CHAPTER 10
EROSION CONTROL

DR 1001-1 General Information

Soil erosion resulting from highway projects may have lasting environmental and engineering effects if not properly controlled. Excessive sediment may have a detrimental effect on stream habitat. Loss of material due to erosion can weaken the roadway slope and the foundation of hydraulic structures. The increased sediment load in the streams can cause culverts to silt up and cause natural channels to become unstable. This can result in localized increases in velocities and/or stage, both upstream and downstream, of the sediment source. Thus, permanent erosion control is needed for highways along ditches, slopes, and culvert outlets.

Erosion is most serious during construction prior to paving the road, constructing permanent ditches, and establishing permanent vegetation. During this time, temporary erosion control measures must be in place. The full scope of erosion control requires the development of a well planned set of erosion control plans that minimizes soil loss during construction and minimizes the discharge of sediment into blue-line streams and onto downstream property owners.

The Cabinet's policy has been written with the intent to encourage the use of techniques that prevent erosion rather that disturb and trap erosion. The guidelines allow the use of techniques such as phased clearing, mulch, and erosion control blanket to reduce the amount of sediment trapping devices.

This chapter discusses the erosion control measures and guidelines that are to be incorporated into the roadway plans. The sections of this chapter are as follows:

- **Section 1002**—Erosion Minimization
- **Section 1003**—Sediment Control
- **Section 1004**—Erosion Control Plan Development
- **Section 1005**—Energy Dissipation
- **Section 1006**—Universal Soil Loss Equation

DR 1001-2 Kentucky Pollutant Discharge Elimination System (KPDES)

The Environmental Protection Agency (EPA) has jurisdiction for disturbance of small watersheds. The EPA wrote eight general permits for industrial activities. States such as Kentucky, municipalities such as Louisville and Lexington, and smaller cities have similar permits.

The Kentucky Pollutant Discharge Elimination System (KPDES) became effective October 1, 1992. The Storm Water General Permit (SWGP) for storm water discharges associated with industrial activity that is construction related (KPDES No. KYR10****) covers the construction of highway projects. **** is a four-digit number given to each application.

The Division of Construction sends a Notice of Intent (NOI) letter to the Kentucky Environmental and Public Protection Cabinet (KEPPC), Department for Environmental Protection (DEP), Division of Water (DOW), and Jefferson County or Fayette County (if applicable) for a project when clearing and grubbing equals one acre or more. The NOI letter includes the contractor's name and the letting date for the project. The requested coverage is documented in the bid proposal by a special note. The KEPPC forwards a copy of the General Permit along with the coverage number to the Division of Construction. The Contractor and the Resident Engineer develop a Best Management Practice (BMP) based upon the Erosion

Control Plan (ECP) depicted on the plans. The Resident Engineer monitors the construction and, in coordination with the contractor, determines when revisions to the ECP are required. The ECP changes throughout the life of the project. All changes are documented by the contractor. Coverage by the SWGP is terminated when construction is complete.

The SWGP states that the BMP shall include any requirements approved by local storm water programs. The project manager shall advise the design engineer of this requirement and, upon completion of the ECP, verify that the appropriate local agency is in agreement with the plan. Communities with local storm water programs include Louisville, Lexington, and Phase 2 communities listed at the following web address:

http://www.kytc.state.ky.us/EnvAnalysis/Stormwaterquality/local_prog_links.htm

This information may also be obtained by contacting DOW, KPDES Branch, MS4 program, at 502-564-3410.

NOTES AND COMMENTS

DR 1002-1 Ground Cover

There are a variety of ways to collect and trap sediment; however, the best erosion control plan will always be the prevention of erosion, thus reducing the need and added expense of having to trap sediment. Each phase of an erosion control plan should strive to disturb a minimum amount of ground and to protect that disturbed ground before entering a new phase of construction.

A healthy ground cover in the watershed area is the best erosion control method. It protects the soil surface from the intense destructive power of the rain and promotes soil infiltration. A permanent vegetative cover should be established as soon as possible in disturbed areas. A natural reestablishment of native grasses and rapidly growing wooded plants is much easier to introduce than attempting heavy maintenance or introducing competitive species.

Erosion control blanket protection should not be limited to channels or ditches. Other liners not appropriate for channel lining may serve a useful purpose elsewhere. Final slopes that are 3H:1V or steeper may require protection greater than that offered by the standard seed and protect methods. In these cases a liner appropriate for the site conditions should be selected.

In a temporary vegetative cover situation, seeding, mulch, or a combination of the two is recommended. A quick-growing native vegetation, usually a grass, is most commonly used, with a straw or hay mulch to provide protection until permanent growth can be established. Temporary seeding or mulch should be utilized when permanent seeding is not possible or practical. Appropriate pay items are "Seeding and Protection" and "Temporary Seeding and Protection." Refer to Sections 212, 213, and 827 of the *Standard Specifications for Road and Bridge Construction* for grass species, seeding methods, fertilizers, and mulching procedures.

DR 1002-2 Channel Lining

Vegetative-lined channels are preferred to rock-lined channels for aesthetic as well as environmental reasons. The selection of an appropriate vegetative liner is based on its ability to provide adequate shear resistance to the design storm. The selection of a vegetative liner includes appropriate choices of plant species for the riparian zone adjacent to the stream in question. An erosion control blanket liner is the default protection for all ditches unless there is a more stringent requirement or natural protection is available. The Division of Environmental Analysis should be consulted in the design of the riparian zone.

Rock riprap is a widely used economical material that may be a combination of gravel, cobble, crushed aggregate, or broken concrete. It is selected by particle size and layer thickness based on its ability to protect the surface on which it is placed. Rock-lined channels are excellent protection against the scouring forces of water, are flexible to adjust to foundation and channel changes, and may be underlaid with filter fabric to protect the underlying soil foundation.

Rock gabion mattresses provide protection and stability through a wide range of slopes and discharges. The gabion mattress permits a smaller size rock than would be recommended for a riprap-lined channel. This is possible because the rock is bound by the wire mesh, which provides stability such that the gabion mattress tends to act as a unit. The designer should avoid the use of gabion mattresses if there is a significant risk of damage to the wire mesh due to high sediment concentrations or rocks moving along the stream bed. The Division of Materials should be consulted in the use of filter fabrics and gabion structures.

NOTES AND COMMENTS

DR 1002-3 Erodible Slopes

It is recommended that all soil-like final slopes steeper than 2:1 be protected with an erosion control blanket. Flatter erodible soil-like slopes may require protection by mulching or sodding before vegetation is established. Erodible soils are site specific but often include soils that consist primarily of sandy or silty materials. These soils may be located along glacial outwash areas, alluvial fans, or other areas of soil deposition. Geologic areas consisting of sandstone or siltstone formations may consist of loosely cemented erodible soils and should be closely examined.

Geotechnical guidelines consider soil-like materials to be erodible if the Plasticity Index < 12 or if site conditions indicate erodibility problems. It is recommended that the designer consult the geotechnical engineering report as an aid in determining the erodibility of soils on a job. It is recommended that the minutes of the Project Team meeting include a summary assessment of the erodibility of soils on the project and a design response to this assessment be shown on the Erosion Control Plans. All areas requiring erosion control blanket protection shall be clearly depicted on the Erosion Control Plans.

Asphalt Wedge Curb may be required as an erosion control measure when a roadway embankment is composed of an erodible material. When used, Asphalt Wedge Curb is placed under the guardrail to control the spread of water on the shoulder and to convey flow away from the roadway. Asphalt Wedge Curb is recommended along shoulders when all of the following conditions exist:

- The shoulder of the highway consists of impervious material such as asphalt pavement, asphalt seal coat, or similar treatment.
- The proposed embankment is at least 20 feet in height and a minimum length of 100 feet.
- The embankment is composed of erodible material. Soil may be considered erodible if the Plasticity Index < 12 or if site conditions indicate erodibility.

Asphalt Wedge Curb may be required in the short term to protect slopes until the vegetation has been established. Short-term problems may be mitigated with erosion control blankets or similar protection in lieu of Asphalt Wedge Curb. Refer to Standard Drawing RPM-100 of the Standard Drawing for Asphalt Wedge Curb.

The use of Asphalt Wedge Curb requires that the curb terminate at an acceptable structure to convey the flow downstream. The following structures are recommended for such use:

- **Flume Inlet Type 1**—This type shall be used in sag situations. Maximum flow capacity is 3.0 cfs. Maximum design spread occurs when the spread encroaches within 2 feet of the driving lane.
- **Flume Inlet Type 2**—This type shall be used in grade situations. Maximum flow capacity is 1.5 cfs. Maximum design spread occurs when the spread encroaches within 2 feet of the driving lane.
- **Drop Box Inlet (DBI) Type 13**—This DBI with polyethylene pipe, is preferred to the flume inlets. Recommended pipe installation is to extend the pipe to the toe of the fill.

When Asphalt Wedge Curb is used on a continuous grade, it is desirable that it be extended to the end of the fill (even though the fill height is less than required) so that the outfall structure will be as short as possible. Refer to Standard Drawing RDD-020 for Flume Inlet Type 1, Standard Drawing RDD-021 for Flume Inlet Type 2, and Standard Drawing RDB-013 to RDB-019 for Drop Box Inlet Type 13.

