-1*

| | | | | |
|---|---|---|---|---|
| MDT MONTANA DEPARTMENT OF TRANSPORTATION | ...\Dgn\PESCMANRDB03001.dgn 9/25/2017 8:52:46 AM u2373 | DESIGNED BY *DESIGNER NAME* *DATE* | ROAD PLANS | *MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET* |
| | | REVIEWED BY *SUPERVISOR NAME* *DATE* | COUNTY NAME(S) | LINED DITCH SAMPLES |
| | | CHECKED BY *CHECKER NAME* *DATE* | | CSF = 0.9999999 UPN NUMBER 12345678 |
| | | | | PROJECT NO. SHEET 999 OF 999 |

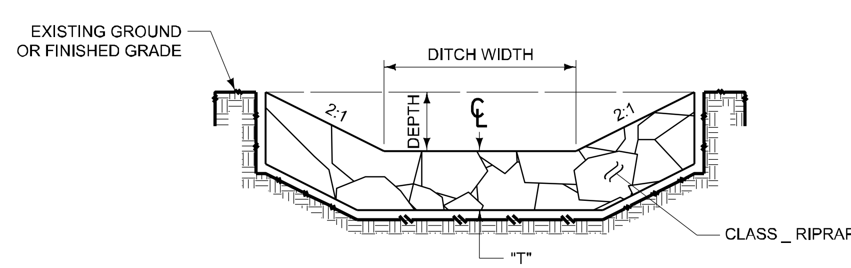



ROLLED EROSION CONTROL LINED DITCH




PLANT MIX LINED DITCH

RESHAPE AND COMPACT EXISTING SLOPES AS NECESSARY TO PROVIDE SUITABLE PAVING SURFACE. COMPACTION REQUIREMENTS FOR PLANT MIX AND GROUND ARE WAIVED BUT SUBJECT TO ENGINEER'S APPROVAL. RESHAPING PAID FOR WITH GRADER HOURS. COMPACTION TO BE INCLUDED IN COST OF OTHER ITEMS.




RIPRAP LINED DITCH

FIG. B3-2

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 3 | MDT MONTANA DEPARTMENT OF TRANSPORTATION | ...\Dgn\PESCMANRDB03002.DGN | DESIGNED BY | DESIGNER NAME | DATE | ROAD PLANS | MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET | SAMPLE LINED DITCH DETAILS | PROJECT NO. |
| 2 | | 9/25/2017 | REVIEWED BY | SUPERVISOR NAME | DATE | | | | |
| 1 | | 8:36:09 AM u2373 | CHECKED BY | CHECKER NAME | DATE | COUNTY NAME(S) | | CSF = 0.9999999 / UPN NUMBER 12345678 | SHEET 999 OF 999 |

## Sample Summary Frame

| LINED DITCH OUTLET SETTLING BASIN * | | | | |
|---|---|---|---|---|
| STATION | | square yards | cubic yards | REMARKS |
| | | TURF REINFORCEMENT MAT - SYNTHETIC | RIP RAP CLASS I | |
| FROM | TO | | | |
| 135+36.74 | 135+16.74 | 54 | 15 | DITCH LT. - SEE DETAIL |
| TOTAL | | 54 | 15 | |

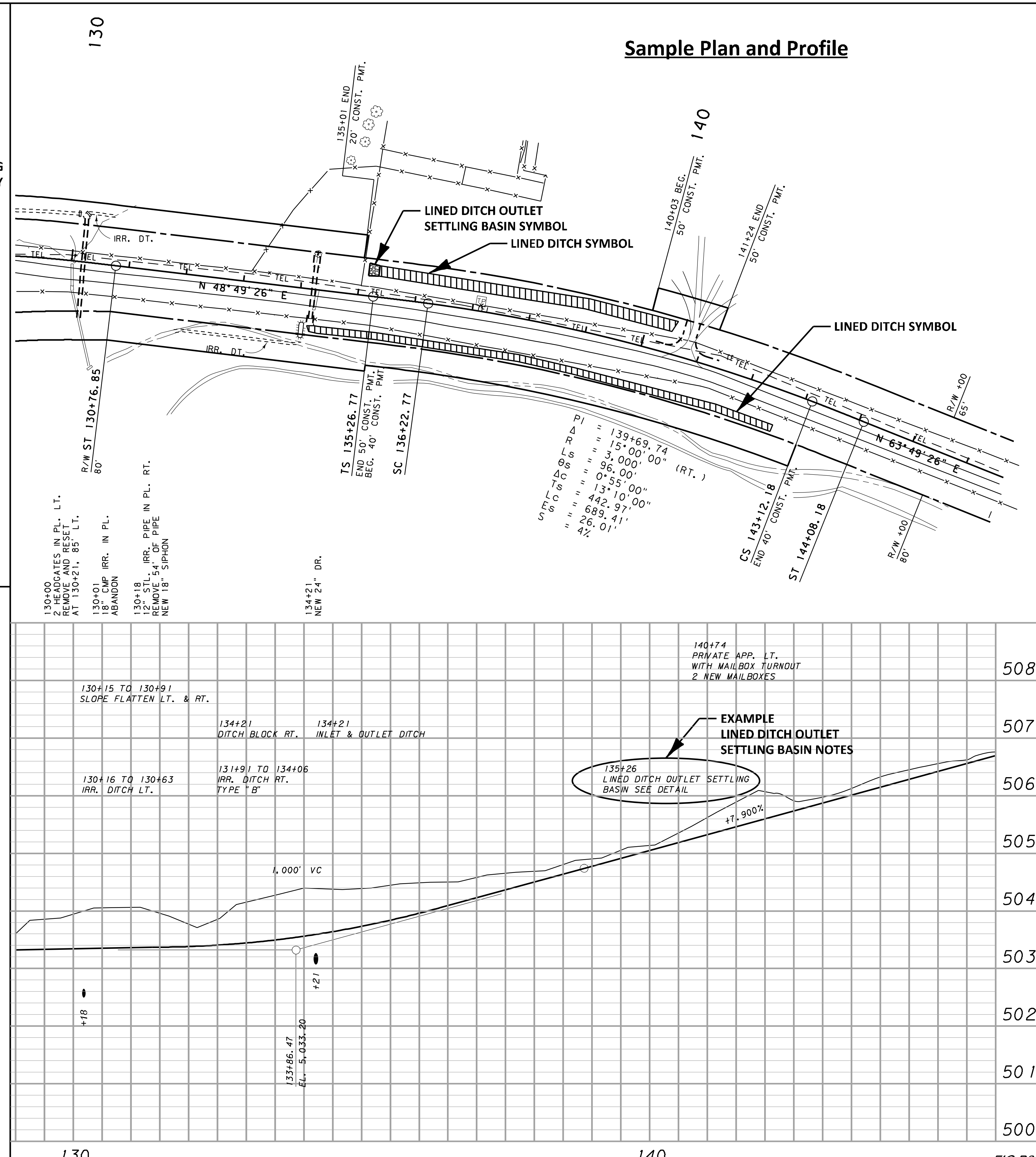
* SEE DETAIL SHEET

**LINED DITCH OUTLET SETTLING BASIN SUMMARY FRAME**

Outlet Settling Basin Reminders:

1. See the Road Design Manual sample plans for other applicable notes.
2. See Section A8 of the Permanent Erosion and Sediment Control Manual for additional information on lined ditch outlet settling basins.

## Sample Plan and Profile




## Sample Cross Section

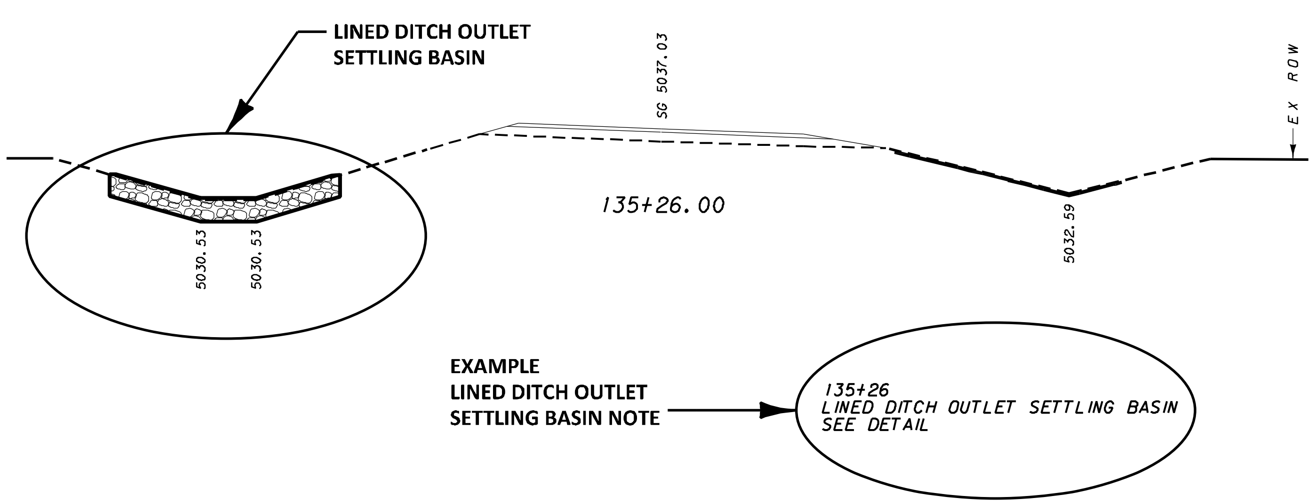
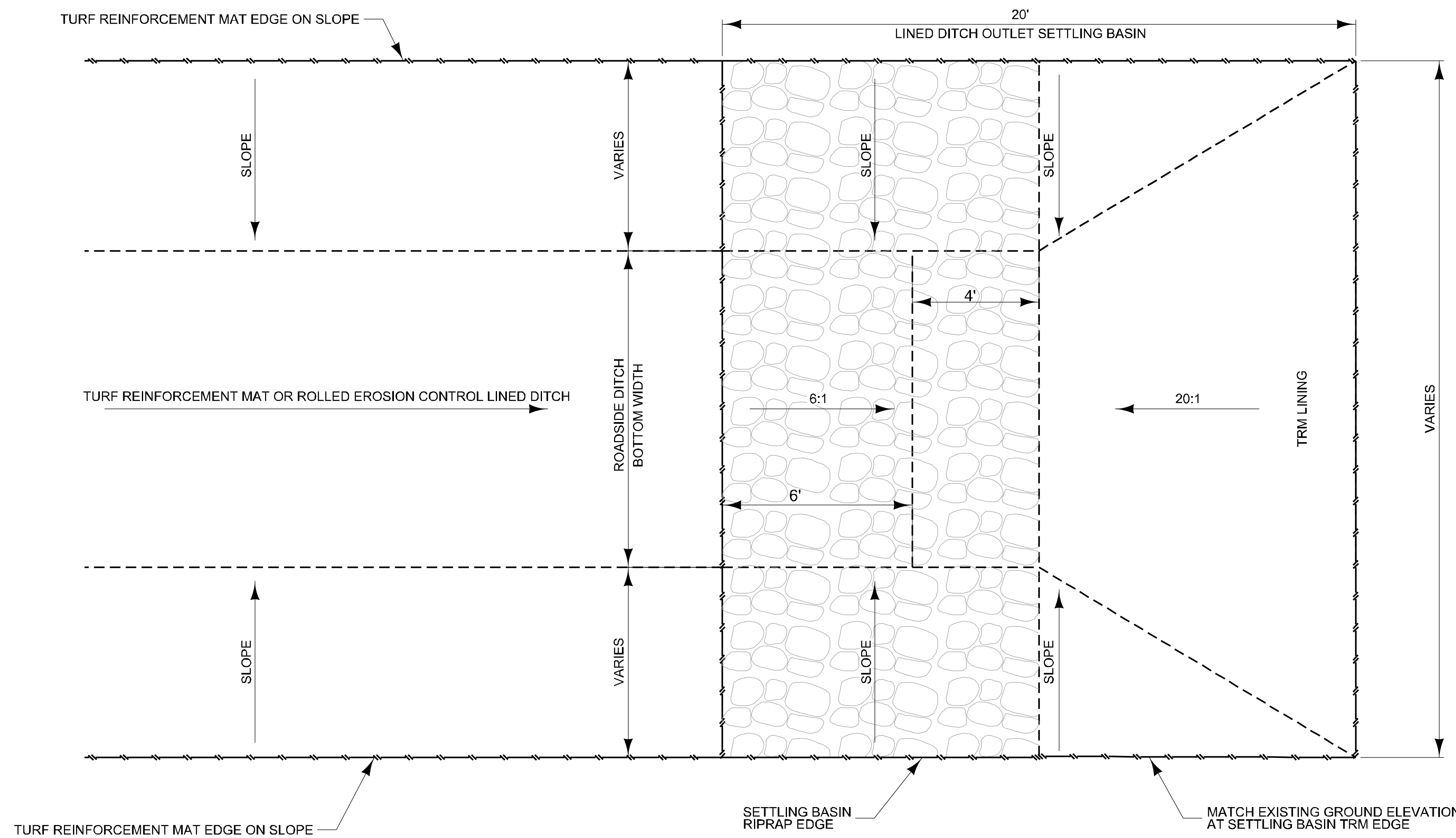
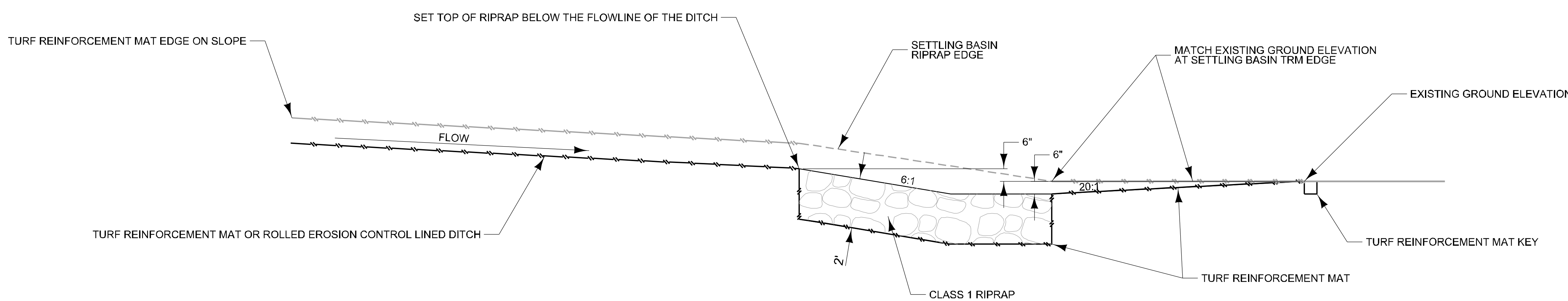



FIG B3-3

| | | | | | |
|---|---|---|---|---|---|
| MDT MONTANA DEPARTMENT OF TRANSPORTATION | ...\Dgn\PESCMANRDB03003.dgn 9/28/2017 9:18:28 AM u2373 | DESIGNED BY: DESIGNER NAME, DATE; REVIEWED BY: SUPERVISOR NAME, DATE; CHECKED BY: CHECKER NAME, DATE | ROAD PLANS / COUNTY NAME(S) | MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET | LINED DITCH OUTLET SETTLING BASIN SAMPLES / CSF = 0.9999999 / UPN NUMBER 12345678 | PROJECT NO. / SHEET 999 OF 999 |




PLAN VIEW




DITCH CENTERLINE PROFILE

FIG. B3-4

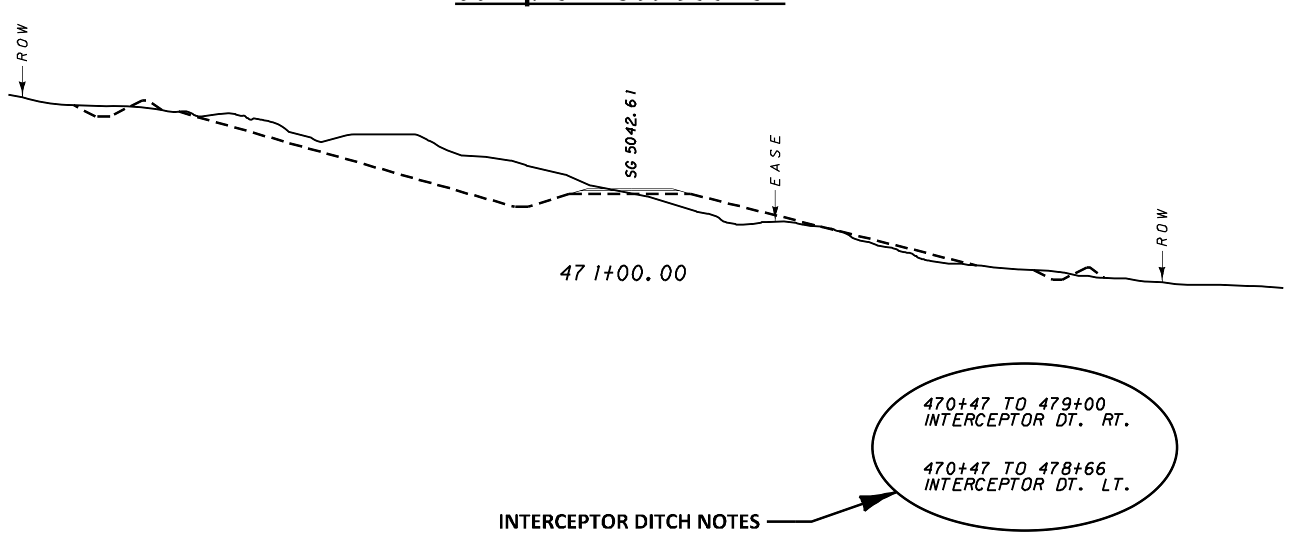
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3 2 1 | MDT MONTANA DEPARTMENT OF TRANSPORTATION | ...\Dgn\PESCMANRDB03004.dgn 9/25/2017 8:53:39 AM u2373 | DESIGNED BY / REVIEWED BY / CHECKED BY | DESIGNER NAME / SUPERVISOR NAME / CHECKER NAME | DATE / DATE / DATE | ROAD PLANS / COUNTY NAME (S) | MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET |

| | | |
|---|---|---|
| LINED DITCH OUTLET SETTLING BASIN DETAILS | | PROJECT NO. |
| CSF = 0.9999999 | UPN NUMBER 12345678 | SHEET 999 OF 999 |

***NOTE:***

***PAYMENT FOR UNLINED INTERCEPTOR DITCHES WILL BE INCLUDED IN MAINLINE OR ADDITIONAL GRADING QUANTITIES. NO ADDITIONAL SUMMARY FRAME NEEDED. SEE SECTION A3 FOR INTERCEPTOR DITCHES REQUIRING LINING.***

## Sample Cross Section




Interceptor Ditch Reminders:

① See Section A4 of the Permanent Erosion and Sediment Control Manual for further Interceptor Ditch details.