NOTES AND COMMENTS

DR 1003-1 General Information

The primary types of temporary erosion control structures recommended for use on highway plans are:

- Silt traps
- Sedimentation basins
- Silt fence

These structures convey runoff while creating a ponding area for sediment deposition. Refer to Section 213 (Water Pollution Controls) of the *Standard Specifications for Road and Bridge Construction* for specific requirements.

DR 1003-2 Silt Trap

Silt traps refer to a combination of berms, digouts, or both placed along a roadway ditch to trap the silt transported to it. All traps are sized based upon a volume of 3,600 cubic feet per disturbed acre. When the total drainage area to a single structure exceeds 10 acres, consideration must be given to the contributing watershed area. In these cases, a sediment basin is necessary, and the structures should be designed according to drainage area. Acreage that has been protected or stabilized may be deducted from the volume requirement. It is recommended that silt traps not be placed in blue-line streams unless space limitations or design limitations provide no other feasible option.

Silt Trap, Type A

"Silt Trap, Type A," formerly referred to as "Silt Traps, Type A and B," consists of excavated basins in natural or constructed channels and constructed berms built to pond water so that the suspended silt load will be deposited. Extra right of way shall be obtained as needed to accommodate this silt trap. It is recommended that the designer include a sufficient number of silt traps to eliminate or minimize the need for additional right of way. Two silt trap options are recommended, depending on the circumstances. Both options are normally removed upon completion of construction when permanent erosion control is established. They may be left in place after construction if long-term ponding of highway runoff is needed.

Option 1 is a shallow excavated basin to be used in roadway ditches, median ditches, surface ditches, and special ditches. This option is best applied in locations where small and infrequent runoffs are expected. The basins may be placed in a series to achieve a specified volume and shall be cleaned out when they are greater than half full.

Option 2 consists of a short berm with or without an excavated basin. Site conditions determine its geometry to obtain a required volume. The berm is constructed of crushed aggregate. Dimensions are specified on the Erosion Control Plan but may be varied at the discretion of the Engineer. The berms shall be cleaned out when they are greater than half full.

The contract unit bid price items for this work are "Silt Trap, Type A," and "Clean Silt Trap A" for each silt trap installed. Installation shall include all work necessary to construct and maintain the silt trap as directed by the plans or by the engineer.

Silt Trap, Type B

"Silt Trap, Type B," formerly referred to as Silt Check Type II or III, consists of one or more small berms placed in a natural drain, an excavated channel, or a ditch. The maximum recommended height is 4 feet or less with a length of 3 feet to 20 feet and side slopes of 2H:1V. The berms shall be constructed of #2 stone or shot rock of similar size and filtered through a Type II geotextile fabric that is covered by a 4-inch layer of No. 4 stone. A 12-inch depression shall be placed at the middle of the berm.

"Silt Trap, Type B," is primarily used in roadway ditches and may be used in a series. They are spaced on the basis of the formula L = d / So, where L = spacing, d = minimum height of silt trap, and So = ditch slope. These relationships are shown in a spreadsheet that is available at the Department's web site. While this spreadsheet is specifically applicable to Silt Trap, Type B, it may also be used for Silt Trap, Type A, where a uniform ditch slope and trapezoidal berm are provided. A portion of the spreadsheet is shown below to illustrate silt trap spacing possibilities.

"FB" DITCH VOLUMES BEHIND SILT TRAPS (ft^3)										
Depth =	1.5 ft.				Bottom Width =	0 ft.				
Slope	SUM of DITCH SIDE SLOPES ($Z_1 + Z_2$)									Silt Trap
ft /ft	4	5	6	7	8	9	10	11	12	Spacing
0.002	1125	1406	1688	1969	2250	2531	2813	3094	3375	750
0.003	750	938	1125	1313	1500	1688	1875	2063	2250	500
0.004	563	703	844	984	1125	1266	1406	1547	1688	375
0.005	450	563	675	788	900	1013	1125	1238	1350	300
0.007	321	402	482	563	643	723	804	884	964	214
0.008	281	352	422	492	563	633	703	773	844	188
0.009	250	313	375	438	500	563	625	688	750	167
0.010	225	281	338	394	450	506	563	619	675	150
0.020	113	141	169	197	225	253	281	309	338	75
0.030	75	94	113	131	150	169	188	206	225	50
0.040	56	70	84	98	113	127	141	155	169	38
0.050	45	56	68	79	90	101	113	124	135	30
0.060	38	47	56	66	75	84	94	103	113	25
0.070	32	40	48	56	64	72	80	88	96	21
0.080	28	35	42	49	56	63	70	77	84	19
0.090	25	31	38	44	50	56	63	69	75	17
0.100	23	28	34	39	45	51	56	62	68	15
0.150	15	19	23	26	30	34	38	41	45	10
0.200	11	14	17	20	23	25	28	31	34	8

Table formula : $V = (d / 2 * (Z1 + Z2) + w) * d^2 / (81 * s)$
d = ponding depth of flow at trap; sag for trap = 6 inches; Depth and width are user supplied values.
Spacing formula : L = d / So

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"Silt Trap, Type B," should normally be removed upon completion of construction after permanent erosion protection has been established. The contract unit bid price items for this work are "Silt Trap, Type B," and "Clean Silt Trap, Type B," for each "Silt Trap, Type B," installed. Installation shall include all work necessary to construct and maintain the silt trap as directed by the plans or by the engineer.

Silt Trap, Type C

"Silt Trap, Type C," consists of a series of porous fabric bags filled with crushed aggregate placed at the inlet of drainage structures to minimize the siltation of those structures.

Typically, these traps are filled with No. 57 stone or with material of similar gradation and quality and are located at drop box inlets, small pipe inlets, or curb inlets. They shall be considered short term in nature if placed at culvert inlets and should be removed as soon as possible. They shall not be placed in blue-line streams. "Silt Trap, Type C," may be reduced in height or eliminated if its use creates an unacceptable ponding situation on the pavement or on an adjacent property owned by another.

The contract unit bid price items for this work are "Silt Trap, Type C," and "Clean Silt Trap, Type C," for each silt trap installed. Installation shall include all work necessary to construct and maintain the silt trap as directed by the plans or by the engineer.

DR 1003-3 Sedimentation Basin

Sedimentation basin design shall be in accordance with current standard practices. In accordance with the KPDES permit, "For common drainage locations that serve more than ten (10) disturbed acres at one time, a sedimentation basin shall be used if possible." The Cabinet's policy takes this a step further by requiring that, if a structure is placed in a drainage way that has 10 acres or more of contributing drainage area, the structure must be sized according to the total drainage area. A sedimentation basin is larger than other erosion control devices and must be used with caution. A sedimentation basin consists of a dam that is usually taller than a Silt Trap, Type A. If limited by natural terrain, an excavated area may be added. A sedimentation basin is appropriate at locations where it is necessary to provide a larger storage volume or to provide more effective sediment control to achieve a specific purpose. A specific purpose may be the protection of highly sensitive waters such as water supply reservoirs, sport-fishing streams, and state and national forest streams.

The dam is constructed of relatively impervious material and equipped with a discharge pipe and an emergency spillway. Sediment basins may be used in a series, if necessary, to obtain the desired storage capacity. A series of basins would require a dam breach analysis. They may be located in drainageways or areas where diversion ditches are used as long as the required storage capacity is obtained. The maximum size of a drainage area for which a basin is designed will usually be controlled by the design runoff, the maximum allowable height of dam, and the number of suitable locations for the basins. Sediment basin design requires an accurate field survey and detailed hydraulic calculations. A sedimentation basin shall be designed in accordance with current standard practices. The design calculations and details shall be included in the Preliminary Drainage Folder for review by the Drainage Section and the Project Design Team.

Details for the construction of a sedimentation basin shall be incorporated into the Roadway Plans and shall include:

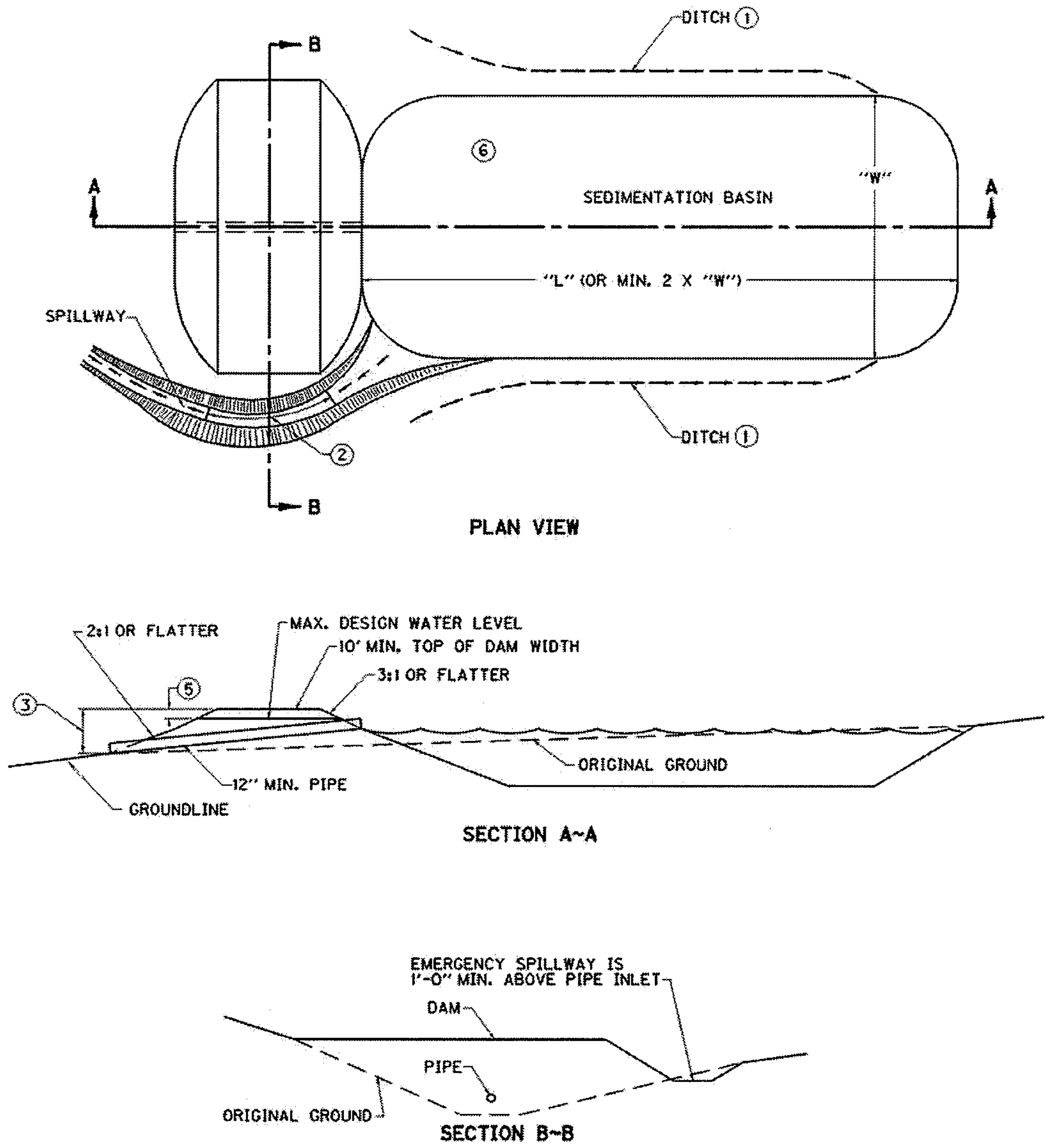
- Plan, profile, and cross sections of the dam
- Profile and cross sections taken perpendicular to the central axis of the storage basin at such intervals required to make accurate volume calculations
- Contour map of the entire storage basin with a maximum contour interval of 1 foot with the expected maximum ponding elevation outlined
- Discharge pipe and spillway details
- Material requirements and specifications
- Construction quantity estimate
- Notes for inspection program and required maintenance
- A generic layout sheet, which may be found on the active sepia list on the Division of Highway Design's Web page

The following criteria shall be applied in the design of a sedimentation basin:

- Dams shall be located at a deep constriction in the natural channel that has a wide area upstream for storage. This will result in the maximum storage volume for the lowest dam-construction cost.
- Maximum height shall not exceed 20 feet. Maximum height is measured from the natural bed of the stream or drainageway at the downstream toe of the barrier to the low point in the top of the dam.
- Maximum impounding capacity shall not exceed 20 acre-feet.
- The basin shall provide an acre-inch (3,600 cubic feet per acre) of sediment storage per acre of contributing watershed.
- Dams shall not be located where a failure would result in severe property damage or would endanger human life. They shall be founded on firm material and keyed into the existing foundation. Topsoil, loose overburden, or other undesirable material shall be removed. All dams shall be designed in accordance with current acceptable engineering practices.
- The outlet of the discharge pipe shall intersect the natural ground line.
- The upstream face of the dam shall be sloped at 3H:1V. The downstream face of the dam shall be sloped at 2H:1V. The minimum top width of the dam shall be 10 feet.
- Dams may be constructed of earth or a combination of end-dumped stone and earth. If constructed of earth, the earth shall be placed in 6-inch lifts and compacted to the same density required by the current standard specifications for roadway embankments.
- The basin shall be cleaned out when the available storage capacity falls below one-fifth the design volume.
- The discharge pipe shall be a minimum diameter of 12 inches.
- The inlet of the emergency spillway shall be located 1 foot above the inlet elevation of the discharge pipe. The emergency spillway shall be designed to accommodate the design discharge for a 10-year storm event.
- The dam shall be sized to provide 1 foot of freeboard above the normal flow depth in the emergency spillway.
- The control section shall be trapezoidal with 2H:1V side slopes. A maximum slope of 1.0 percent over the crest of the dam shall be provided. The spillway shall be extended a minimum distance of 4 feet beyond the toe of the dam embankment.

The designer shall include in the plans the Sedimentation Basin Example that is on the active sepia list on the Department of Highways' Web site. Refer to the following graphic for a representation of a sedimentation basin:

SEDIMENTATION BASIN EXAMPLE



~NOTES~

BID ITEM AND UNIT TO BID:

CODE	PAY ITEM	PAY UNIT
2711	SEDIMENTATION BASIN	CU. YD.
2712	CLEAN SEDIMENTATION BASIN	CU. YD.

1. INFLOW MUST BE ROUTED TO BACK OF SEDIMENTATION BASIN.
2. THE CONTROL SECTION WILL HAVE A SLOPE OF 1% OR LESS. CONTROL SECTION WILL BE DESIGNED TO CARRY THE DISCHARGE FROM A 10YR-24HR EVENT AND HAVE A SUFFICIENT LINER TO PREVENT EROSION.
3. MAXIMUM HEIGHT FROM ORIGINAL GROUND LINE AT TOE OF DAM TO TOP OF DAM NOT TO EXCEED 20 FEET.
4. THE BASIN WILL PROVIDE 3600 CUBIC FEET OF STORAGE CAPACITY PER DISTURBED ACRE DRAINED.
5. TOP OF DAM WILL PROVIDE AT LEAST 1' FREEBOARD ABOVE THE FLOW FOR THE 10YR-24HR EVENT.
6. VOLUME OF BASIN NOT TO EXCEED 20 ACRE FEET.

Sedimentation basins are normally removed upon completion of construction. If it is decided that a sedimentation basin is to remain, a special note shall be included in the plans. A program for the required inspection, cleaning, and disposal of sediment must be established. The necessary right of way or permanent easement for its operation must be provided. The contract unit bid price items for this work are "Sedimentation Basin" and "Clean Sedimentation Basin" in cubic yards. Installation shall include all work necessary to construct and maintain the silt trap as shown on the plans or as directed by the engineer.

NOTES AND COMMENTS

DR 1003-4 Temporary Silt Fence

Silt fence is often placed as a perimeter silt control measure but is often misused. It is recommended that silt fence be placed along lines of equal contour to intercept sheet flow. A 20-foot-wide grassy buffer area is recommended downslope from the fence. A single row of silt fence is effective for slopes less than 100 feet deep. For slope depths greater than 100 feet, multiple rows of silt fence are recommended, or temporary diversion ditches shall be installed. The contract unit bid price items for this work are "Temporary Silt Fence" and "Clean Temporary Silt Fence" in linear feet. Installation shall include all work necessary to construct and maintain the silt fence as directed by the plans or by the engineer. Refer to Standard Drawings RDX-210 and RDX-215 for construction of silt fence.

DR 1003-5 Temporary Silt Ditch

Temporary silt ditches are located along the right-of-way limits. Their purpose is to intercept sheet runoff before discharging onto adjacent property owned by another. They are not intended to convey large volumes of water. Temporary silt ditches deemed critical to the ECP are located on the plans by the designer. A silt trap is recommended at the ditch outlet. This work includes any necessary maintenance or silt removal in the life of the ditch. The contract unit bid price item for this work is "Temporary Silt Ditch," measured in linear feet. Installation shall include all work necessary to construct and maintain the silt ditch as directed by the plans or by the engineer.

DR 1003-6 Temporary Drainageways

Temporary drainageways may be located anywhere within the disturbed limits and are recommended to divert runoff from disturbed surfaces as they are exposed to a desirable discharge point such as a silt trap. These ditches may include temporary interceptor ditches, temporary surface ditches, and temporary special ditches. Temporary drainageways deemed critical to the ECP are located on the plans by the designer.

Phasing of these ditches is critical because their locations and effectiveness are dependent upon construction phasing and progress of work. A berm or interceptor ditch may be used at the top of cut slopes where the runoff from the surrounding area has a tendency to flow across a cut slope. This work includes any necessary maintenance or silt removal in the life of the ditch. The contract unit bid price item for this work is "Temporary Drainageway," measured in linear feet. Installation shall include all work necessary to construct and maintain the silt ditch as directed by the plans or by the engineer.

DR 1003-7 Permanent Ditches

Permanent ditches are those ditches indicated on the plans that are placed at final grade. They include surface ditches, "V"-shaped ditches, normal ditches, special ditches, and interceptor ditches. It is recommended that these ditches be placed as soon as possible once clearing has begun. If placed early in a construction phase, these ditches may provide service as an erosion control device. Erosion control blanket protection or channel lining shall be placed at the time of construction. If it is not possible or practical to place a permanent ditch at the outset of a construction phase, it is recommended that temporary drainageways be constructed to accommodate the flow and to provide erosion control. The pay item for permanent-ditch construction is "Roadway Excavation" and is measured in cubic yards.