## Sample Plan and Profile

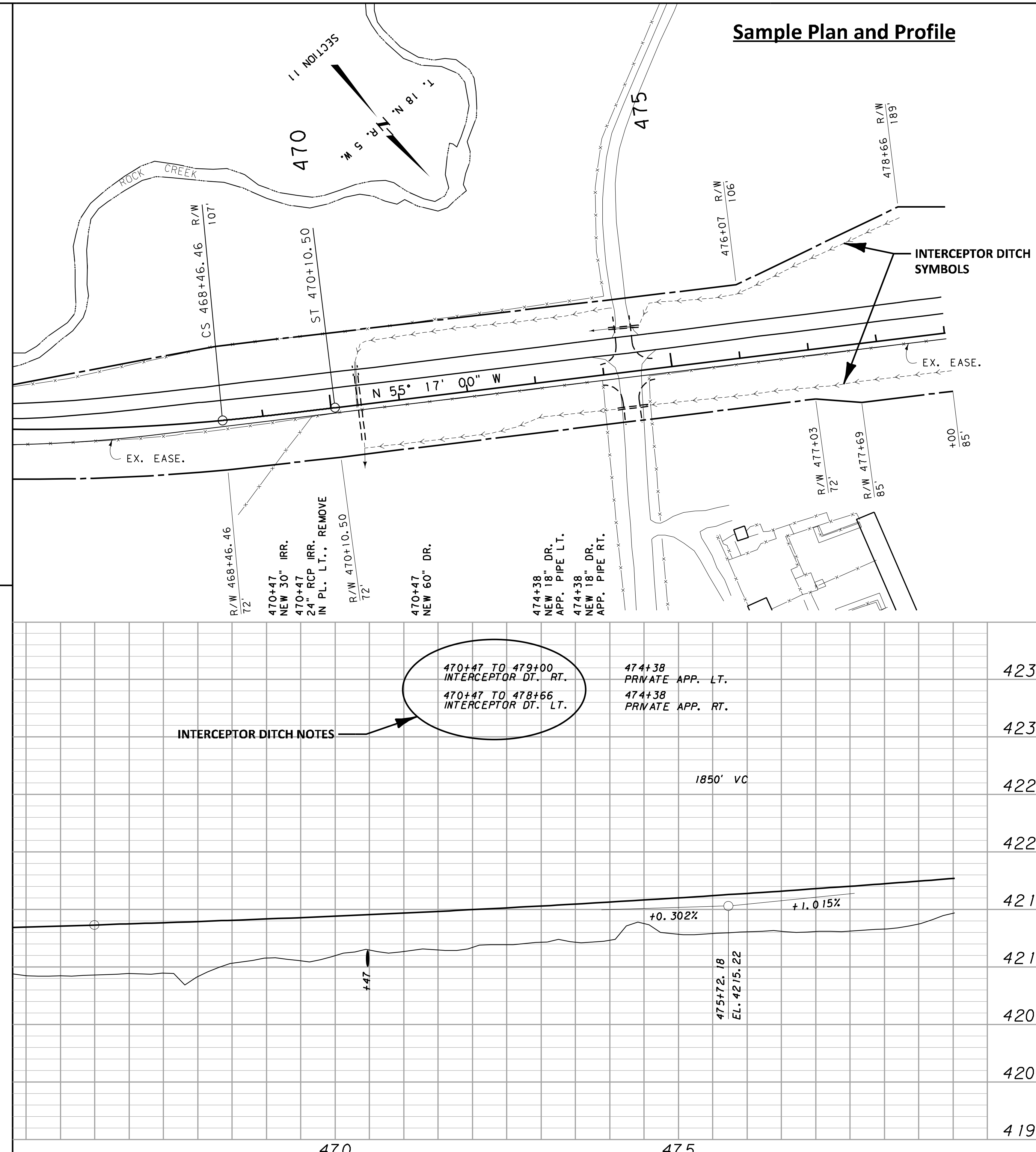
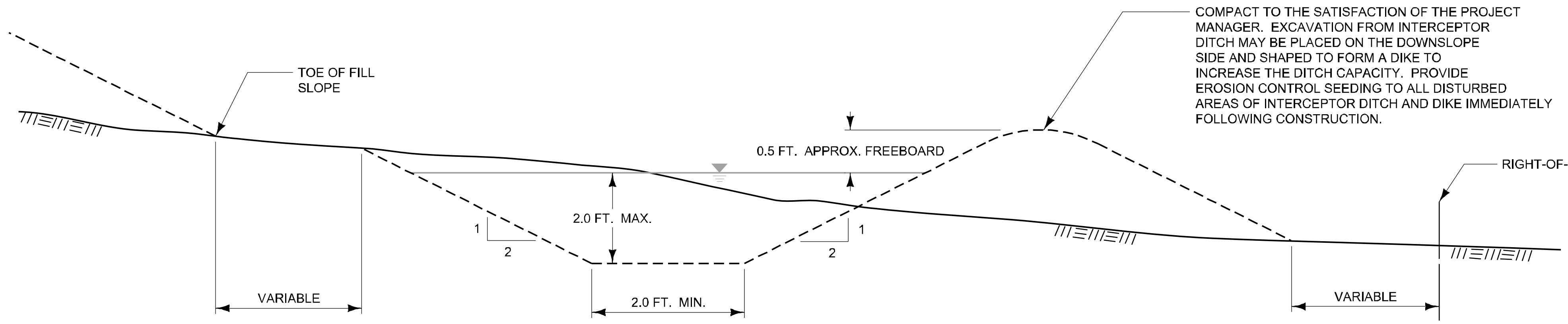



FIG B4-1

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| MDT MONTANA DEPARTMENT OF TRANSPORTATION | ...\Dgn\PESCMANRDB04001.dgn | DESIGNED BY | DESIGNER NAME | DATE | ROAD PLANS | MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET | INTERCEPTOR DITCH SAMPLES | PROJECT NO. |
| | 9/25/2017 | REVIEWED BY | SUPERVISOR NAME | DATE | | | | |
| | 8:54:15 AM u2373 | CHECKED BY | CHECKER NAME | DATE | COUNTY NAME(S) | | CSF = 0.9999999 / UPN NUMBER 12345678 | SHEET 999 OF 999 |

## INTERCEPTOR DITCH AT TOE OF SLOPE

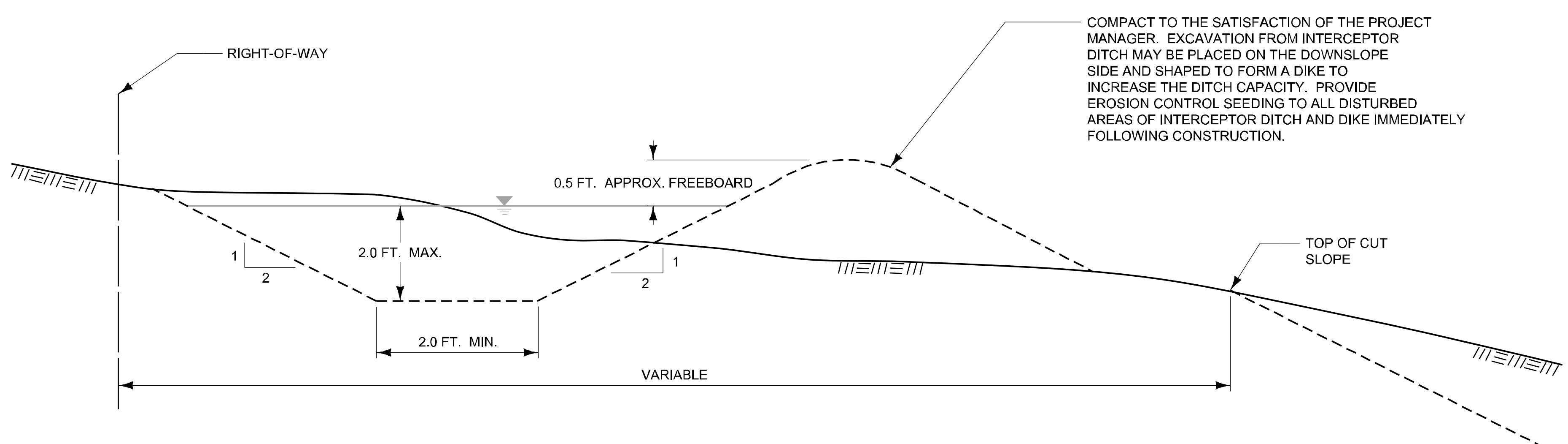



*Interceptor Ditch Reminders*:

① *Dimensions shown are preliminary only. Final dimensions to be determined by the Hydraulics Section.*

② *See Chapter A4 of the Permanent Erosion and Sediment Control Manual for additional guidance.*

## INTERCEPTOR DITCH AT TOP OF CUT




*Interceptor Ditch Reminders*:

① *Dimensions shown are preliminary only. Final dimensions to be determined by the Hydraulics Section.*

② *See Chapter A4 of the Permanent Erosion and Sediment Control Manual for additional guidance.*

INTERCEPTOR DITCH DETAIL

NO SCALE

*FIG B4-2*

| | | | | | |
|---|---|---|---|---|---|
| 3 / 2 / 1 | MDT MONTANA DEPARTMENT OF TRANSPORTATION | ...\Dgn\PESCMANRDB04002.dgn<br>9/25/2017<br>8:54:44 AM u2373 | DESIGNED BY *DESIGNER NAME* *DATE*<br>REVIEWED BY *SUPERVISOR NAME* *DATE*<br>CHECKED BY *CHECKER NAME* *DATE* | ROAD PLANS<br>COUNTY NAME(S) | *MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET* |

| | | |
|---|---|---|
| **INTERCEPTOR DITCH SAMPLE DETAILS** | | PROJECT NO. |
| CSF = 0.9999999 | UPN NUMBER 12345678 | SHEET 999 OF 999 |

## Sample Summary Frame

| EMBANKMENT PROTECTORS | | | | | | | |
|---|---|---|---|---|---|---|---|
| STATION | | linear feet | | | | cubic yards | REMARKS |
| | | EMBANKMENT PROTECTOR 18" | | CONCRETE CURB | | BANK PROTEC-TION | |
| FROM | TO | LEFT | RIGHT | LEFT | RIGHT | TYPE 3 | |
| 136+60.00 | 141+85.00 | | | | 525.0 | | MAINLINE |
| 136+80.00 | | | 50 | | | 1.5 | 25 DEGREE ELBOW |
| SUBTOTAL | | | 50 | | 525.0 | 1.5 | |
| TOTAL | | 50 | | 525.0 | | 1.5 | |

CHANNELIZING CURB SUMMARY ENTRY

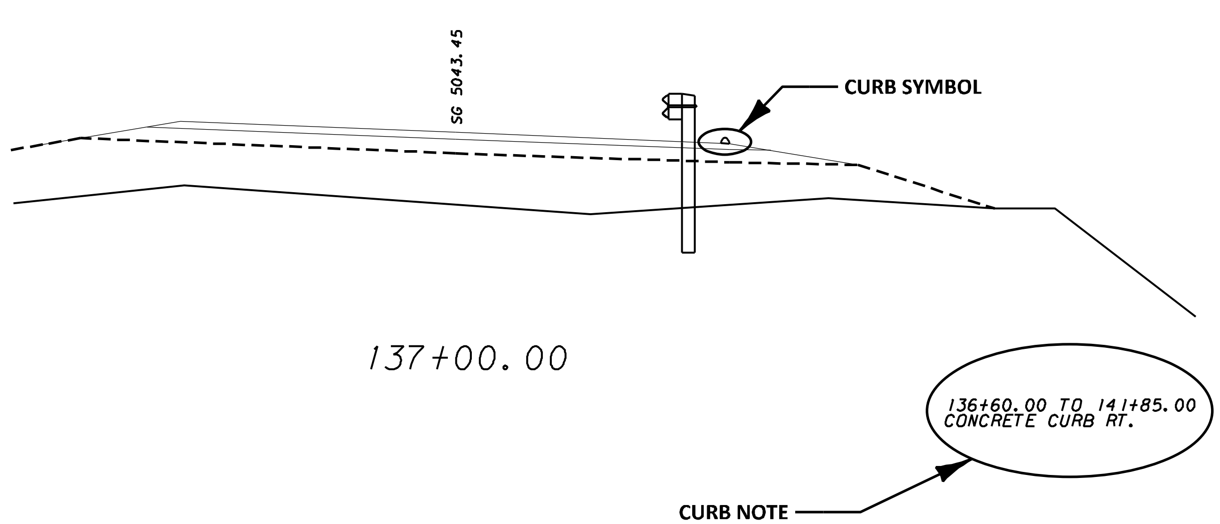
*Channelizing Curb Reminders:*

① See Detail Drawing 609-05 for additional curb details.

② See Detail Drawing 603-28 when using curb in conjunction with guardrail and embankment protectors. Use maximum of 4" high curbs with guardrail.

③ See Figure B6-1 for embankment protector sample drawing.

## Sample Cross Section




## Sample Plan and Profile

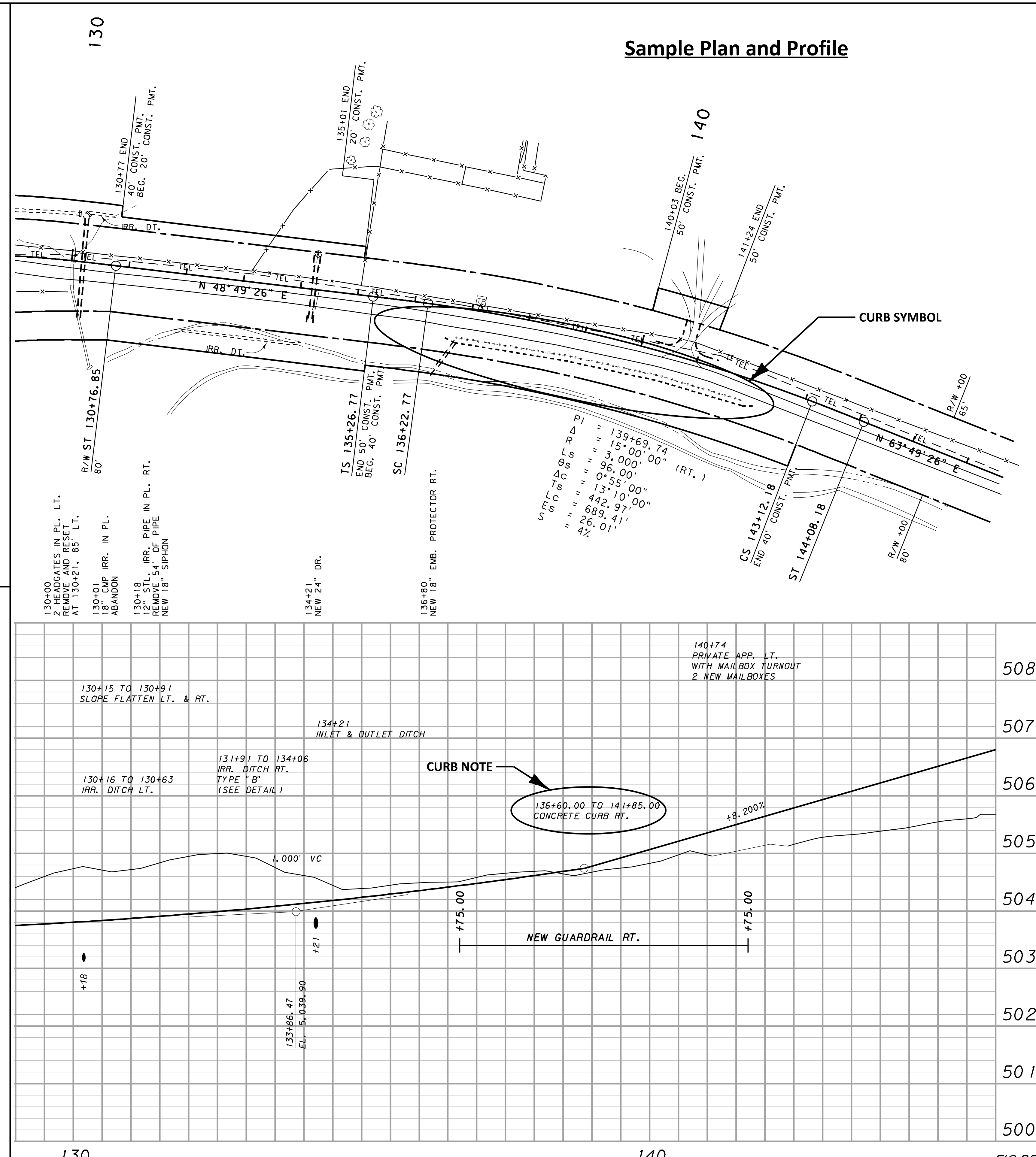



FIG B5-1

| | | | | | |
|---|---|---|---|---|---|
| MDT MONTANA DEPARTMENT OF TRANSPORTATION | ...\Dgn\PESCMANRDB05001.dgn<br>9/25/2017<br>8:55:12 AM u2373 | DESIGNED BY DESIGNER NAME DATE<br>REVIEWED BY SUPERVISOR NAME DATE<br>CHECKED BY CHECKER NAME DATE | ROAD PLANS<br>COUNTY NAME(S) | MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET | CHANNELIZING CURB SAMPLES<br>CSF = 0.9999999 UPN NUMBER 12345678 |
| | | | | | PROJECT NO.<br>SHEET 999 OF 999 |

## Sample Summary Frame

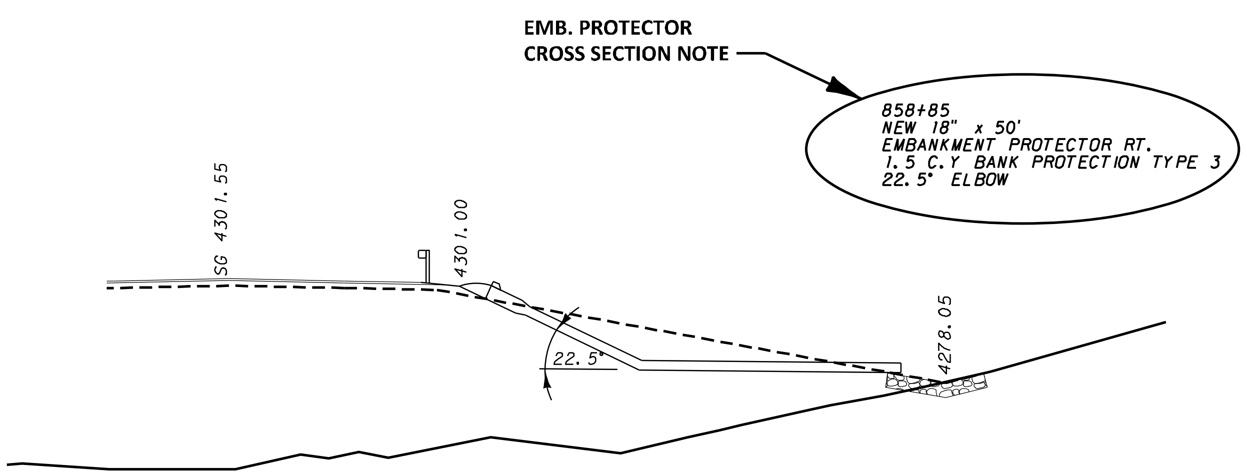
| EMBANKMENT PROTECTORS | | | | | | | |
|---|---|---|---|---|---|---|---|
| STATION | | linear feet | | | | cubic yards | REMARKS |
| | | EMBANKMENT PROTECTOR* 18" | | CONCRETE CURB | | BANK PROTEC-TION | |
| FROM | TO | LEFT | RIGHT | LEFT | RIGHT | TYPE 3 | |
| 852+50 | 858+85 | | | | 635.0 | | |
| 857+80 | 858+85 | | | 105.0 | | | |
| 858+85 | | 50 | 50 | | | 1.5 | 22.5° ELBOW (1) |
| 859+95 | 863+25 | | | | 330.0 | | |
| 859+95 | 865+15 | | | 520.0 | | | |
| 861+10 | | 50 | 50 | | | 1.5 | 40° ELBOW (1) |
| SUBTOTAL | | 100 | 100 | 625.0 | 965.0 | | |
| TOTAL | | 200 | | 1590.0 | | 3.0 | |

* CULVERT EXC. INCLUDED IN COST OF EMB. PROTECTOR

*Embankment Protector Reminders;*

1. *Specify degree of bend on elbow.*
2. *See Detail Drawing 603-28 when using an Embankment Protector in conjuction with Curb and Guardrail.*
3. *See Road Design Manual drainage facilities section for Embankment Protector criteria.*

## Sample Cross Section




858+85.00

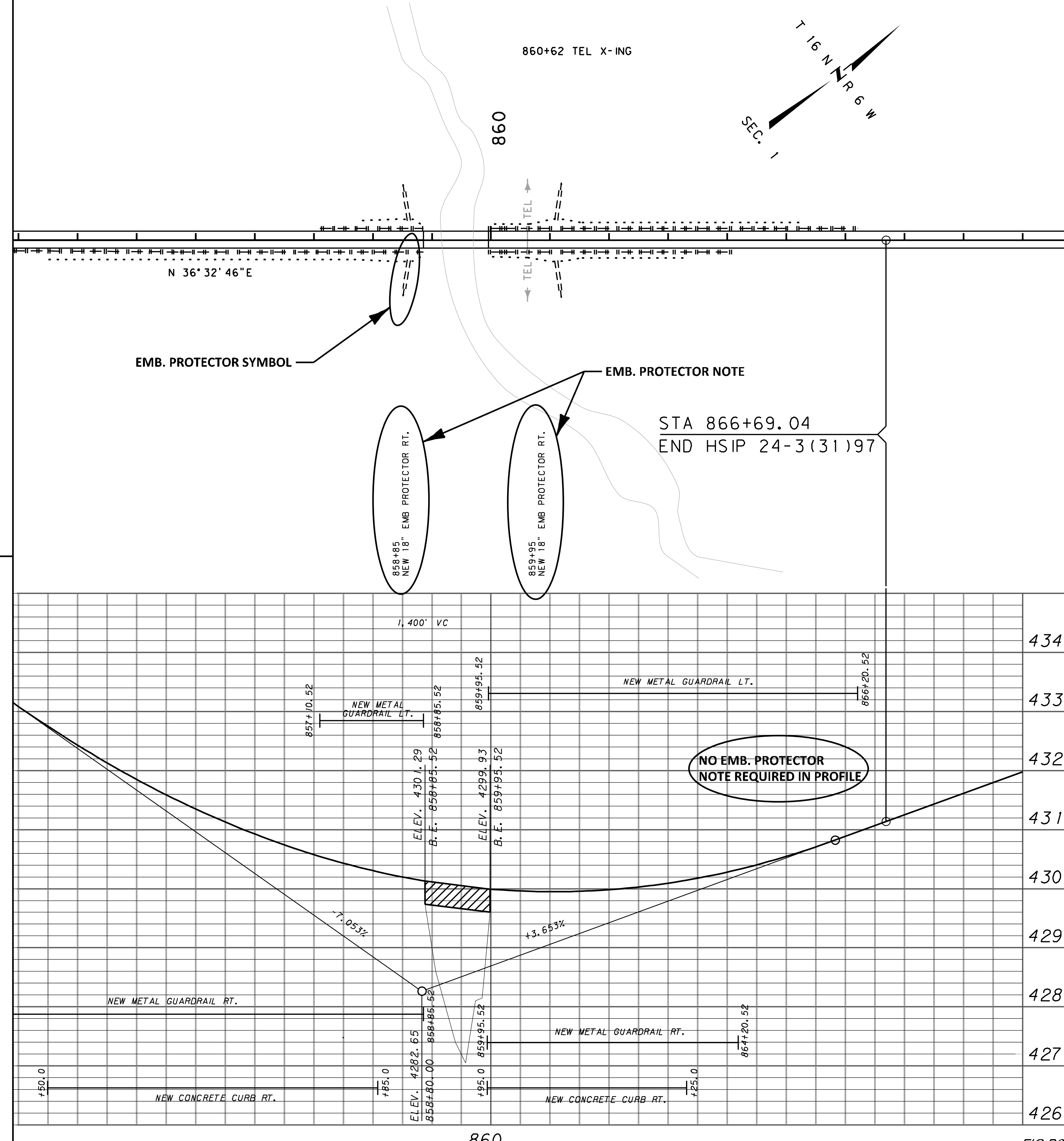



FIG B6-1

| | | | | | |
|---|---|---|---|---|---|
| MDT MONTANA DEPARTMENT OF TRANSPORTATION | ...\Dgn\PESCMANRDB06001.dgn 9/25/2017 8:55:37 AM u23?3 | DESIGNED BY: DESIGNER NAME DATE; REVIEWED BY: SUPERVISOR NAME DATE; CHECKED BY: CHECKER NAME DATE | ROAD PLANS / COUNTY NAME(S) | *MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET* | PROJECT NO. |
| | | | | EMBANKMENT PROTECTOR SAMPLES / CSF = 0.9999999 / UPN NUMBER 12345678 | SHEET 999 OF 999 |

## Sample Summary Frame

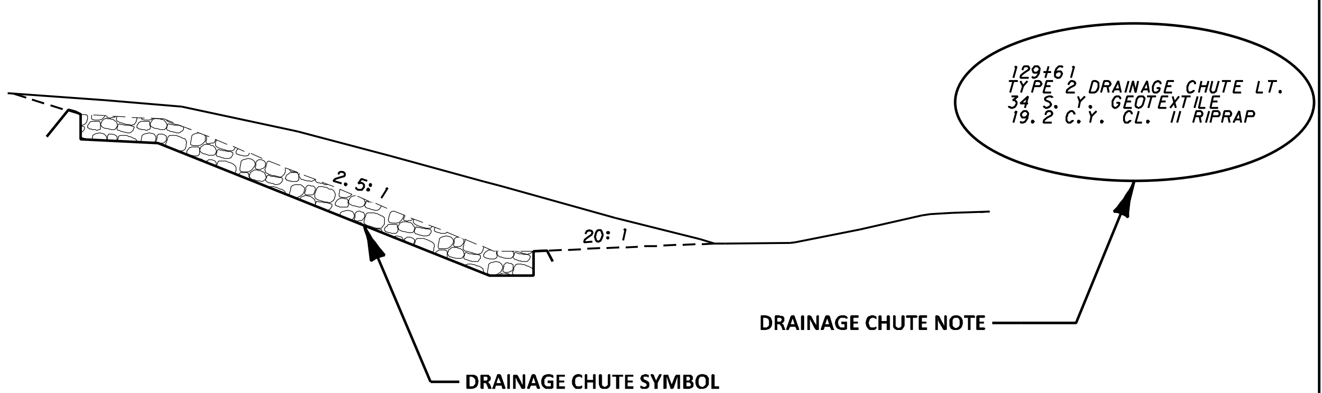
| RANDOM RIPRAP | | | | | |
|---|---|---|---|---|---|
| STATION | | cubic yards<br>RANDOM RIPRAP | | square yards<br>GEOTEXTILE<br>PERM. EROS. CNTRL.<br>HIGH SURV. CLASS B | REMARKS |
| FROM | TO | CL. II | CL. | | |
| 129+61 | | 19.2 | | 34 | RAMP "C4" - TYPE 2 DRAINAGE CHUTE LT. |
| 132+23 | | 46.8 | | 73 | RAMP "C4" - TYPE 3 DRAINAGE CHUTE LT. |
| 132+45 | | 7.0 | | 15 | RAMP "C4" - OUTLET DITCH RT. |
| 135+81 | | 59.0 | | 59 | RAMP "C4" - TYPE 3 DRAINAGE CHUTE LT. |
| TOTAL | | 132.0 | | 181 | |

**DRAINAGE CHUTE SUMMARY ENTRY**

*Drainage Chute Reminders:*

1. *See the BMP Manual for additional geotextile details.*
2. *See Detail Drawing 613-18 for additional drainage chute details.*
3. *See Chapter A7 of the Permanent Erosion and Sediment Control Manual for additional guidance.*

## Sample Cross Section (Backslopes)




## Sample Plan and Profile

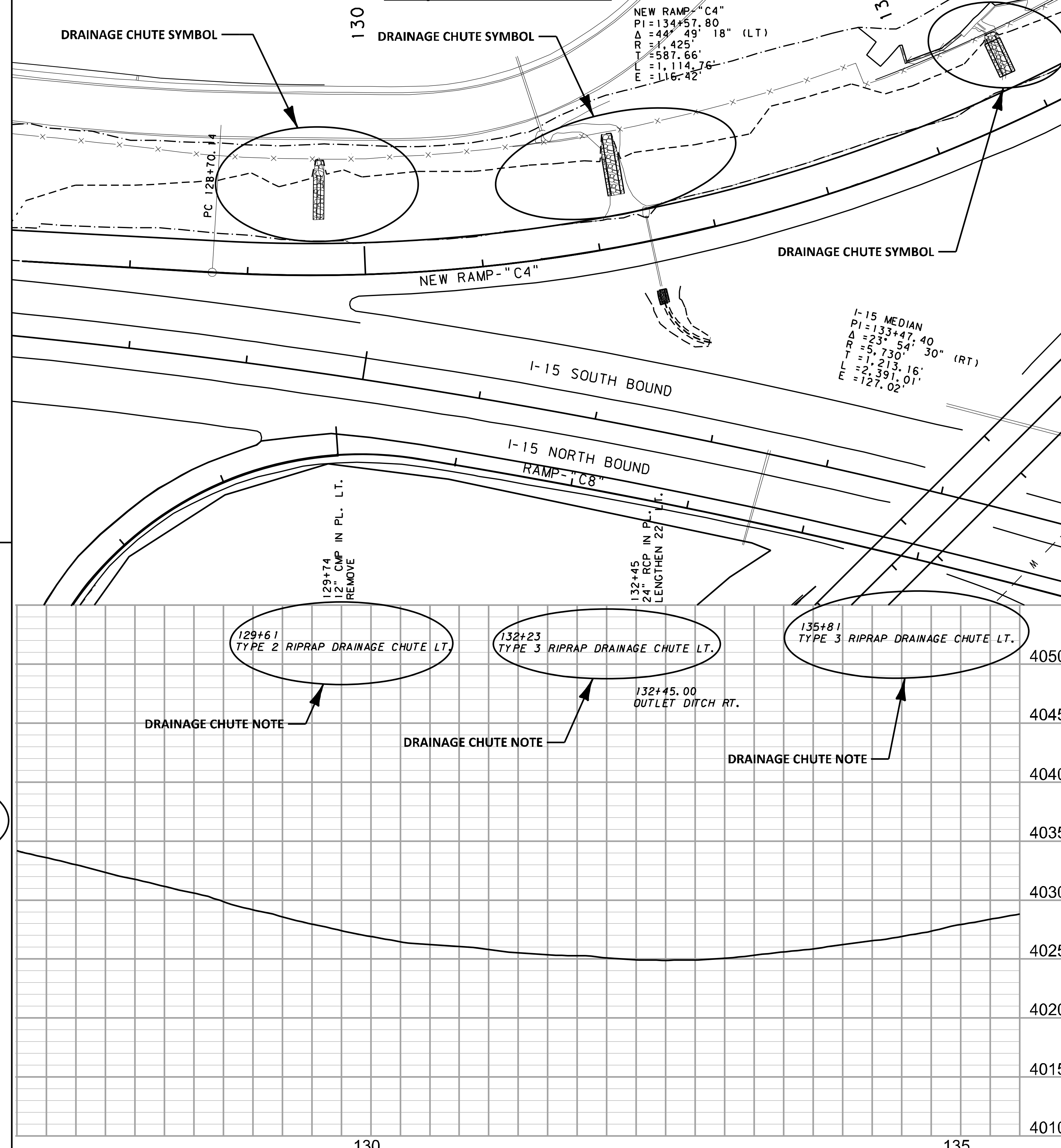



FIG B7-1

| | | | | | |
|---|---|---|---|---|---|
| MDT MONTANA DEPARTMENT OF TRANSPORTATION | ...\Dgn\PESCMANRDB07001.dgn<br>9/25/2017<br>8:56:04 AM u2373 | DESIGNED BY DESIGNER NAME DATE<br>REVIEWED BY SUPERVISOR NAME DATE<br>CHECKED BY CHECKER NAME DATE | ROAD PLANS<br>COUNTY NAME(S) | MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET | DRAINAGE CHUTE SAMPLES : BACKSLOPES<br>CSF = 0.9999999 UPN NUMBER 12345678 | PROJECT NO.<br>SHEET 999 OF 999 |

## Sample Summary Frame

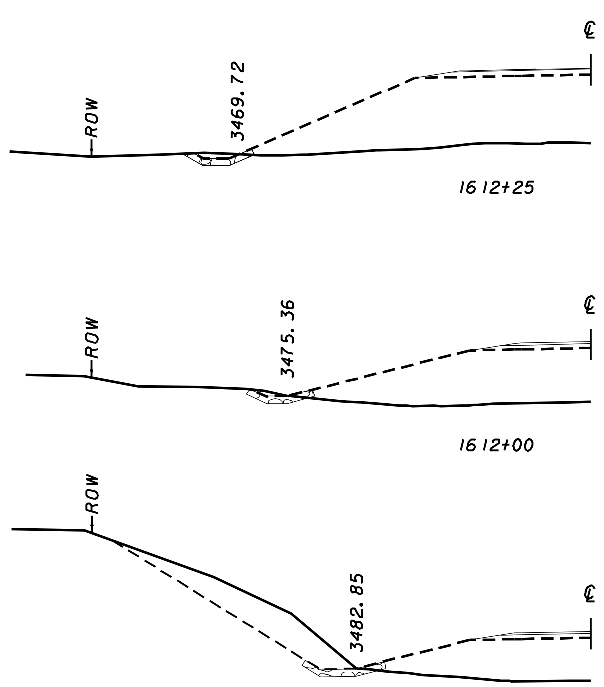
| DRAINAGE CHUTES | | | | |
|---|---|---|---|---|
| STATION | | cubic yards | square yards | REMARKS |
| | | RANDOM RIPRAP | GEOTEXTILE PERM. EROS. CNTRL. | |
| FROM | TO | CL. 2 | HIGH SURV. CLASS B | |
| 1611+50 | 1612+50 | 64.0 | 145 | TYPE 3 DRAINAGE CHUTE LT. |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| TOTAL | | 64.0 | 145 | |

**DRAINAGE CHUTE SUMMARY ENTRY**

*Drainage Chute Reminders:*

1. *See the BMP Manual for additional geotextile details.*
2. *See Detail Drawing 613-18 for additional drainage chute details, including material options.*
3. *See Chapter A7 of the Permanent Erosion and Sediment Control Manual for additional guidance.*

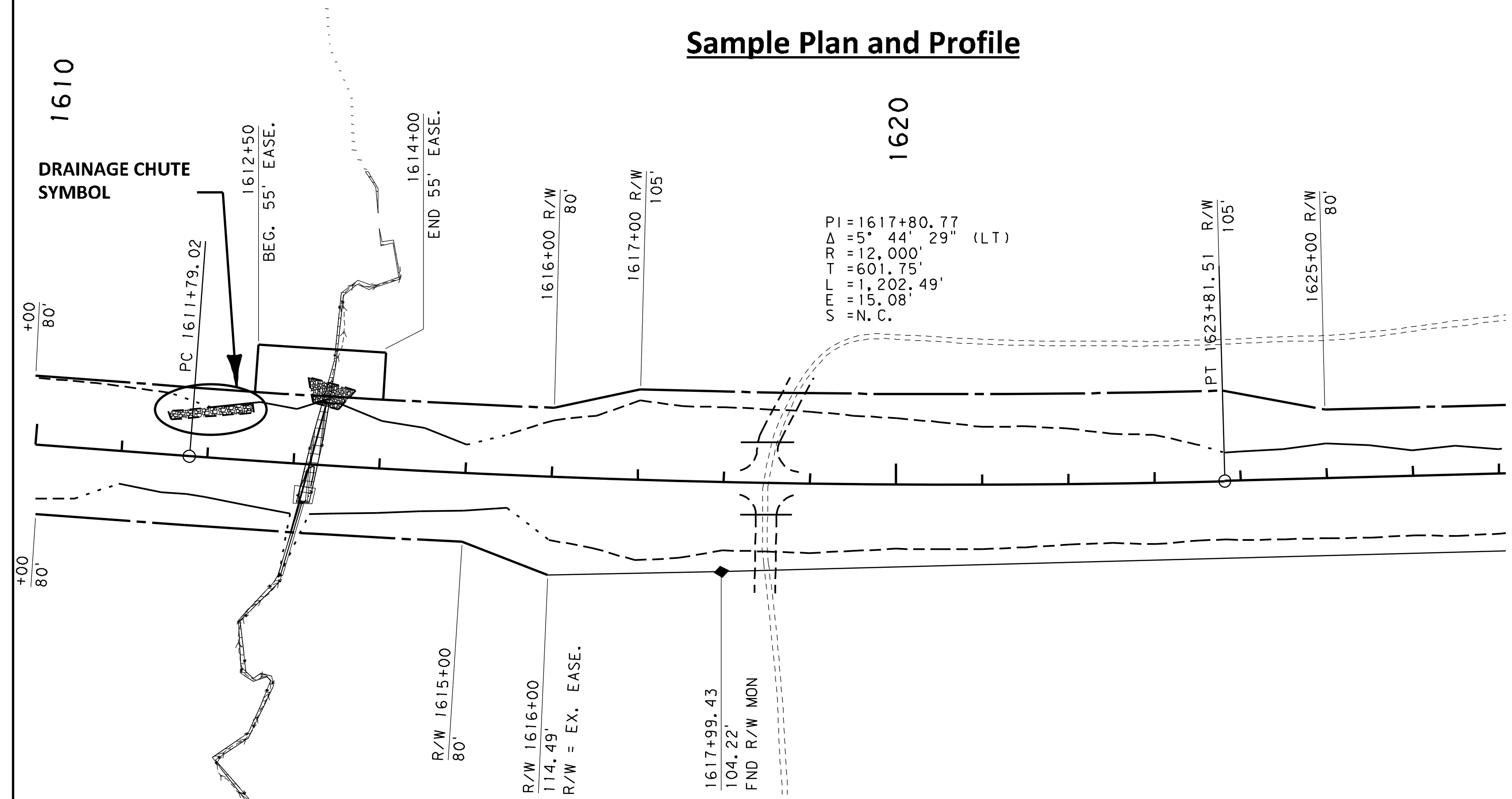
## Sample Cross Section (Cut To Fill)