DR 1004-1 General Information

An Erosion Control Plan includes contour maps, construction notes, and a narrative of the proposed development describing erosion control measures that will provide a favorable impact upon the natural land and water conditions. These plans depict:

- Drainage features
- Environmentally sensitive areas
- Surface waters of Kentucky
- Drainage ditches
- Existing contours
- Site specific permanent and temporary erosion control features that may be used to meet the KPDES permit requirement
- An estimated number of erosion control features for the project

The designer must first distinguish between the surface waters of Kentucky, drainage ditches, and overland flows. Drainage facilities shall be designed to interfere as little as possible with the quantity and quality of the waters of Kentucky. Surface waters of Kentucky shall be disturbed as little as possible. Flow generated solely from highway runoff or sheet flow from adjoining property shall not be considered surface waters.

Drainage ditches outfall into other drainage ditches or into the surface waters and need to be established as soon as possible in the construction phase in order to trap sediment. If permanent ditches are constructed early in the construction phase, they may be used to trap sediment generated during construction.

Overland flow areas need to be stabilized to minimize erosion. Overland or sheet flow areas adjacent to the surface waters of Kentucky shall be protected before flow is discharged into the surface waters of Kentucky.

Desirable erosion control practices may require the use of temporary or permanent right-of-way easements. Adequate area shall be provided, as indicated below, to construct and clean these measures:

- At least a 10-foot buffer adjacent to ditches, sedimentation basins, and silt fences
- Staging area for bridge construction equal to the area of the bridge
- Area for a sludge pond with a volume equal to the volume of excavation needed for pier construction within the channel banks

DR 1004-2 Construction Phasing

The most effective and economical way to control or minimize erosion is the development of a BMP consisting of a phased erosion control plan based upon the construction sequence. A BMP is much more effective if it is coordinated with a planned construction sequence. Likewise, a planned construction sequence may be selected to create an effective BMP.

For example, if vegetative stripping is performed only at the beginning of each phase, less land will be exposed than if all of the vegetative stripping is performed for the entire project at the outset of the project. As each phase of the construction is completed, it is more effective to protect the land with vegetative cover than it is to provide protection at the completion of the entire project.

The goals of a BMP are to minimize soil erosion of exposed slopes and to maximize sediment retention on-site. An Erosion Control Plan helps to achieve these goals as each planned sequence of construction events is executed. Erosion control structures shall be placed in accordance with the following guidelines:

- Locate, size, and protect ditches with erosion control mat, sod, or crushed aggregate.
- Locate and size silt traps.
- Place energy dissipaters at the outlet of 36-inch-diameter pipes and larger or where deemed necessary.
- Place silt fence along lines of equal contour to intercept overland flow.
- Prior to reaching final grade, locate temporary silt ditches to convey flow away from the exposed slopes to stabilized ditches.
- Prior to reaching final grade, locate temporary silt ditches to convey flow away from the exposed slopes to temporary silt traps.

Erosion control structures shall be sized in accordance with Part IV, Best Management Practices, of *General KPDES Permit for Storm Water Point Source Discharges Construction Activities.*

Occasionally, it may be more practical or economical to construct one sediment basin to control siltation. Such a basin shall be placed at the farthest downstream point just prior to discharging onto an adjacent property owned by another. Sedimentation basins shall be sized to store the sediment generated and may include a storm-water detention volume. This requirement is fulfilled by sizing the basins based on total drainage area rather that on disturbed area. They may be placed in surface waters of Kentucky.

In lieu of using the above procedure to determine required storage volumes, the designer may elect to use the Universal Soil Loss Equation to determine soil loss. This calculation applies to exposed areas not protected by permanent or temporary erosion control measures. The goal is to trap 80 percent of the silt generated by the exposure of these areas as determined by the Universal Soil Loss Equation.

Sediment basins and silt traps are used to accumulate the computed volume for the disturbed area affected. The results of these calculations for the project shall be summarized on the Erosion Control Plans.

DR 1004-3 Plan Generation

The Erosion Control Plan (ECP) has been an essential component of the plan development process for several years as necessitated by the KPDES requirements. The development of the ECP should reflect the erosion control needs for a specific phase of construction at the time it is being performed. An ECP that shows all the erosion control structures needed for the life of the project without addressing specific needs for a phase of construction is not a BMP.

Trying to development site-specific erosion control plans for any particular phase by a designer is at times an educated guess. The Contractor and Resident Engineer are in the best position to generate an effective Erosion Control Plan as a job progresses. The goal in the development of the Erosion Control Plans is to achieve the Best Management Practices Plan.

The following steps are essential in the development of the Erosion Control Plan:

- The Erosion Control Plan provided by the designer shall show a required volume to contain sediment prior to discharging onto each adjacent downstream property owned by another. The required volume and the maximum disturbed acreage in that watershed used to compute the volume shall be shown at the point of containment. The disturbed area will usually be bounded by the clearing and grubbing limits.

- The required volume shall be computed based on 3,600 cubic feet per disturbed acre as required by the KPDES permit. However, when a single device is placed in a location that has a drainage area larger that 10 acres, the total drainage area must be considered, and a sediment basin must be used.

- A silt control structure shall be sized to accommodate the required volume at the point of containment. Multiple structures may be used to accommodate the total volume requirement. Easements shall be shown as needed to contain all silt control structures.

- A sedimentation basin shall be designed in accordance with current standard practices. Detailed site plans shall be added to the plan set, which shall include a sedimentation basin detail sheet. This sheet may be obtained from the active sepia list on the Department of Highways' Web page. Refer to section DR 1003-3 for a discussion of the requirements for the design of a sedimentation basin.

- The designer shall include in the plans an estimate of the number of Silt Traps A, B, and C required for the job. The actual number will be determined during construction by the contractor with approval of the engineer. A spreadsheet tool has been placed on the Division of Highway Design's homepage to assist in the calculation of volumes upstream of silt traps placed in roadway ditches or similar situations.

- Erosion control features, methods, or practices that are deemed critical in the development of the Best Management Practices shall be shown on the Erosion Control Plan by the designer.

- As the job progresses during construction, the Erosion Control Plan shall be modified to reflect specific construction activities or phases. Silt control structures may be added or removed as necessary to accommodate the required volume.

- The required volume calculation for each silt control structure shall be determined by the contractor and verified by the engineer. To achieve the BMP, the required volume as shown on the ECP may be reduced by the following amounts:

  - Areas not disturbed (acres)

  - Areas that have been reclaimed and protected by erosion control blankets or other ground protection material (acres)

  - Areas that have been protected by silt fence (acres)

    Note: Areas protected by silt fence shall be computed at the rate of 100 square feet / linear feet of silt fence.

  - Areas that have been protected by silt traps (acres)

- The development of the Best Management Practices Plan shall be documented by the contractor with approval of the engineer by showing each erosion control method or device and each silt containment structure used on the project. This information shall be shown on the Erosion Control Plan and shall be documented by other state-approved means.

- The CADD standards include line styles for blue-line streams. The designer will use these line styles to depict all blue-line streams on the project.

NOTES AND COMMENTS

DR 1004-4 Plan Details

Silt trap volumes shall be based upon the maximum disturbed area in the contributing watershed for each silt trap. This shall include all temporary or construction easements. Silt trap volumes shall be shown at the farthermost downstream point prior to discharging into a stream or onto an adjacent property owned by another. The actual number and location of all silt control structures will be determined during construction. The designer shall locate all silt control structures that are considered critical or essential for the project. Silt control structures may be adjusted, added, or moved by the contractor prior to or during construction with concurrence of the engineer and as described herein. Ultimate location and approval of all erosion control devices placed by the contractor will be by the engineer.

The Erosion Control Plans shall include:

- Existing contours
- Existing right-of-way limits
- Proposed right-of-way limits including all construction and permanent easements
- Maximum disturbed watershed boundary for each watershed
- Drainage areas noted in acres for point discharges with contributing watersheds of 10 acres or more and their associated 10-year peak flow rate
- All permanent ditches, temporary erosion control structures, and construction notes

A summary of the erosion control requirements based upon maximum disturbance shall be shown on the Erosion Control Plans near the right-of-way limit for each discharge point as follows:

DISTURBED DRAINAGE AREA - DDA1
MAXIMUM DISTURBED AREA = 24.2 ACRES DESIGN TRAP VOLUME = 24.2 AC X 3600 CF/AC = 62280 CF

The following typical notes shall be included on all Erosion Control Plans:

- All silt traps shall be sized to retain a volume of 3,600 cubic feet per disturbed contributing acre.

- The contractor shall conduct all grading and construction operations to minimize the amount of disturbed ground during each phase of construction. The contractor shall compute the volume necessary to control sediment during each phase of construction. As work proceeds, silt traps may be added or removed in order to achieve the Best Management Plan. The required volume at each added silt trap shall be computed as upgradient contributing areas are disturbed or are stabilized to the satisfaction of the engineer. The required volume calculation for each silt trap shall be determined by the contractor and verified by the engineer. The required volume at each silt trap may be reduced by the following amounts:

  - Upgradient areas not disturbed (acres)

  - Upgradient areas that have been reclaimed and protected by erosion control blanket or other ground protection material (acres)

- Upgradient areas that have been protected by silt fence (acres). Areas protected by silt fence shall be computed at a maximum rate of 100 square feet per linear foot of silt fence.