16 11+50 TO 16 12+50
TYPE 3 RIPRAP DRAINAGE CHUTE LT.
145 S.Y. GEOTEXTILE
64.0 C.Y. CL. 2 RIPRAP

**DRAINAGE CHUTE NOTE**

## Sample Plan and Profile




**DRAINAGE CHUTE NOTE**

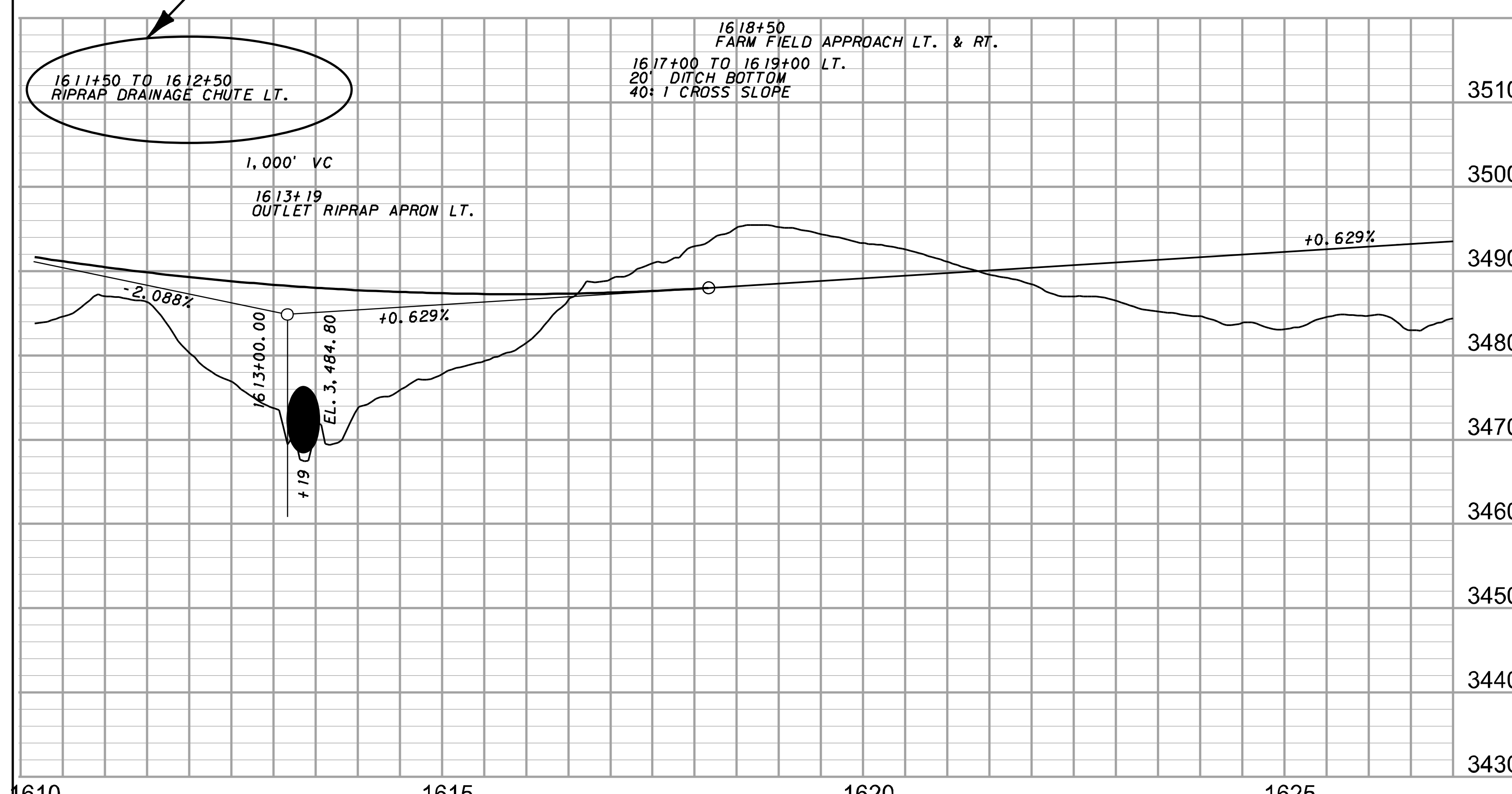



FIG B7-2

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| MDT MONTANA DEPARTMENT OF TRANSPORTATION | ...\Dgn\PESCMANRDB07002.dgn 9/25/2017 8:56:29 AM u2373 | DESIGNED BY: DESIGNER NAME DATE; REVIEWED BY: SUPERVISOR NAME DATE; CHECKED BY: CHECKER NAME DATE | ROAD PLANS / COUNTY NAME(S) | MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET | DRAINAGE CHUTE SAMPLES : CUT TO FILL | CSF = 0.9999999 / UPN NUMBER 12345678 | PROJECT NO. / SHEET 999 OF 999 |

## Sample Summary Frame

| RANDOM RIPRAP | | | | | | |
|---|---|---|---|---|---|---|
| STATION | | cubic yards | | square yards | | REMARKS |
| | | RANDOM RIPRAP | | GEOTEXTILE | | |
| | | | | PERM. EROS. CNTRL. | | |
| FROM | TO | CL. 2 | CL. 3 | MOD SURV. CLASS A | HIGH SURV. CLASS A | |
| 351+51.00 | | 141.4 | | 254 | | OUTLET APRON RT. |
| TOTAL | | 141.4 | | 254 | | |

OUTLET PROTECTION SUMMARY ENTRY

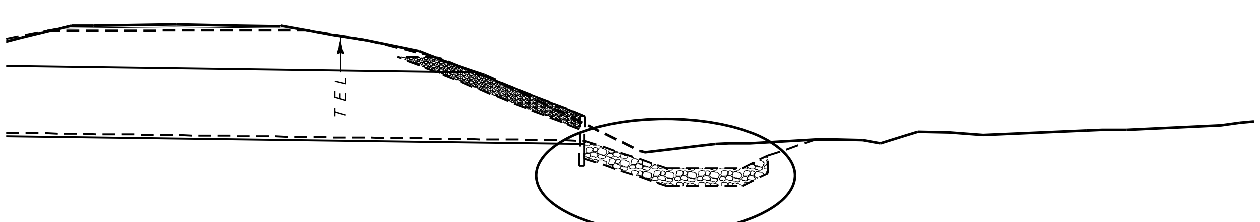
*Outlet Protection Reminders:*

1. *See the BMP Manual for additional geotextile details.*
2. *See Chapter A8 of the Permanent Erosion and Sediment Control Manual for additional guidance.*
3. *A separate detail sheet will typically be needed for Outlet Protection. The Hydraulics Section will provide the detail to include in the plans.*

## Sample Cross Section

OUTLET PROTECTION NOTE (ADD QUANTITIES TO CULVERT NOTE)

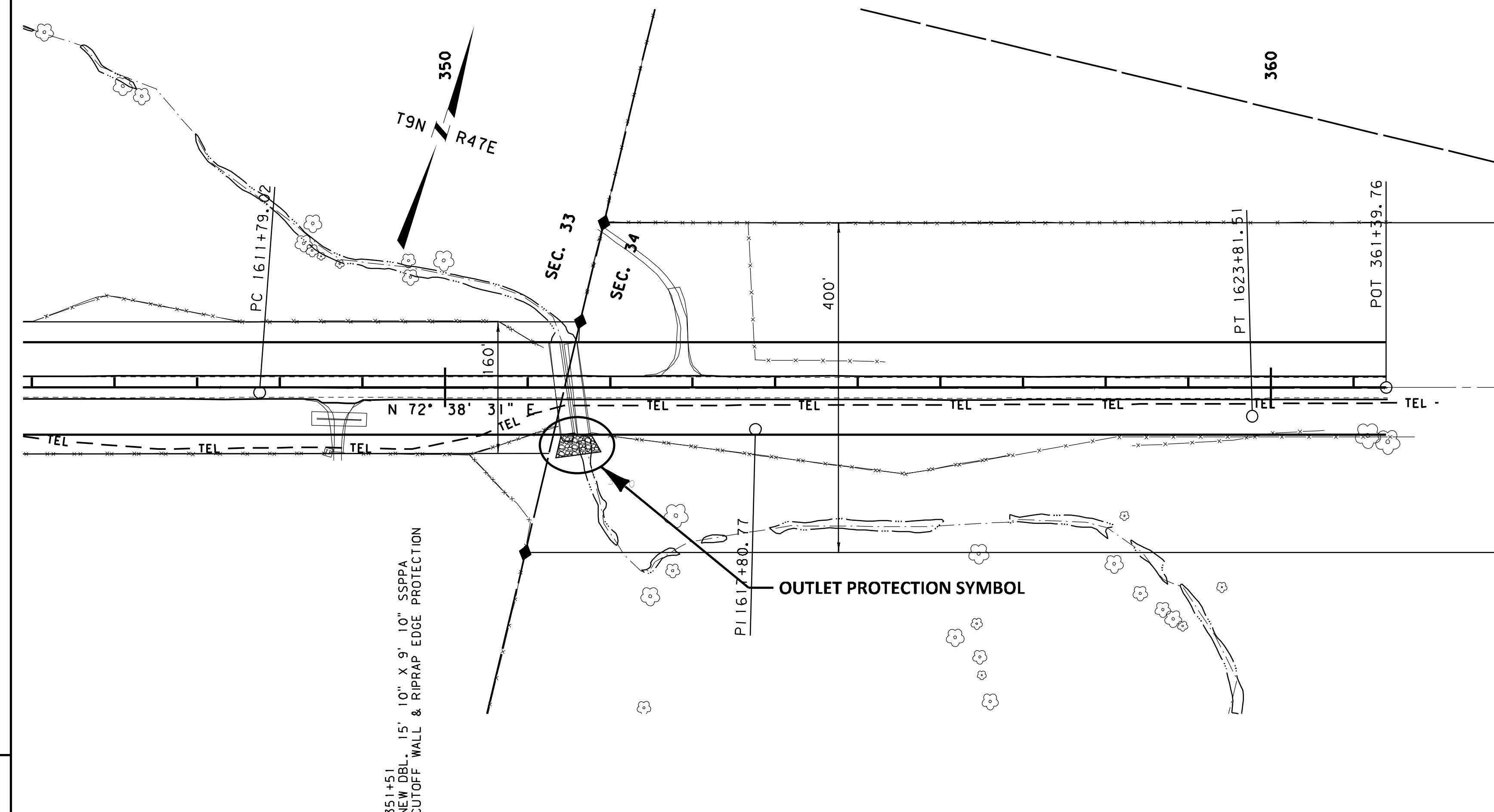
351+51
NEW DOUBLE 15' 10" x 9' 10" SSPPA
15.2 C.Y. CL. DD CONC. CUTOFF WALL LT. AND RT.
36.8 C.Y. CL. I RIPRAP-OUTLET RIPRAP EDGE PROTECTION
141.4 C.Y. CL. II RIPRAP-OUTLET RIPRAP APRON
254 S.Y. GEOTEXTILE
(SEE DETAIL)




351+51.00

OUTLET PROTECTION CROSS SECTION SYMBOL

## Sample Plan and Profile



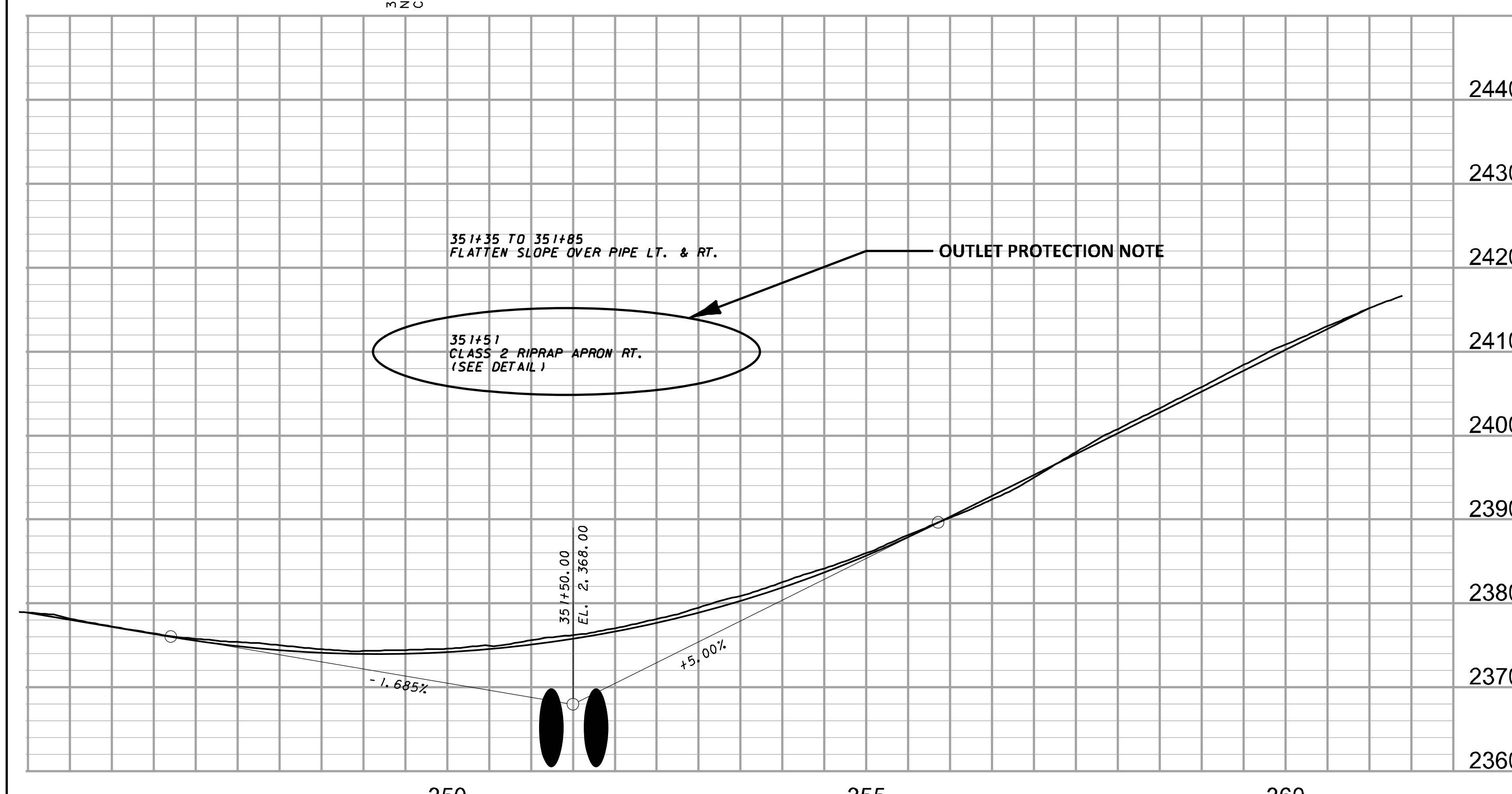




FIG B8-1

| | | | | | |
|---|---|---|---|---|---|
| MDT MONTANA DEPARTMENT OF TRANSPORTATION | ...\Dgn\PESCMANRDB08001.dgn | DESIGNED BY | DESIGNER NAME | DATE | ROAD PLANS |
| | 9/25/2017 | REVIEWED BY | SUPERVISOR NAME | DATE | COUNTY NAME(S) |
| | 8:56:55 AM u2373 | CHECKED BY | CHECKER NAME | DATE | |

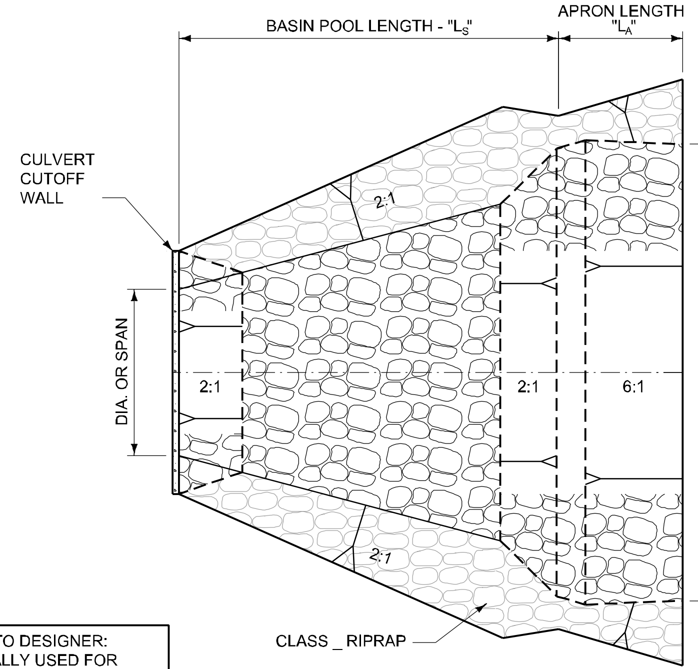
*MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET*

OUTLET PROTECTION SAMPLES

CSF = 0.9999999 | UPN NUMBER 12345678

PROJECT NO.

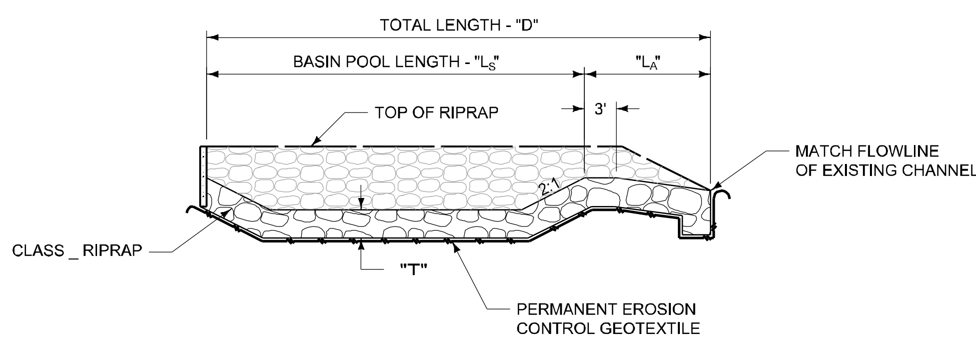
SHEET 999 OF 999




NOTE TO DESIGNER:
TYPICALLY USED FOR PIPES GRERATER THAN 48" EQUIVALENT.

PLAN VIEW

SCALE ~ 1:100

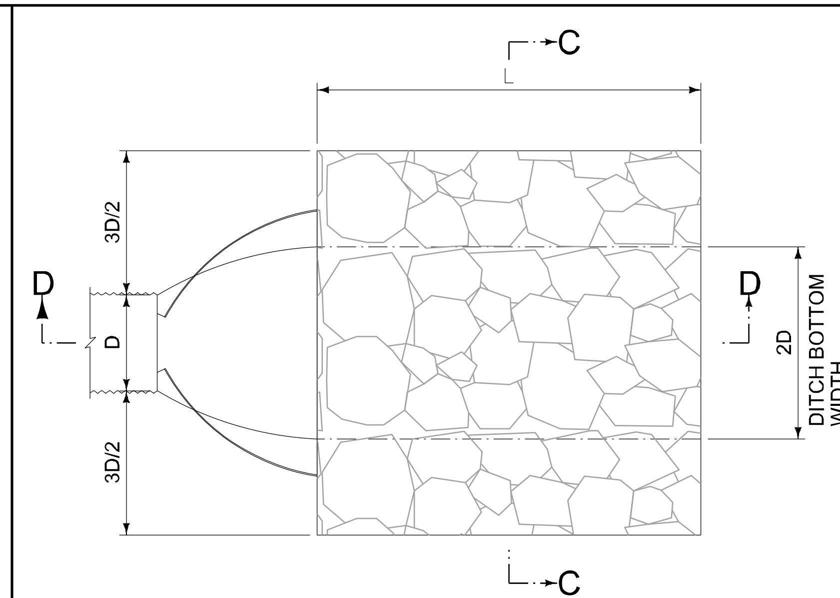



PROFILE VIEW

SCALE ~ 1:100

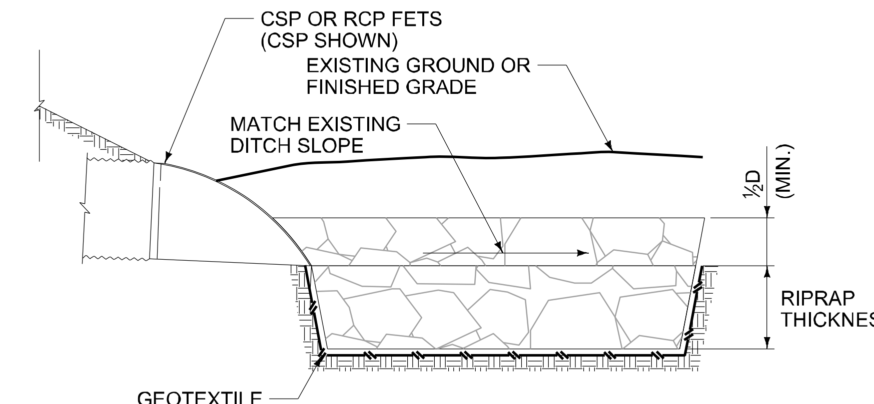
| STATION | "$L_S$" (ft) | "$L_A$" (ft) | "C" (ft) | "T" (ft) | CLASS _ RIPRAP ($yd^3$) | PERMANENT EROSION CONTROL GEOTEXTILE ($yd^2$) |
|---|---|---|---|---|---|---|
| | | | | | | |

RIPRAP BASIN



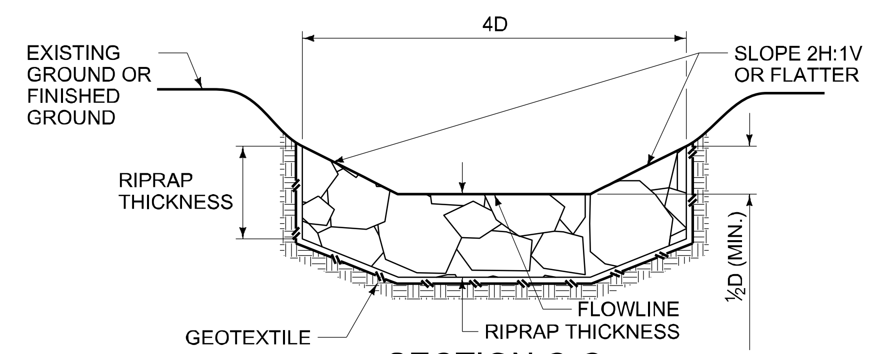

PLAN VIEW

NO SCALE




SECTION D-D

NO SCALE




SECTION C-C

NO SCALE

| OUTLET RIPRAP APRON | | | | | | |
|---|---|---|---|---|---|---|
| STATION | PIPE SIZE/TYPE | DIMENSIONS (ft.) | | CLASS ? RIPRAP (cu.yd.) ① | PERMANENT EROSION CONTROL GEOTEXTILE② (sq.yd.) | REMARKS |
| | | D | L | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

①SEE HYDRAULIC STANDARD DETAIL FOR RIPRAP QUANTITIES.
CLASS I RIPRAP: 2' THICK. CLASS II RIPRAP: 2.5' THICK.
②SEE HYDRAULIC STANDARD DETAIL FOR PERMANENT EROSION CONTROL GEOTEXTILE - HIGH SURVIVABILITY - CL."?", QUANTITY
③SEE HYRAULIC STANDARD DETAIL FOR CULVERT OUTLET RIPRAP WITHOUT DITCH.

CULVERT OUTLET RIPRAP WITH DITCH ③

FIG. B8-2

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3 2 1 | MDT MONTANA DEPARTMENT OF TRANSPORTATION | ...\Dgn\PESCMANRDB08002.dgn 9/28/2017 9:10:16 AM u2373 | DESIGNED BY DESIGNER NAME DATE; REVIEWED BY SUPERVISOR NAME DATE; CHECKED BY CHECKER NAME DATE | ROAD PLANS / COUNTY NAME(S) | MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET | SAMPLE RIPRAP APRON DETAILS / CSF = 0.9999999 / UPN NUMBER 12345678 | PROJECT NO. / SHEET 999 OF 999 |

## Sample Summary Frame

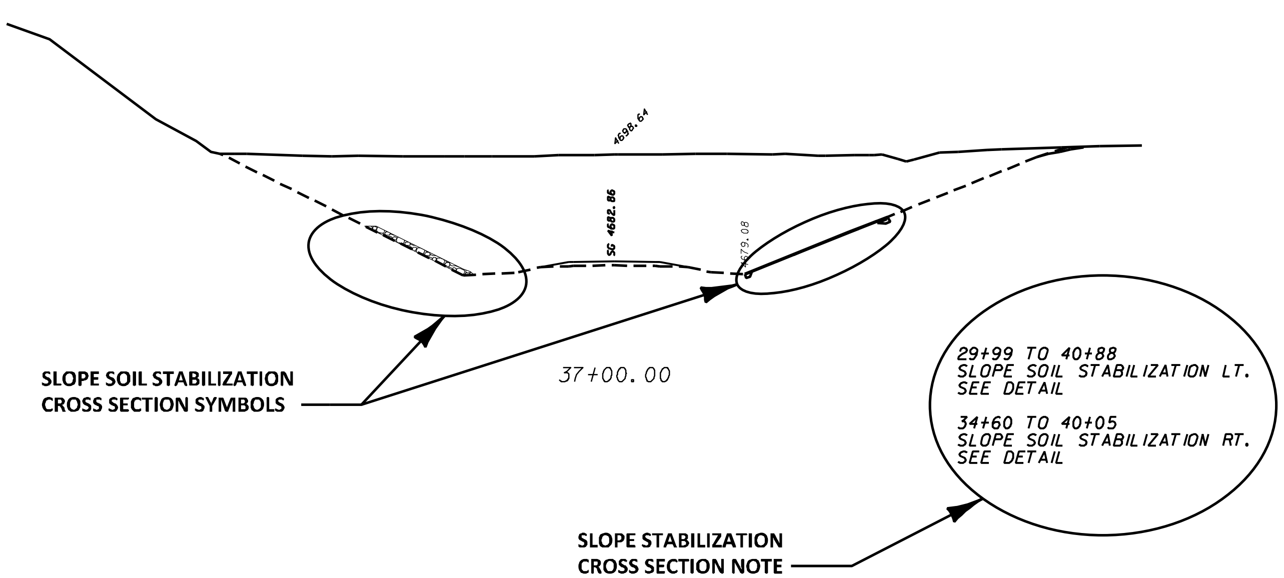
| SLOPE SOIL STABILIZATION | | | | | |
|---|---|---|---|---|---|
| STATION | | cubic yards | square yards | | REMARKS |
| | | RANDOM RIPRAP | EROSION CONTROL BLANKET-LONG-TERM | TURF REINFORCEMENT MAT-NATURAL FIBER | |
| FROM | TO | CL. I | | | |
| 29+99 | 40+88 | 2,400.0 | | 1,543 | SLOPE STABILIZATION LT. |
| 34+60 | 40+05 | | 3,500 | | SLOPE STABILIZATION RT. |
| TOTAL | | 2,400.0 | 3,500 | 1,543 | |

SLOPE SOIL STABILIZATION SUMMARY ENTRY

*Slope Soil Stabilization Reminders:*

1. *See the BMP Manual for additional slope soil stabilization details.*
2. *See Chapter A9 of the Permanent Erosion and Sediment Control Manual for additional guidance.*

## Sample Cross Section




## Sample Plan and Profile

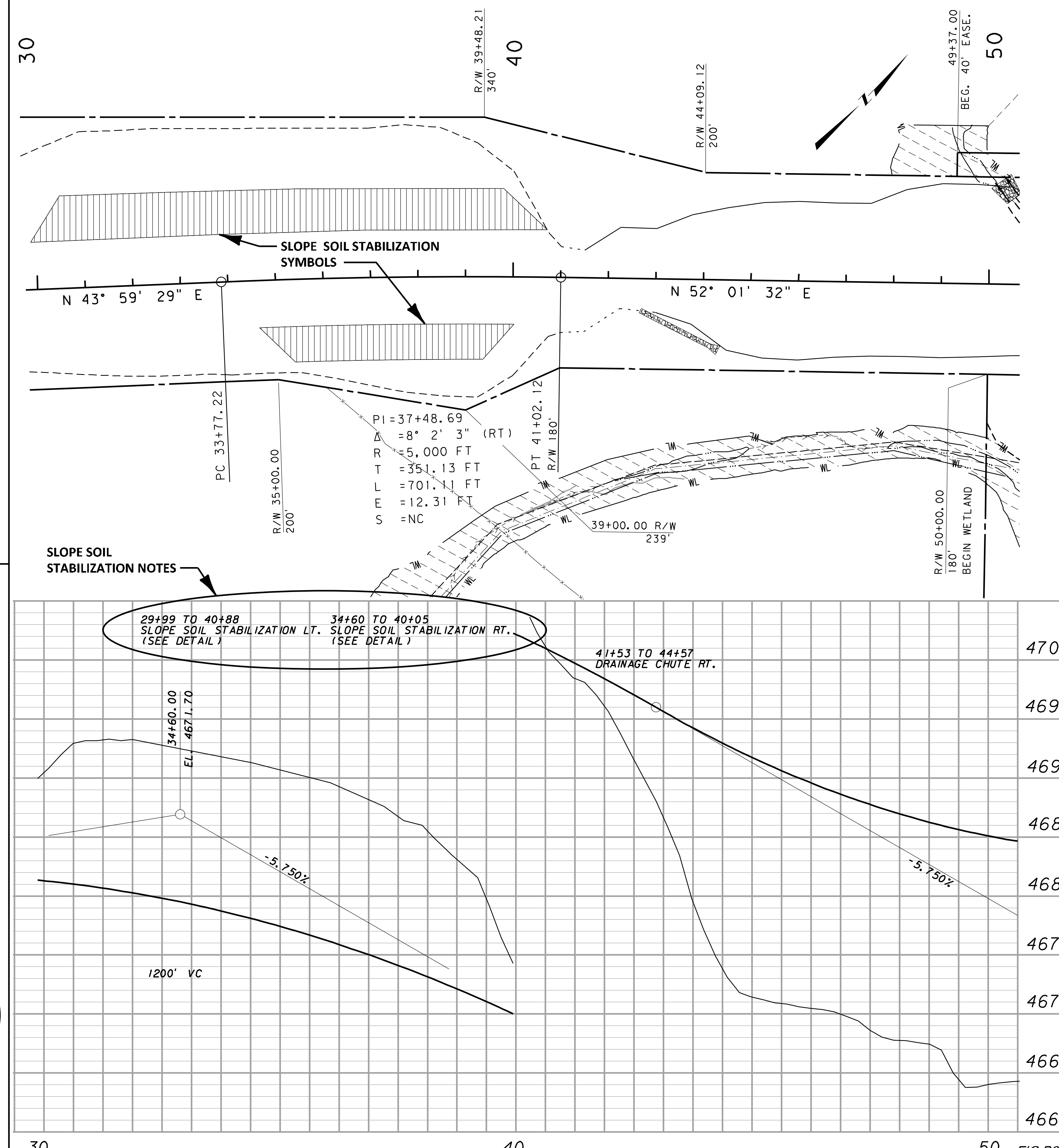
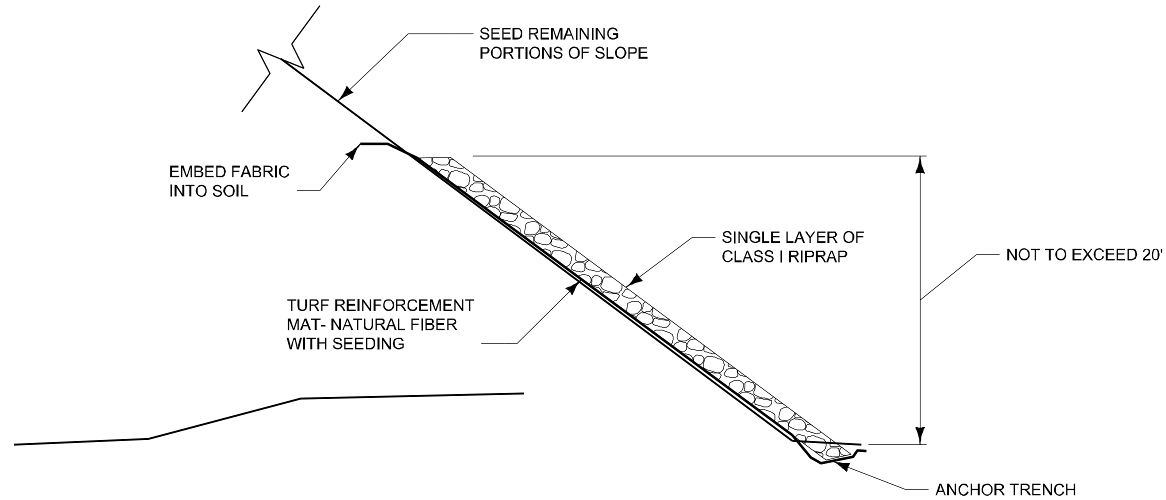



FIG B9-1

| | | | | | | |
|---|---|---|---|---|---|---|
| MDT MONTANA DEPARTMENT OF TRANSPORTATION | ...\Dgn\PESCMANRDB09001.dgn 9/25/2017 8:57:23 AM u2373 | DESIGNED BY *DESIGNER NAME* *DATE*; REVIEWED BY *SUPERVISOR NAME* *DATE*; CHECKED BY *CHECKER NAME* *DATE* | ROAD PLANS / COUNTY NAME(S) | *MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET* | SLOPE SOIL STABILIZATION SAMPLES / CSF = 0.9999999 / UPN NUMBER 12345678 | PROJECT NO. / SHEET 999 OF 999 |

## ROCK VENEER WITH SEEDING



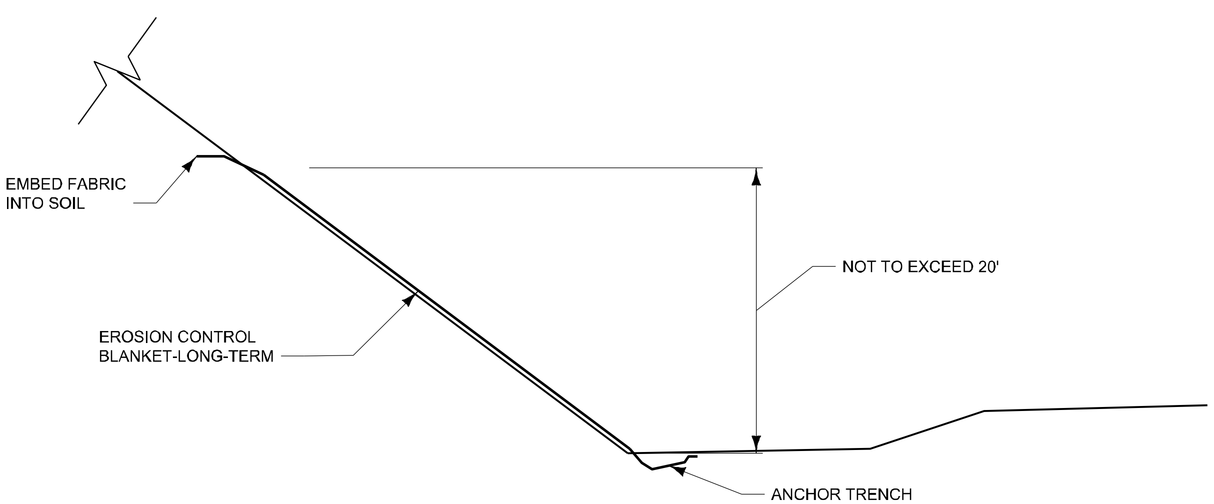

NOTES:

UPPER LIMIT OF SLOPE TREATMENT VARIES. TREAT BOTTOM THIRD OF SLOPE UNLESS 20 FOOT MAXIMUM HEIGHT IS EXCEEDED.