- Upgradient areas that have been protected by silt traps (acres)

▶ The Erosion Control Plan shall be annotated as the work proceeds by the contractor to detail the selection of each erosion control device used and the volume provided by each silt trap in accordance with the documentation procedures established by the Division of Construction.

▶ A minimum of one Silt Trap, Type A, alternate number 2, or Silt Trap, Type B, shall always be placed immediately prior to discharging into any blue-line stream, other regulated water or onto an adjacent property. Silt traps shall not be placed in blue-line streams or other regulated waters.

All Contract Proposals will include a bid item to cover the various types of erosion control item that might be needed on the project. While all the items might not be used on each project, it is the intent of the Design Engineer to provide the Resident Engineer and the Contractor flexibility in choosing erosion control devices and/or methods to create the BMP.

Unless the Design Engineer has knowledge of factors which indicate other values should be used, the estimated quantities should be calculated using the guidelines described in Construction Memo 05-2015. The current Bid Items list is available on KYTC's website.

If the designer determines that the project is conducive to constructing a sediment basin, this needs to be identified and a bid item provided as well. Sedimentation basins shall be individually designed and included in the plans with a complete set of construction notes and specifications.

NOTES AND COMMENTS

DR 1005-1 General Information

The failure of many culverts can be traced to unchecked erosion and extreme forces in the channel due to the high flow velocities. To protect a culvert and the surrounding areas, it is often useful to employ an energy dissipating device at the culvert outlet. The design of the riprap basin dissipater is outlined in this section. For more details about the design procedure and energy dissipaters in general, refer to the *Hydraulic Engineering Circular Number 14*.

Energy dissipaters may be classified as internal versus external. Internal dissipaters are classified as increased resistance and tumbling flow dissipaters. External dissipaters include riprap aprons, wingwalls, drop structures, at streambed impact basins, and stilling basins. Refer to the following table when selecting an appropriate energy dissipater. The designer shall consider efficiency and cost when selecting an energy dissipater from more than one alternative. Riprap placed at culvert outlets and SAF stilling basins are preferred.

ENERGY DISSIPATER GUIDELINES

DISSIPATER TYPE	DESCRIPTION	DESIGNATION	FROUDE NUMBER	COMMENT
Internal	Increased Resistance	–	–	–
	Tumbling Flow	–	> 1.0	–
External	Outlet Protection	Culvert with Headwall	≤ 1.5	Place 25' - 30' Riprap
			> 1.5 (Pipe D < 48")	Place 25' - 30' Riprap*
			> 1.5 (Pipe D > 48")	Design Riprap Transition*
		Protruding Culvert	≤ 1.5	Place 25' - 30' Riprap
			> 1.5 (Pipe D < 48")	Place 25' - 30' Riprap*
			1.5 – 3.0	Design Riprap-Lined Basin*
			> 3.0	Design SAF Dissipater
	Drop Structure	Straight	< 1.0	–
		Box Inlet	< 1.0	–
	@ Streambed Impact Basin	CSU Basin	< 3.0	–
		Contra Costa Basin	< 3.0	–
		Hook Basin	1.8 – 3.0	–
		USBR – 6	–	–
	Stilling Basin	S A F Basin	1.7 – 17	–
		USBR – 4	2.5 – 4.5	–
		USBR – 2	4.0 – 14	–
		USBR – 3	4.5 – 17	–

*The designer shall verify that the recommended design satisfies stability requirements.

DR 1005-2 Riprap-Lined Basin

The design procedure for riprap energy dissipaters is based on data obtained during a study, "Flood Protection at Culvert Outfalls," sponsored by the Wyoming Highway Department and conducted at Colorado State University. This procedure is applicable in situations where the culvert protrudes from the embankment without a headwall. The following conclusions were drawn from the analysis of the experimental data:

- The depth (h_S), length (L_S), and width (W_S) of the scour hole are related to the characteristic size of the riprap (d_{50}), discharge (Q), brink depth (y_o), and tailwater depth (TW).
- The dimensions of a scour hole in a basin constructed with angular rock are approximately the same size as the dimensions of a scour hole in a basin constructed of rounded material with all other variables being similar.
- When the ratio of tailwater depth to brink depth (TW / y_o) < 0.75 and the ratio of scour depth to size of riprap (h_S / d_{50}) is greater than 2.0, the scour hole functioned very efficiently as an energy dissipater.
- The mound of material that formed on the bed downstream of the scour hole contributed to the dissipation of energy and reduced the size of the scour hole. If the mound was removed, the scour hole enlarged.
- When the ratio of tailwater depth to brink depth (TW / y_o) > 0.75, the high velocity of water emerging from the culvert retained its jetlike character as it passed through the basin. The scour hole was much shallower and generally longer; thus riprap may be required in the channel downstream.

General sizing details for the basin are as follows:

- The basin is preshaped and lined with riprap.
- The floor of the basin is constructed a depth of h_S below the culvert outlet.
- The ratio of h_S to d_{50} should be greater than 2.0 and less than 4.0.
- The length of the pool is $10*h_S$ or $3*W_O$, whichever is greater.
- The flow properties at the brink of the culvert are estimated.
- The brink invert elevation is established such that TW / y_O is less than 0.75 for the design discharge.

The design procedure is as follows:

1. Using the design discharge and culvert geometry, calculate $Q / BD^{1.5}$ for rectangular culverts or $Q / D^{2.5}$ for circular culverts.
2. Subcritical Flow
   a. For rectangular culverts set on mild or horizontal slopes (subcritical flow), use the results from Step 1 in **Figure 1005-2-A** to determine brink depth, y_O. Brink depth is obtained by multiplying the structure height, D, by the y_O / D ratio obtained from the graph.

   b. For circular culverts set on mild or horizontal slopes (subcritical flow), use the results from Step 1 in **Figure 1005-2-B** to determine brink depth, y_O. Brink depth is obtained by multiplying the pipe diameter, D, by the y_O / D ratio obtained from the graph.