DO NOT DROP RIPRAP FROM A DISTANCE GREATER THAN 2 FEET.

BROADCAST SEED THE AREA WITH "AREA 2" SEED MIXTURE BEFORE PLACING RIPRAP.

## EROSION CONTROL BLANKET WITH SEEDING

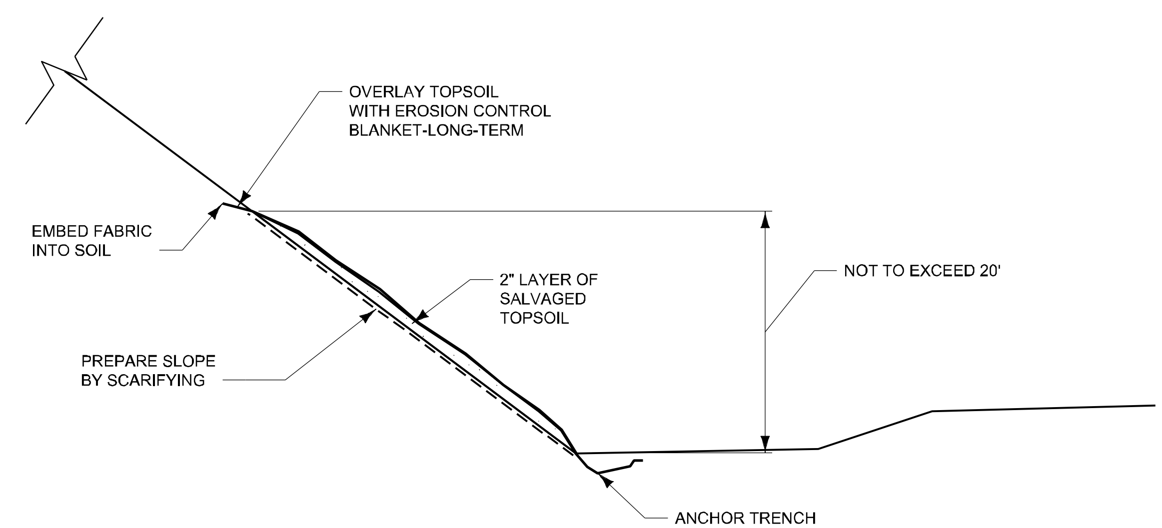



NOTES:

UPPER LIMIT OF SLOPE TREATMENT VARIES. TREAT BOTTOM THIRD OF SLOPE UNLESS 20 FOOT MAXIMUM HEIGHT IS EXCEEDED.

BROADCAST SEED THE AREA WITH "AREA 2" SEED MIXTURE PRIOR TO PLACING EROSION CONTROL BLANKET.

## TOPSOILING AND EROSION CONTROL BLANKET WITH SEEDING




NOTES:

UPPER LIMIT OF SLOPE TREATMENT VARIES. TREAT BOTTOM THIRD OF SLOPE UNLESS 20 FOOT MAXIMUM HEIGHT IS EXCEEDED.

BROADCAST SEED THE TOPSOIL WITH "AREA 2" SEED MIXTURE PRIOR TO PLACING EROSION CONTROL BLANKET.

FIG. B9-2

## Sample Summary Frame

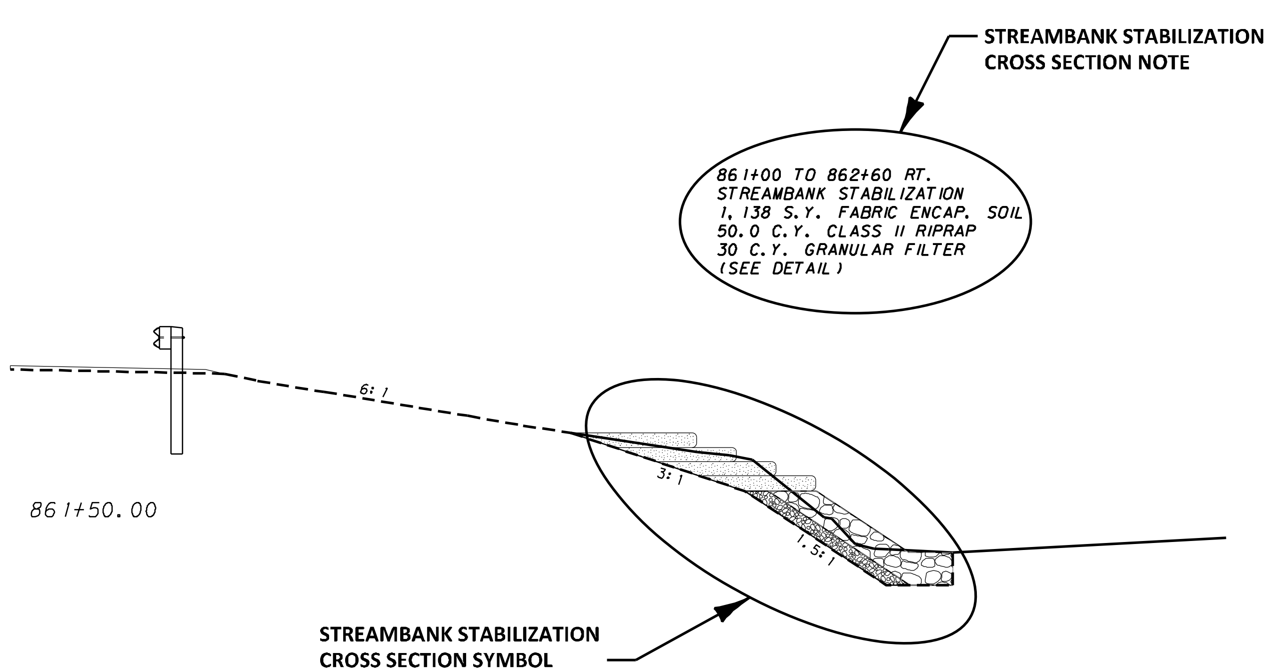
| STREAMBANK STABILIZATION (SEE DETAIL SHEETS & CROSS SECTIONS) | | | | | | |
|---|---|---|---|---|---|---|
| STATION | | cubic yards | | square yards | lump sum | REMARKS |
| | | RANDOM RIPRAP | GRANULAR FILTER # | FABRIC ENCAP. SOIL | REVEGETATION | |
| FROM | TO | CLASS 2 | | | | |
| 861+00.00 | 862+60.00 | 50.0 | 30 | ✱ 1,138 | 1 | 4 LAYERS TOTAL |
| | | | | | | |
| TOTAL | | 50.0 | # 30 | | 1 | |

# - FOR INFORMATION ONLY - INCLUDED IN THE COST OF RIPRAP
✱ - ESTIMATED AT 160 ft. LONG x 8 ft. WIDE AVERAGE PER LAYER

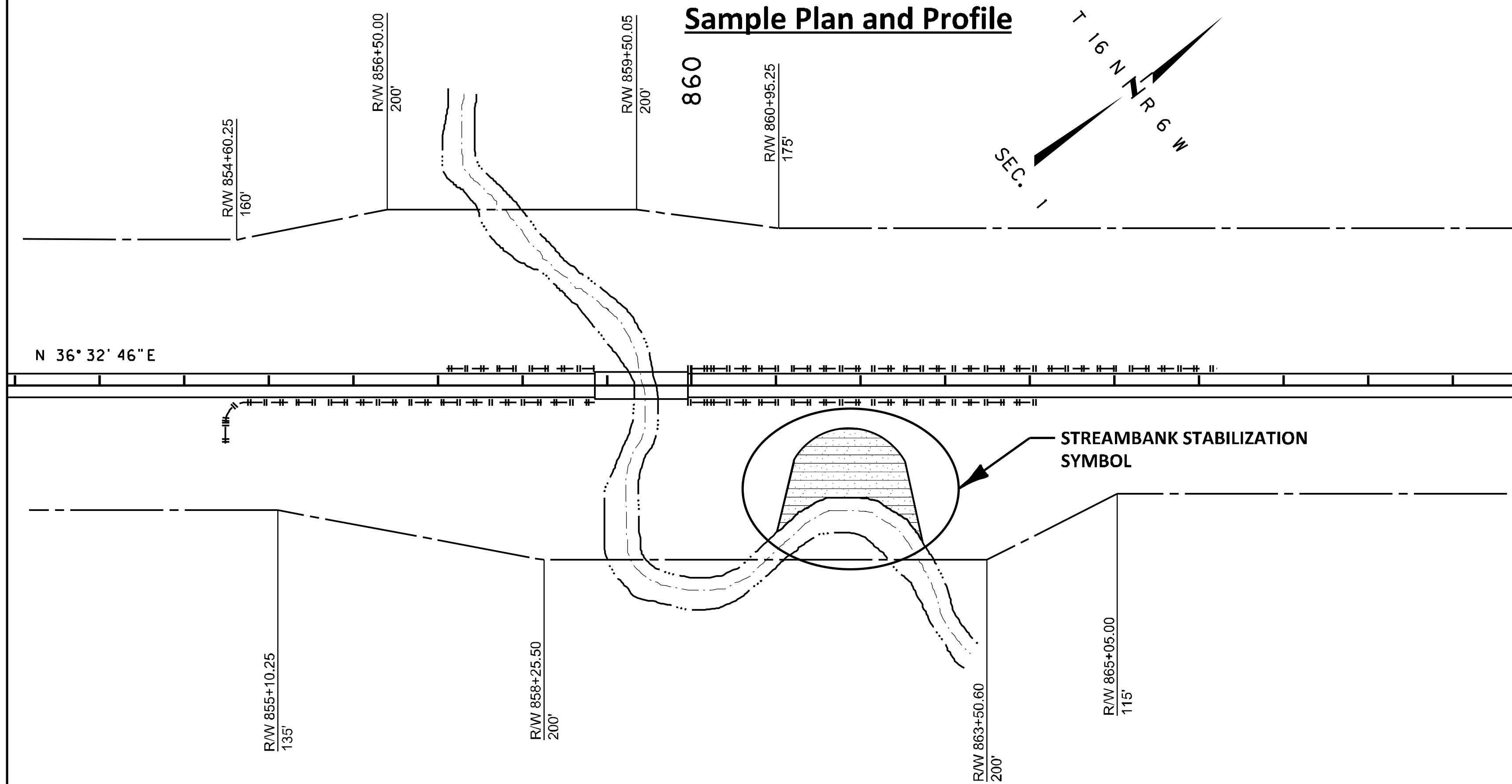
*Streambank Stabilization Reminders:*

1. *See section A10 for additional information on streambank stabilization.*
2. *Typically a detail should be prepared showing design features unique to the project as recommended by the Hydraulics Section.*

## Sample Cross Section




## Sample Plan and Profile



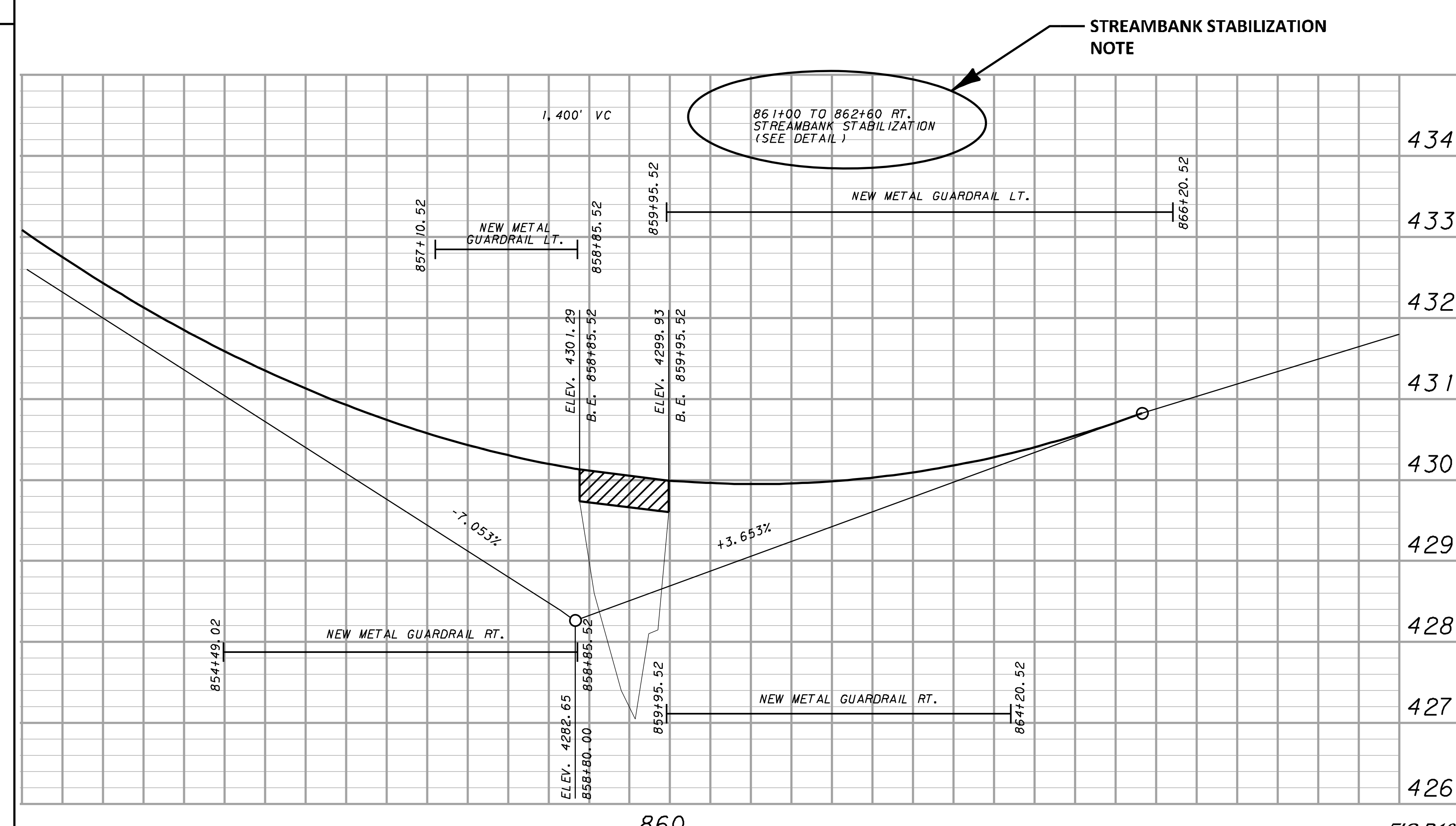
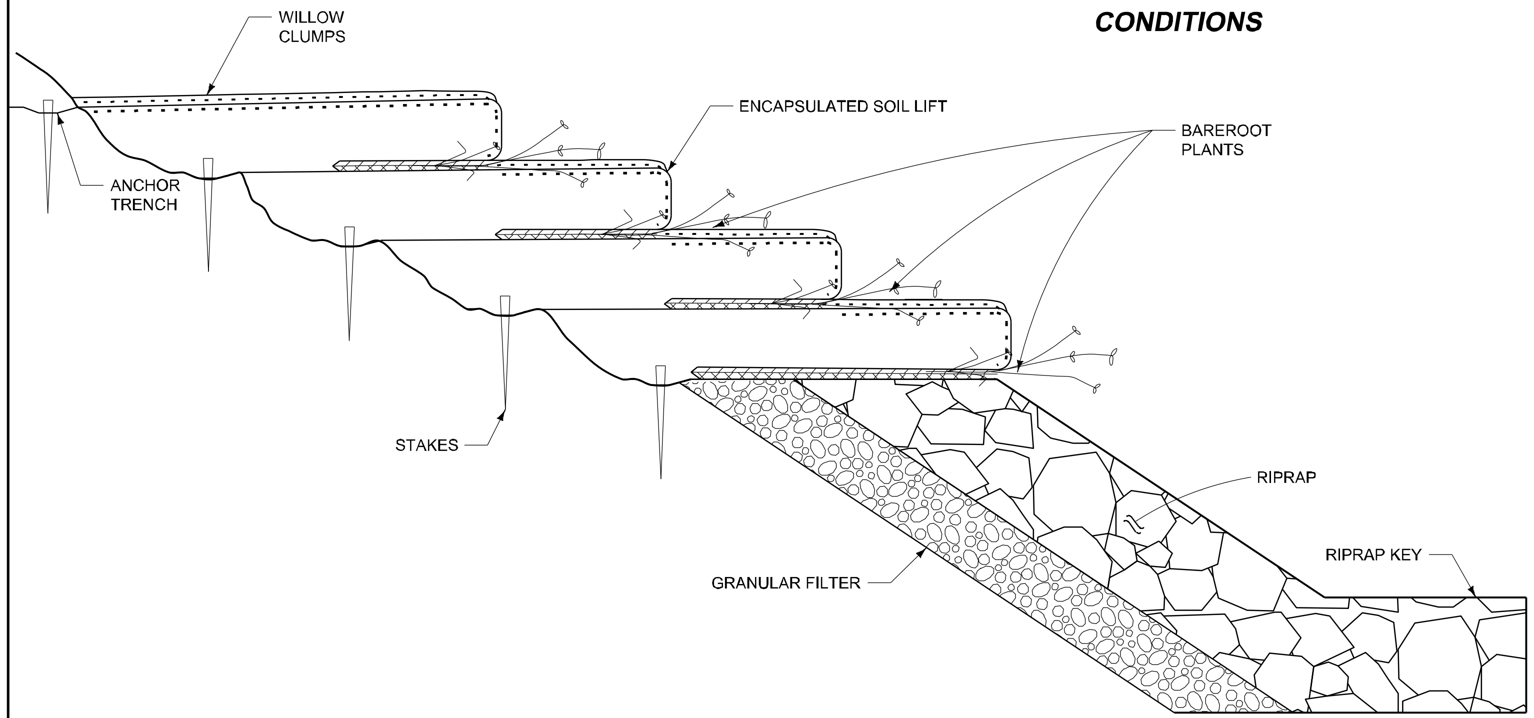




FIG B10-1

| | | | | |
|---|---|---|---|---|
| MDT MONTANA DEPARTMENT OF TRANSPORTATION | ...\Dgn\PESCMANRDB10001.dgn 9/25/2017 8:59:30 AM u2373 | DESIGNED BY *DESIGNER NAME* *DATE*; REVIEWED BY *SUPERVISOR NAME* *DATE*; CHECKED BY *CHECKER NAME* *DATE* | ROAD PLANS / COUNTY NAME(S) | *MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET* |