Figure 1005-2-A
BRINK DEPTH FOR RECTANGULAR CULVERTS

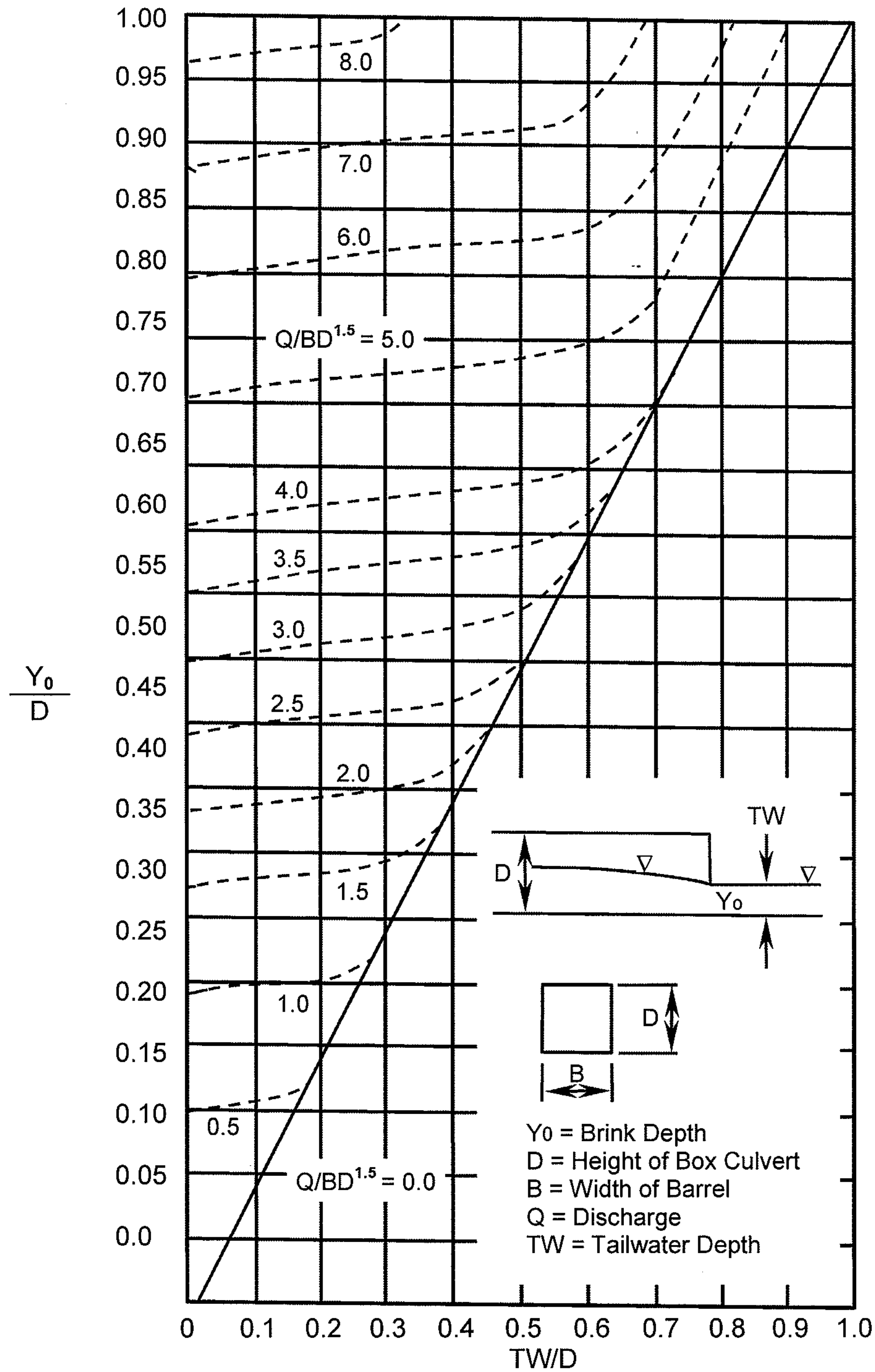
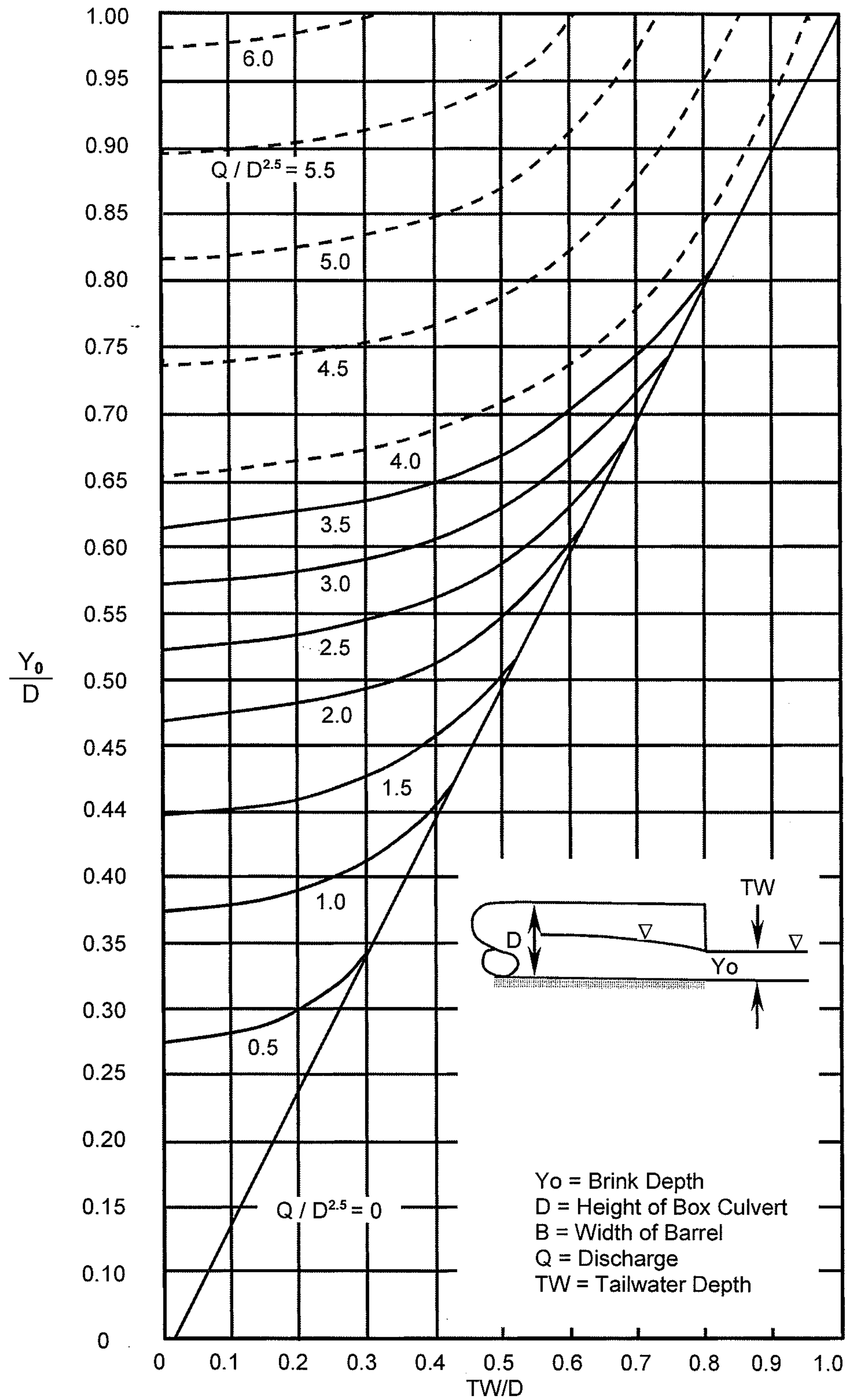


Figure 1005-2-B
BRINK DEPTH FOR CIRCULAR CULVERTS



c. Determine wetted area, A_O, associated with the brink depth, y_O. Wetted area, A_O, is calculated as follows:

(1) For rectangular culverts, the wetted area, $A_O = (B)(y_O)$.

(2) For circular culverts, for $y_O > r$, the wetted area, $A_O = \pi r^2(1-\beta/360)+y(r^2-y^2)^{0.5}$ where $\beta = 2\arccos(y/r)$, y is the portion of the brink depth greater than half full ($y = y_O - r$), and r is the radius of the pipe.

(3) For circular culverts, for $y_O < r$, the wetted area, $A_O = \pi r^2\beta/360 - y(r^2-y^2)^{0.5}$ where $\beta = 2\arccos(y/r)$, $y = r - y_O$ and r is the radius of the pipe.

d. Obtain the culvert outlet velocity, V_O, by dividing the design flow, Q, by the wetted area, A_O.

e. Compute the Froude number, Fr, based on brink conditions to verify flow regime. $Fr = V_O / \sqrt{(gy_O)}$ where g is the gravitational constant, 32.2 ft/sec^2. Subcritical flow occurs if $Fr < 1$. If $Fr > 1$, go to Step 3 and recompute.

3. Supercritical Flow

For culverts set on steep slopes (supercritical flow), a trial V_O and A_O are computed by assuming a brink depth so that a trial flow, Q, can be obtained. This flow is compared to the design flow, and the brink depth is adjusted until a solution is obtained.

a. Assume a brink depth, y_O.

b. Wetted area, A_O, is calculated as noted in step 2c.

c. Wetted perimeter, WP_O, is calculated as follows:

(1) For rectangular culverts, the wetted perimeter, $WP_O = B + 2*y_O$ where B is the culvert width.

(2) For circular culverts, for $y_O > r$, the wetted perimeter, $WP_O = \pi D(360-\beta) / 360$ where $\beta = 2\arccos(y/r)$ and y is the portion of the brink depth greater than half full.

(3) For circular culverts, for $y_O < r$, the wetted perimeter, $WP_O = \pi D(\beta/360)$ where $\beta = 2\arccos(y/r)$ and $y = r - y_O$.

d. V_O is calculated by using the Manning Equation, $V = 1.49*R^{2/3}*S^{1/2}/n$. Hydraulic radius, R, is defined as wetted area (A_O) divided by wetted perimeter, WP_O. S is the slope of the pipe (ft/ft), and n is the Manning roughness number.

e. Compute trial flow, $Q_O = V_O * A_O$, and compare to design flow, Q. Adjust brink depth and recompute beginning at Step 3b. (Try next $y_O = y_O * (Q / Q_O)^{0.5}$.)

f. Once a solution has been obtained by iteration, compute the Froude number, Fr, to verify flow regime. $Fr = V_O/\sqrt{(gy_O)}$ where g is the gravitational constant, 32.2

ft/sec^2. Supercritical flow occurs if $Fr > 1$. If $Fr < 1$, recalculate subcritical flow beginning in Step 2.

4. Determine tailwater (TW) at the outlet such that $TW / y_O \leq 0.75$. If out of range, adjust brink outlet elevation or redesign outlet channel, recompute situation, and recalculate beginning at Step 1.

5. Ensure that channel protection is possible and practical based on site inspection or by use of the Froude number.

6. Determine equivalent brink depth for nonrectangular sections. The Colorado State energy dissipater research was based on rectangular culverts, so an equivalent brink depth for nonrectangular sections was developed. An equivalent section is based on a rectangle that is twice as wide as it is tall. For rectangular culverts, use $y_e = y_O$. For nonrectangular sections the equivalent brink depth is $y_e = (A_O/2)^{1/2}$. Equivalent brink depth is used to determine riprap size.

7. Select a riprap size. A recommended range for satisfactory results is $0.25 < D_{50}/y_e < 0.45$. Obtain h_S/y_e ratio from **Figure 1005-2-C**, compute h_S, and check to see if $2 < h_S/D_{50} < 4$. Revise the design if the result is not within this range.

8. The final step is to size the basin as shown in **Figure 1005-2-D**.

9. In the exit region of the basin, the walls and apron of the basin shall be transitioned so that the cross section of the basin at the exit conforms to the natural channel. An optional key may be added, and riprap may be extended downstream if channel degradation is expected.

Figure 1005-2-C
RIPRAP SELECTION FOR DISSIPATER BASINS

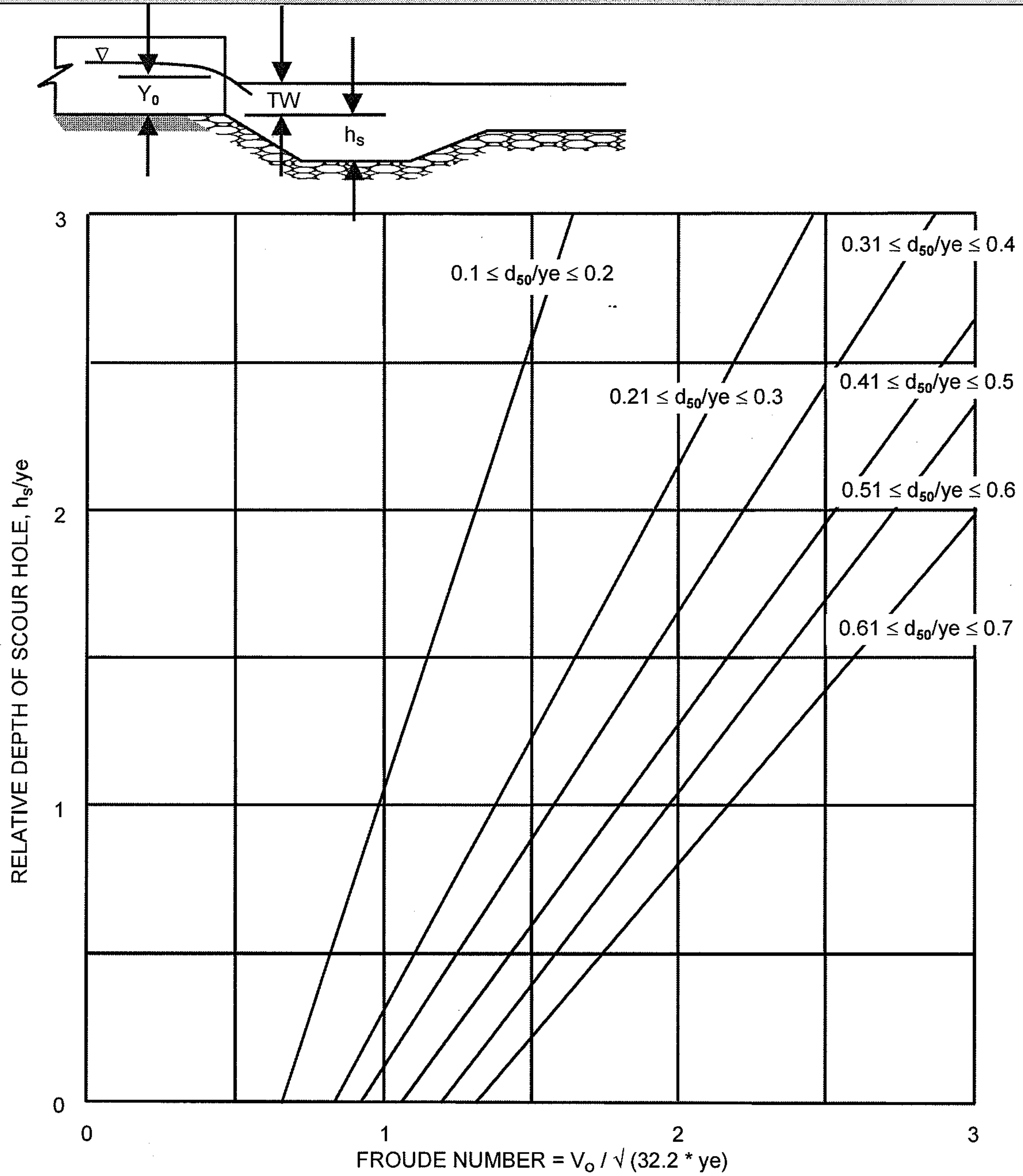


Figure 1005-2-D
ENERGY DISSIPATER DETAILS

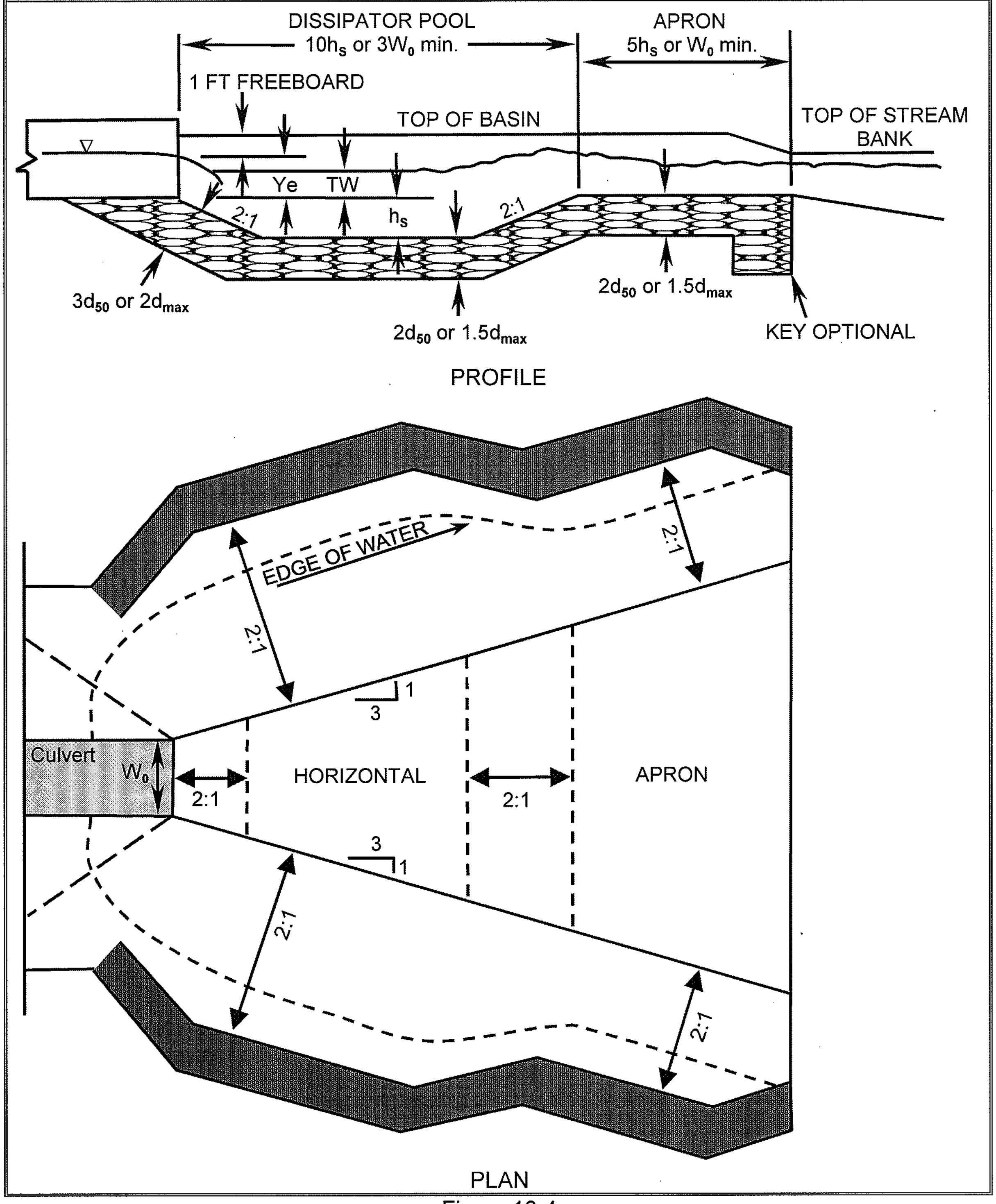


Figure 10-4

NOTES AND COMMENTS

DR 1005-3 Riprap-Lined Outlet Transition

Culvert outlets having outlet Froude numbers greater than 1.5 and circular diameters (or equivalent) greater than 48 inches require additional consideration when designing scour prevention measures. An abrupt flow expansion and transition exist from the culvert outlet to the point of normal depth and velocity in the channel. A headwall with a concrete apron provides scour protection not offered by a protruding culvert.

It is recommended that a 50-foot-long (minimum) blanket of stable material be provided beyond the concrete apron. The blanket shall be extended up the side slopes of the channel to a depth equal to the normal depth of the design storm or to a depth that is shown to have a stable side slope. The flow exiting the blanket shall not exceed the shear stress of the existing channel. It is recommended that the designer refer to *HEC-14, Sept. 1983, Chapter IV, Flow Transitions,* and *Chapter V, Estimating Erosion at Culvert Outlets*, if situations warrant a detailed analysis. It is recommended that the designer refer to *Chapter V, Hydraulic Jump,* and *Chapter VII, Forced Hydraulic Jump Basins,* when the protection provided by Class III channel lining is inadequate.

DR 1005-4 Saint Anthony Falls (SAF) Basin

The Saint Anthony Falls--or SAF—stilling basin is a generalized design that uses a hydraulic jump to dissipate energy. The design is based on model studies conducted by the Soil Conservation Service at the Saint Anthony Falls Hydraulic Laboratory at the University of Minnesota.