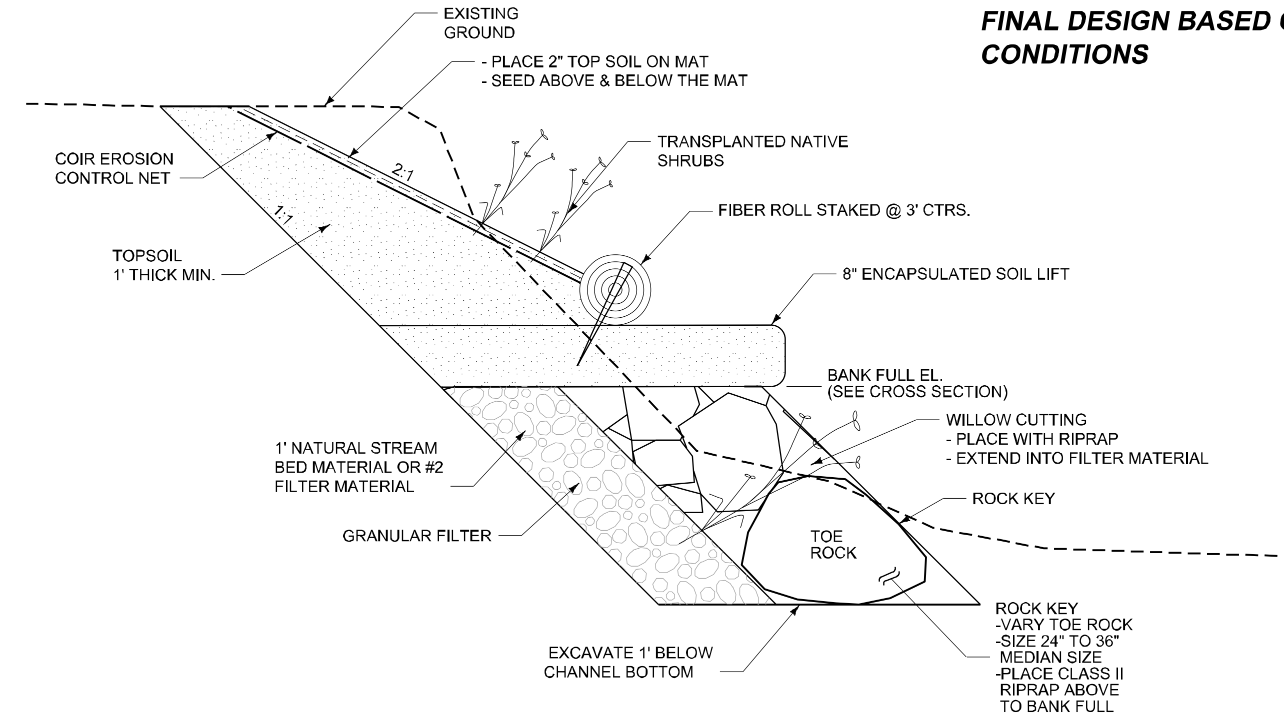
| STREAMBANK STABILIZATION SAMPLES | | PROJECT NO. |
|---|---|---|
| CSF = 0.9999999 | UPN NUMBER 12345678 | SHEET 999 OF 999 |

***NOTE TO DESIGNER:***
***FINAL DESIGN BASED ON SITE CONDITIONS***

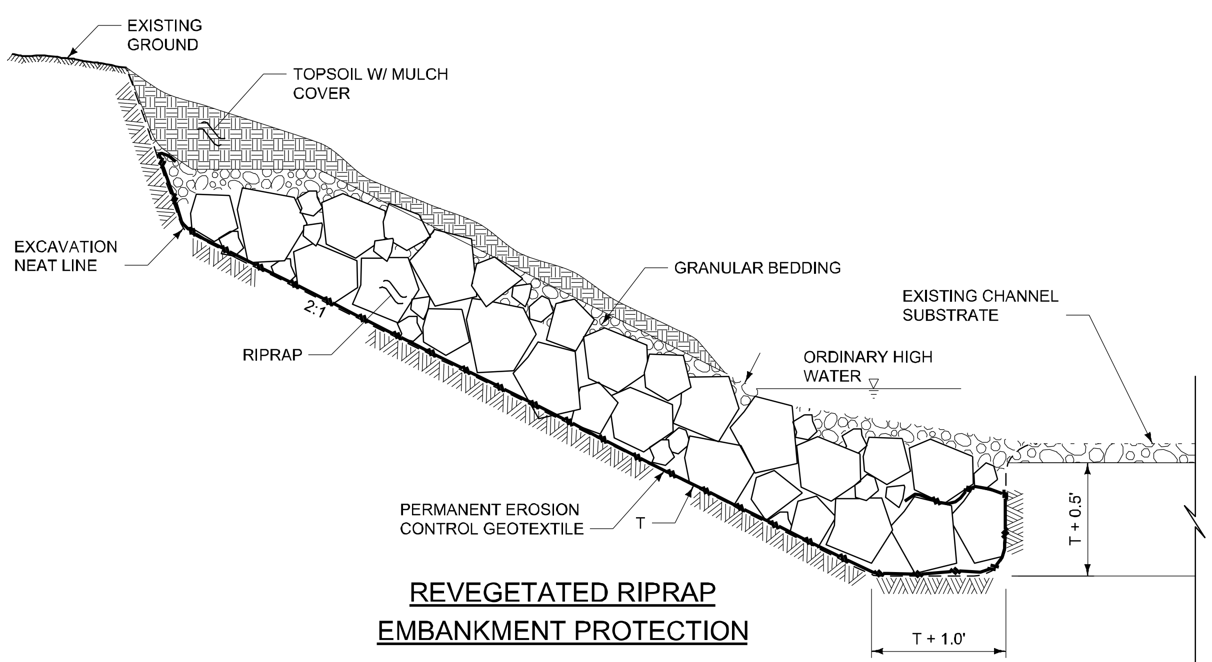



ENCAPSULATED SOIL WITH RIPRAP KEY

***NOTE TO DESIGNER:***
***FINAL DESIGN BASED ON SITE CONDITIONS***




REVEGETATION/SLOPE WITH ROCK TOE DETAIL




REVEGETATED RIPRAP
EMBANKMENT PROTECTION

MINIMUM T FOR:

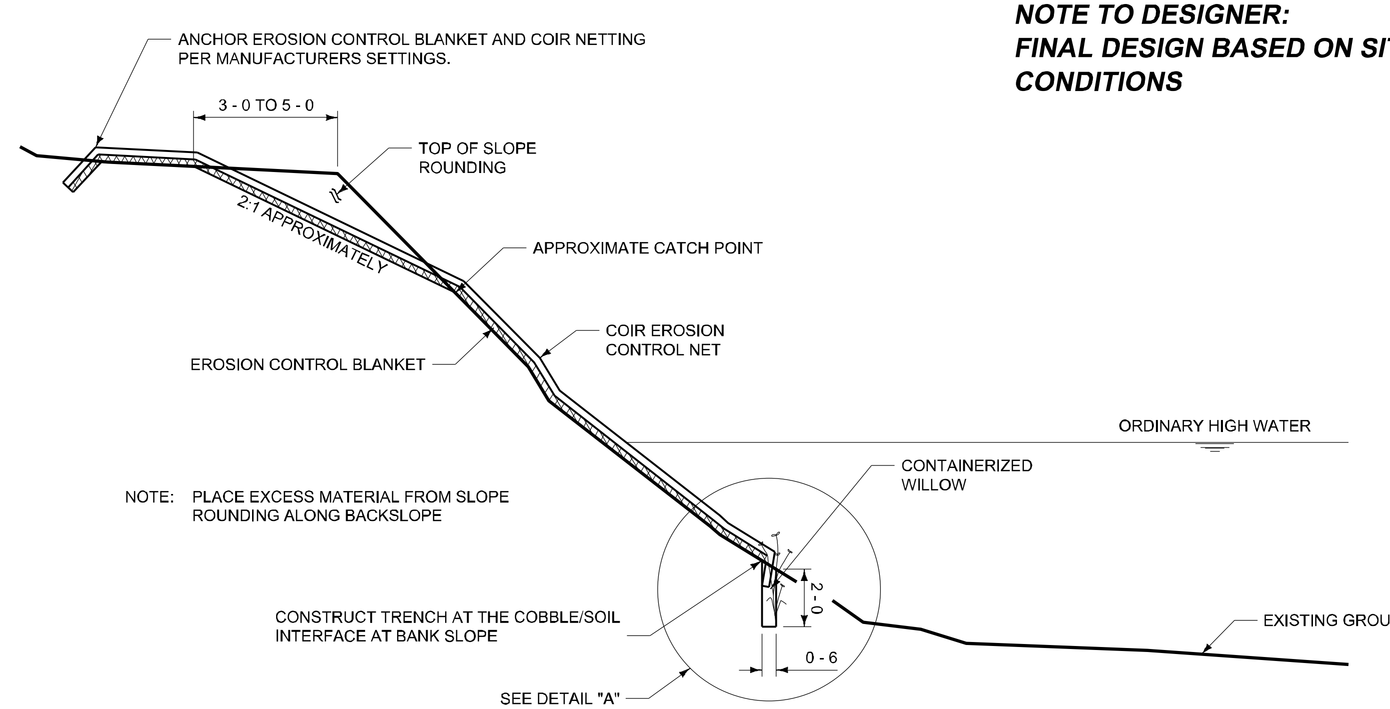
CLASS I RIPRAP = 1'-6"
CLASS II RIPRAP = 2'-6"
CLASS III RIPRAP = 3'-0"

NOTES:

FILL RIPRAP VOIDS WITH GRANULAR BEDDING, OR A MATERIAL OF SIMILIAR GRADATION OBTAINED ON SITE TO PROVIDE A UNIFORM SURFACE FOR THE PLACEMENT OF TOPSOIL, AS APPROVED BY THE PROJECT ENGINEER.

PLACE TOPSOIL WITH A MINIMUM THICKNESS OF 8".

***NOTE TO DESIGNER:***
***FINAL DESIGN BASED ON SITE CONDITIONS***



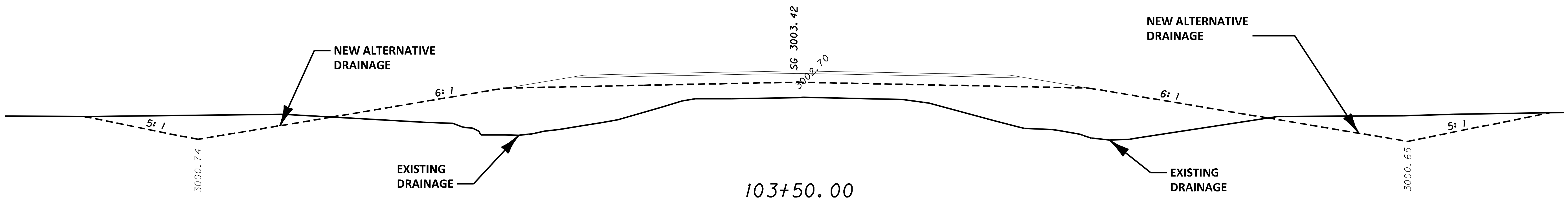

NOTE: PLACE EXCESS MATERIAL FROM SLOPE ROUNDING ALONG BACKSLOPE

BANK STABILIZATION AND REVEGETATION DETAIL

*FIG B10-2*

| | | | | | |
|---|---|---|---|---|---|
| 3 / 2 / 1 | MDT MONTANA DEPARTMENT OF TRANSPORTATION | ...\Dgn\PESCMANRDB10002.dgn<br>12/18/2017<br>10:11:15 AM u2373 | DESIGNED BY *DESIGNER NAME* *DATE*<br>REVIEWED BY *SUPERVISOR NAME* *DATE*<br>CHECKED BY *CHECKER NAME* *DATE* | ROAD PLANS<br>COUNTY NAME(S) | *MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET* |
| | | | | **SAMPLE STREAMBANK STABILIZATION DETAILS** | PROJECT NO. |
| | | | | CSF = 0.9999999 / UPN NUMBER 12345678 | SHEET 999 OF 999 |

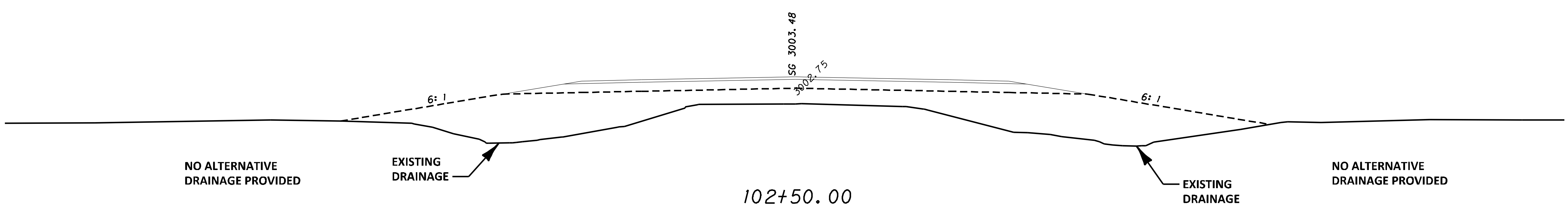
# Good Example of Maintaining Drainage




*Maintenance of Existing Drainage Reminder* :

① *Traversable ditches are required within the clear zone and should also be used outside of the clear zone if practical. See Road Design Manual section 14.3.6.1.*

# Bad Example of Maintaining Drainage




FILLING IN DITCHES AS SHOWN ABOVE IS GENERALLY NOT AN ACCEPTABLE PRACTICE UNLESS AN ALTERNATIVE DRAINAGE ROUTE IS PROVIDED OR SITE SPECIFIC CONDITIONS DICTATE.

FIG B11-1

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3 2 1 | MDT MONTANA DEPARTMENT OF TRANSPORTATION | ...\Dgn\PESCMANRDB11001.dgn 9/25/2017 9:01:15 AM u2373 | DESIGNED BY DESIGNER NAME DATE<br>REVIEWED BY SUPERVISOR NAME DATE<br>CHECKED BY CHECKER NAME DATE | ROAD PLANS<br>COUNTY NAME(S) | MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET | MAINTENANCE OF EXISTING DRAINAGE<br>CSF = 0.9999999 UPN NUMBER 12345678 | PROJECT NO.<br>SHEET 999 OF 999 |

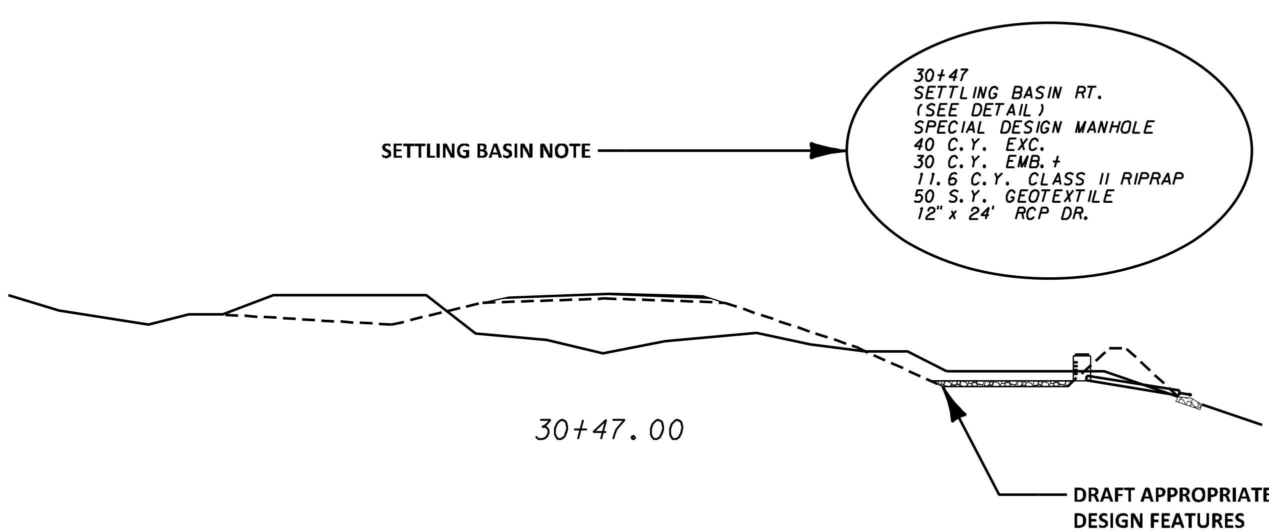
## Sample Summary Frame

| SETTLING BASIN | | | | | | | |
|---|---|---|---|---|---|---|---|
| STATION | | linear feet | square yards | cubic yards | | each | REMARKS |
| | | REINFORCED CONCRETE OUTLET PIPE | HEAVY DRAINAGE GEOTEXTILE | UNCL. EXC. | CLASS II RIPRAP | MANHOLE SPECIAL DESIGN | |
| FROM | TO | 12" CL.2 | | | | | |
| 30+47 | | 24 | 50 | 40 | 11.6 | 1 | SETTLING BASIN RT. (SEE DETAIL) |
| TOTAL | | 24 | 50 | 40 | 11.6 | 1 | |

*Settling Basin Reminders:*

1. *Settling Basins are typically designed by the MDT Hydraulics Section. The road designer will review locations and ensure that the design details are included in the plans.*
2. *Refer to section A12 of the Permanent Erosion and Sediment Control Manual for design guidlines.*
3. *A separate detail sheet will typically be needed for Settling Basins. The Hydraulics Section will provide the detail to include in the plans.*

## Sample Cross Section




## Sample Plan and Profile

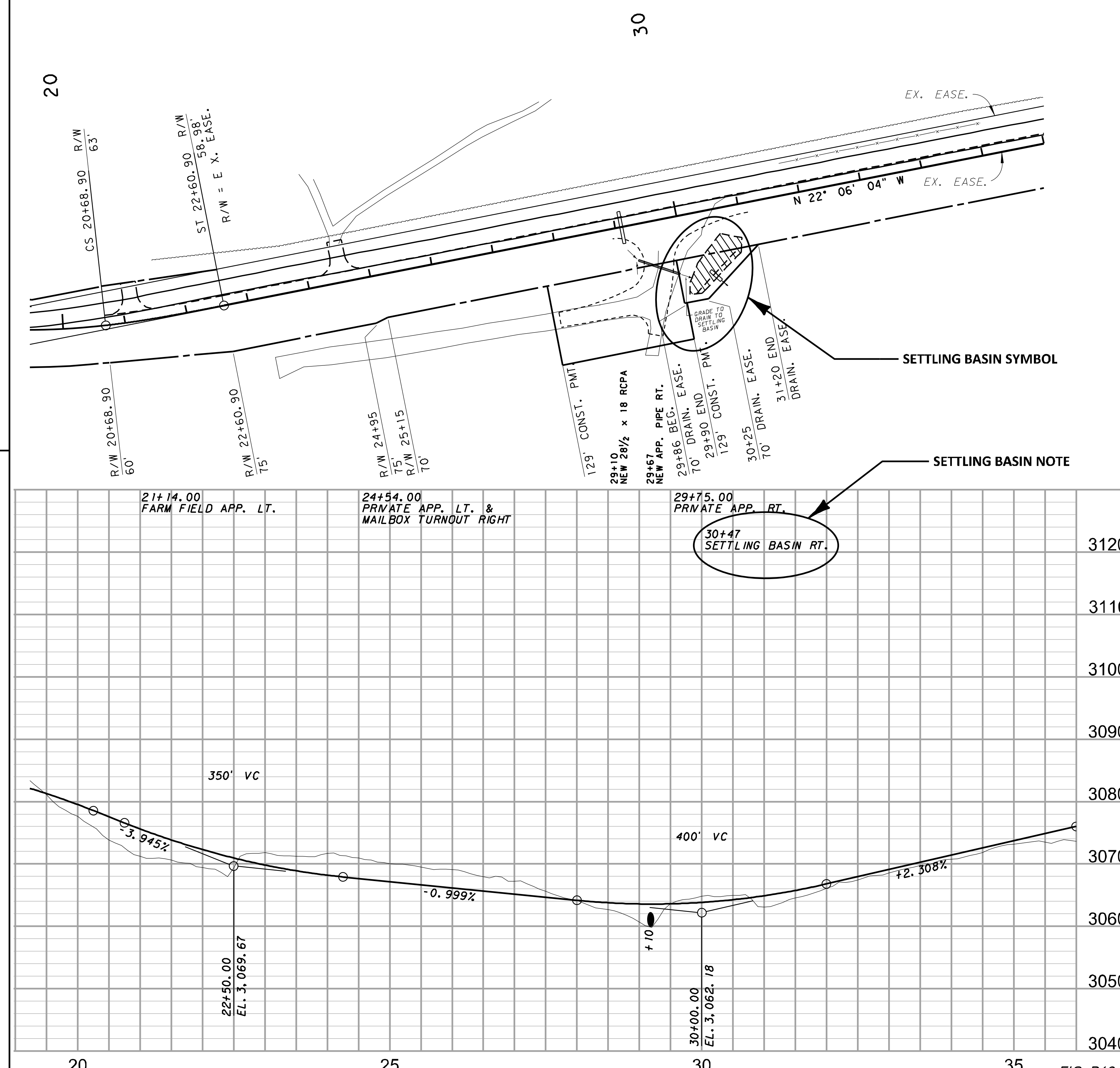



FIG. B12-1

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| MDT MONTANA DEPARTMENT OF TRANSPORTATION | ...\Dgn\PESCMANRDB12001.dgn 9/25/2017 9:01:57 AM u2373 | DESIGNED BY DESIGNER NAME DATE; REVIEWED BY SUPERVISOR NAME DATE; CHECKED BY CHECKER NAME DATE | ROAD PLANS / COUNTY NAME(S) | *MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET* | SETTLING BASIN SAMPLES | CSF = 0.9999999 / UPN NUMBER 12345678 | PROJECT NO. / SHEET 999 OF 999 |

## Sample Summary Frame

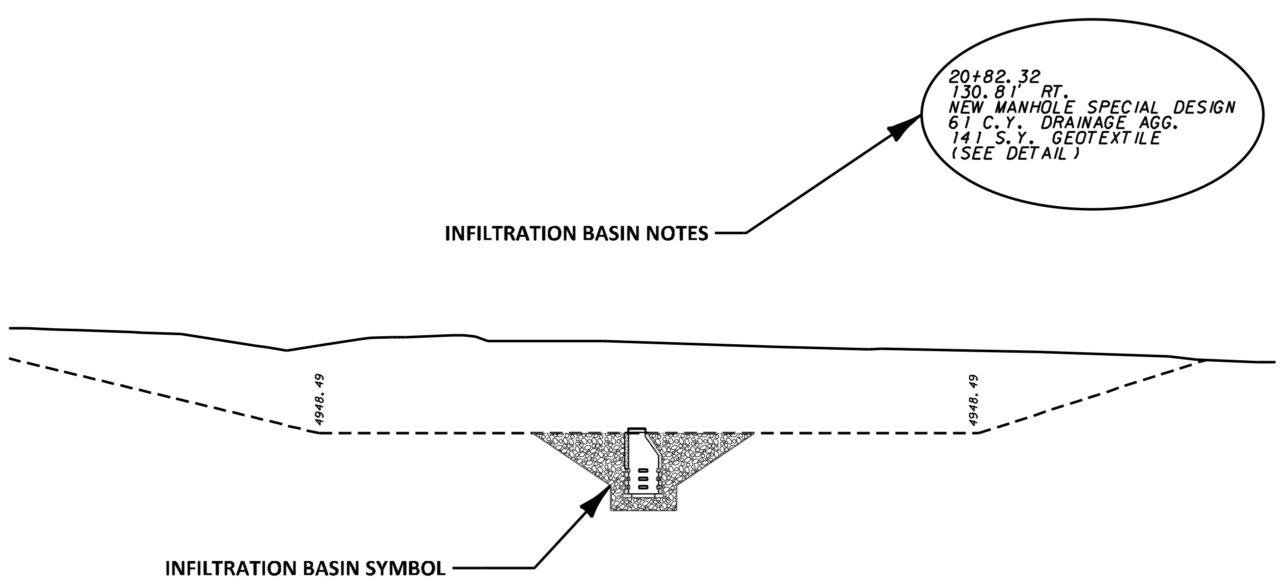
| INFILTRATION FACILITY * | | | | | |
|---|---|---|---|---|---|
| STATION | | square yards | cubic yards | each | |
| | | HEAVY DRAINAGE GEOTEXTILE | DRAINAGE AGGREGATE | MANHOLE SPECIAL DESIGN | REMARKS |
| FROM | TO | | | | |
| 20+82.32 | | 141 | 61 | 1 | 130.81' RT. OF GATEWAY S. RD. |
| TOTAL | | 141 | 61 | 1 | |

* SEE DETAIL

*Infiltration Basin Reminders:*

1. *A separate detail sheet will typically be needed for Infiltration Basins. The Hydraulics Section will provide the detail to include in the plans.*
2. *See Section A13 of the Permanent Erosion and Sediment Control Manual for further Infiltration Basin details.*

## Sample Cross Section




## Sample Plan and Profile

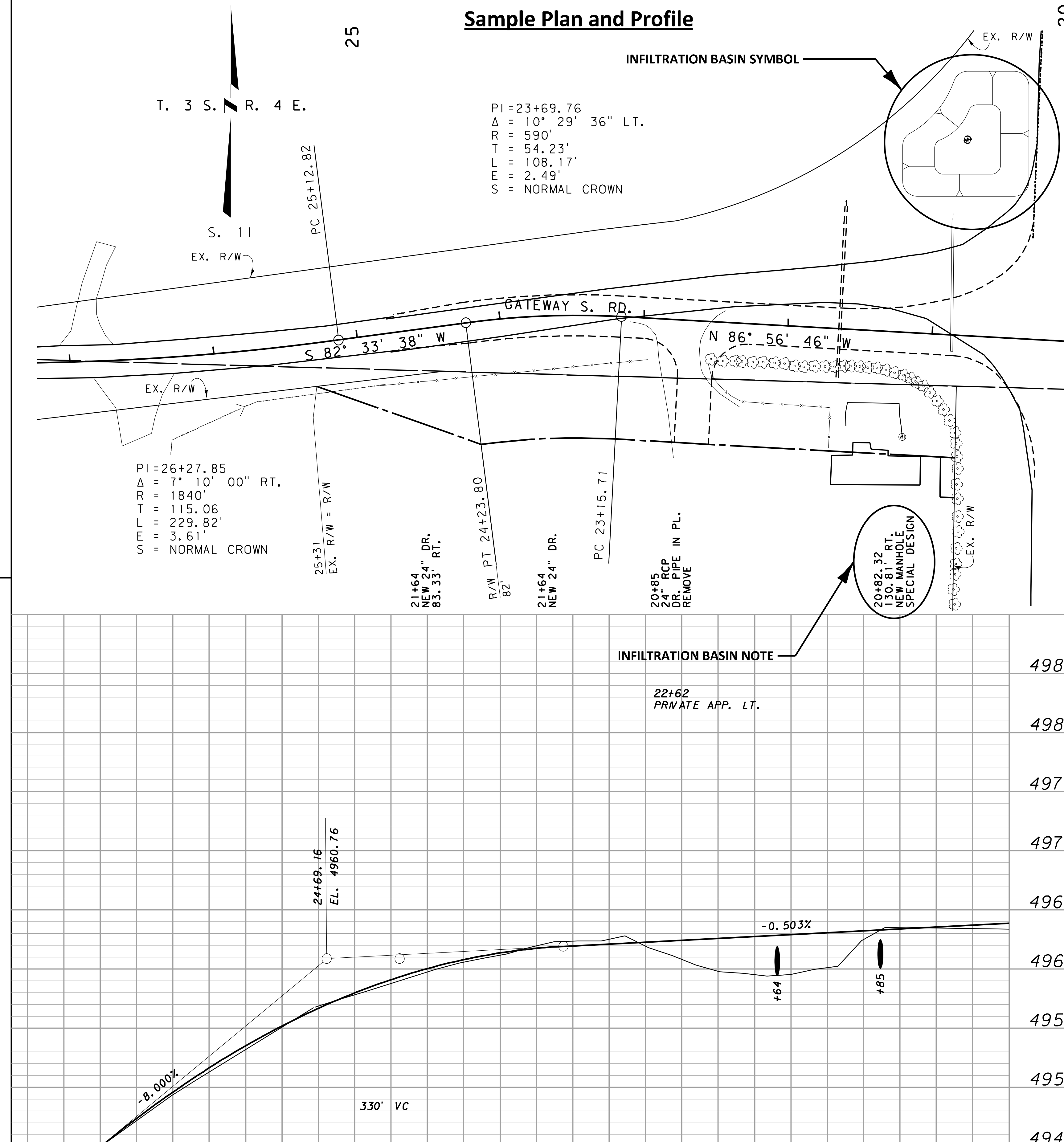
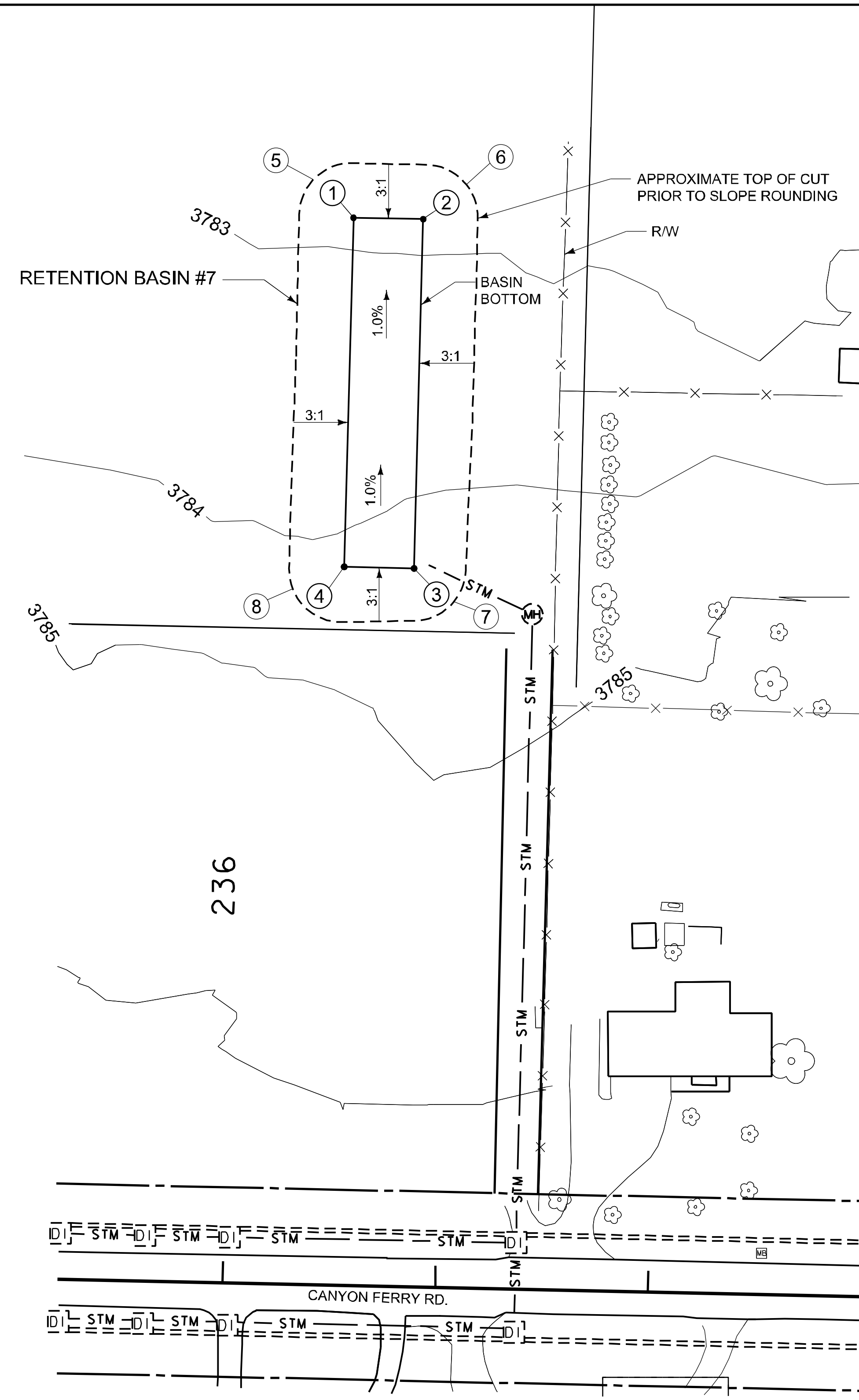



FIG B13-1

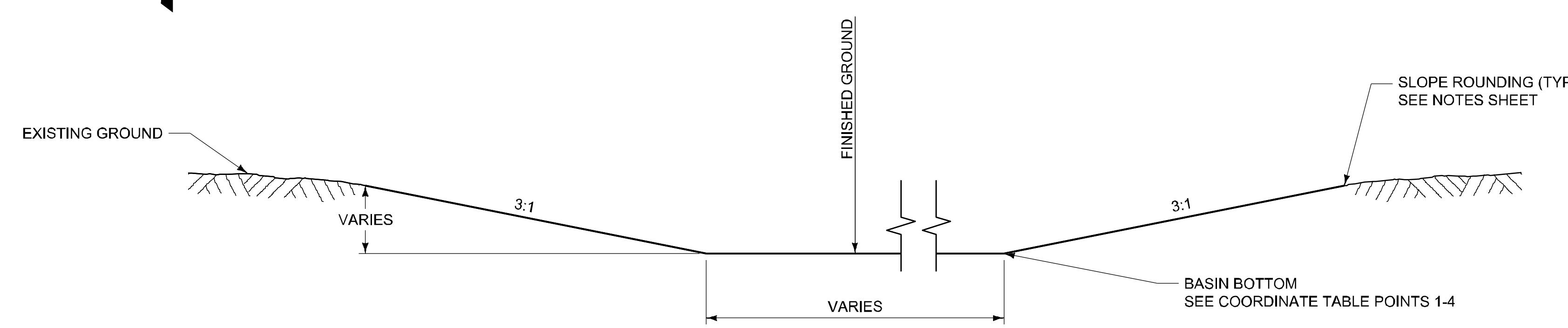
| | | | | | |
|---|---|---|---|---|---|
| MDT MONTANA DEPARTMENT OF TRANSPORTATION | ...\Dgn\PESCMANRDB13001.dgn<br>9/25/2017<br>9:02:59 AM u2373 | DESIGNED BY DESIGNER NAME DATE<br>REVIEWED BY SUPERVISOR NAME DATE<br>CHECKED BY CHECKER NAME DATE | ROAD PLANS<br>COUNTY NAME(S) | MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET | INFILTRATION BASIN SAMPLES<br>CSF = 0.9999999 UPN NUMBER 12345678 | PROJECT NO.<br>SHEET 999 OF 999 |




RETENTION BASIN
PLAN VIEW

STA. 236+30 TO 237+02

| COORDINATE TABLE | | | | | | | |
|---|---|---|---|---|---|---|---|
| POINT NUMBER | STATION | OFFSET | NORTHING | EASTING | ELEV. | RADIUS | REMARKS |
| 1 | 236+50.75 | 501.00 FT. LT. | 872,701.973 | 1,365,942.286 | 3775.92 | | |
| 2 | 236+83.56 | 501.00 FT. LT. | 872,701.265 | 1,365,975.086 | 3775.92 | | |
| 3 | 236+82.84 | 337.00 FT. LT. | 872,537.278 | 1,365,970.787 | 3777.56 | | |
| 4 | 236+50.03 | 337.00 FT. LT. | 872,537.986 | 1,365,937.988 | 3777.56 | | |
| 5 | 236+32.35 | 519.50 FT. LT. | 872,720.749 | 1,365,924.304 | 3784.22 | 24.5 FT. MIN. | |
| 6 | 237+01.94 | 519.50 FT. LT. | 872,719.248 | 1,365,993.862 | 3784.28 | 24.5 FT. MIN. | |
| 7 | 237+00.07 | 319.75 FT. LT. | 872,519.699 | 1,365,987.655 | 3785.70 | 24.5 FT. MIN. | |
| 8 | 236+31.63 | 318.00 FT. LT. | 872,519.343 | 1,365,919.174 | 3785.32 | 24.5 FT. MIN. | |




RETENTION BASIN
TYPICAL SECTION

NOTES:

SALVAGE AND REPLACE TOPSOIL EVENLY OVER ALL DISTURBED AREAS, DEPTH NOT TO EXCEED 4". FINISHED GROUND ELEVATIONS INCLUDE TOPSOIL.

SEED ALL DISTURBED AREAS.

FINISH BASIN BOTTOM AND CUT SLOPES IN A ROUGHENED CONDITION. CONFORM TO SLOPE ROUGHENING BMP IN ACCORDANCE WITH DETAILED DRAWING NO. 208-22.

RETENTION BASIN
DETAIL

NO SCALE

FIG B13-2

| | | | | | |
|---|---|---|---|---|---|
| MDT MONTANA DEPARTMENT OF TRANSPORTATION | ...\Dgn\PESCMANRDB13002.dgn 9/25/2017 9:04:46 AM u2373 | DESIGNED BY DESIGNER NAME DATE<br>REVIEWED BY SUPERVISOR NAME DATE<br>CHECKED BY CHECKER NAME DATE | ROAD PLANS<br>COUNTY NAME(S) | MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET | RETENTION BASIN EXAMPLE<br>CSF = 0.9999999 UPN NUMBER 12345678 | PROJECT NO.<br>SHEET 999 OF 999 |