The design provides special appurtenances, chute blocks, baffle or floor blocks, and an end sill, which allow the basin to be shorter than free hydraulic jump basins. It is recommended for use at small structures such as spillways, outlet works, and canals where Fr = 1.7 to 17. Fr is the Froude number at the dissipater entrance. The reduction in basin length achieved through the use of appurtenances is about 80 percent of the free hydraulic jump length.

At the design flow, the SAF stilling basin provides an economical method of dissipating energy and preventing dangerous streambed erosion. Design recommendations are as follows:

- The width, W_B, of the stilling basin is equal to the box culvert width, W_O. For circular conduits, W_B is the larger of D_O or $0.3D(Q/D)^{2.5}$.
- The basin can be flared to fit an existing channel as indicated in **Figure 1005-4-A**. The sidewall flare ratio, z, should not be smaller than 2 such that the slope will be 2H:1V or flatter.
- The length, L_B, of the stilling basin for Froude numbers between 1.7 and 17 is proportional to the sequent depth, y_J, found for the hydraulic jump equation:
  - $y_J = y_1 [\sqrt{(1 + 8^*Fr_1^{\ 2})} - 1] / 2$
  - $L_B = 4.5\, y_J / Fr^{0.76}$
- The height of the chute block is y_1, and the width and spacing of the blocks are approximately 0.75 y_1.
- Floor or baffle blocks should be staggered with respect to the chute blocks and should be placed downstream a distance of $L_B/3$. They should occupy between 40 and 55 percent of the stilling basin width. Widths and spacings of the floor blocks for diverging stilling basins should be increased in proportion to the increase in stilling basin width at the floor block location. No floor blocks should be placed closer to the side wall than $3y_1 / 8$.
- The height of the end sill is $0.07y_J$ where y_J is the sequent depth corresponding to y_1.
- The depth of tailwater, y_2, above the stilling basin floor is determined as follows:

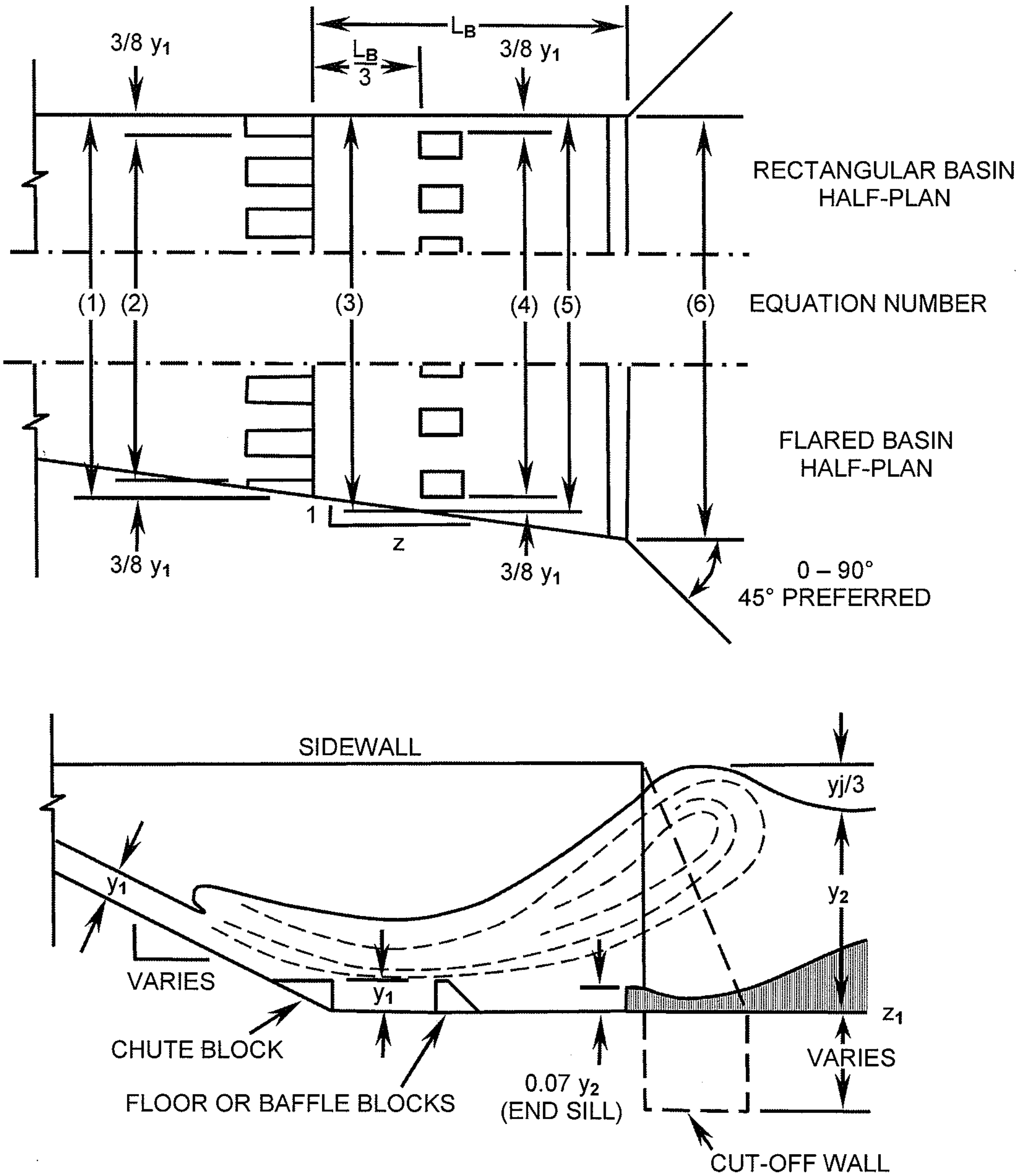
Froude Number	Tailwater Depth, y_2	Equation Number
1.7 – 5.5	$(1.1 - Fr_1^2/120)\, y_J$	1005-4-A
5.5 – 11	$0.85y_J$	1005-4-B
11 – 17	$(1.0 - Fr_1^2/800)y_J$	1005-4-C

- Wingwalls should be equal in height and length to the stilling basin sidewalls. The top of the wingwall should be a 1:1 slope. Flaring wingwalls are preferred to perpendicular or parallel wingwalls. The best overall conditions are obtained if the triangular wingwalls are located at an angle of 45 degrees to the outlet centerline.

- The stilling basin sidewalls may be parallel (rectangular stilling basin) or may diverge as an extension of the transition sidewalls (flared stilling basin). The height of the sidewall above the maximum tailwater depth to be expected during the life of the structure is given by $y_J/3$.

- A cut-off wall of adequate depth should be used at the end of the stilling basin to prevent undermining. The depth of the cut-off wall must be greater than the maximum depth of anticipated erosion at the end of the stilling basin.

Figure 1005-4-A
SAF STILLING BASIN DETAILS



(1) W_B = Upstream Basin Width
(2) N Blocks at 3/4 y1 ±
(3) $0.42\ W_{B2} \leq$ Aggregate Block Width $\leq 0.55\ W_{B2}$
(4) N Blocks at 3/4 y1 W_{B2} / W_B ±
(5) $W_{B2} = W_B + 2L_B / 3Z$
(6) $W_{B3} = W_B + 2L_B / Z$

Typical Design Procedure

1. Choose basin configuration and flare dimension, z.

2. Refer to Section IV of *HEC-14,* "Supercritical Expansion into Hydraulic Jump Basins," to determine basin width (W_B), elevation (z_1), length(L_B), total length (L), incoming depth (y_1), incoming Froude number (Fr_1), and jump height, y_2.

    a. In Step 5E in *HEC-14*, y_2 is computed by equation 1005-4-A, 1005-4-B, or 1005-4-C shown above as is applicable. Compute $y_J = y_1[\sqrt{}(1+8F_{R1}^2)-1] /2$.

    b. In the calculation of z3 in Step 5F in *HEC-14*, use $L_B = 4.5\ y_J / Fr^{0.76}$.

3. Chute block sizing:

    a. Height, $h_1 = y_1$
    b. Width, W_1 = spacing; $W_2 = 0.75\ y_1$
    c. Number of blocks, $N_C = W_B / 2\ W_1$ (rounded to whole number)
    d. Adjusted $W_1 = W_2 = W_B / 2\ N_C$ (including half block on each side)

4. Baffle block sizing:

    a. Height, $h_3 = y_1$
    b. Width, W_3 = spacing, $W_4 = 0.75\ y_1$
    c. Basin width at baffle blocks, $W_{B2} = W_B + 2\ L_B / 3\ z$
    d. Number of blocks, $N_B = W_{B2} / 2\ W_3$ (rounded to whole number)
    e. Adjusted $W_3 = W_B = W_{B2} / 2\ N_B$
    f. Check total block width to ensure that 40% - 55% of W_{B2} is occupied.
    g. Distance from chute blocks to baffle blocks = $L_B / 3$

5. End sill height, $h_4 = 0.07\ y_J$

6. Sidewall height = $y_2 + y_J /3$

7. Size the basin as shown in **Figure 1005-4-A**.

It is recommended that the designer use the HY8Energy computer program to size an SAF basin. This program can be obtained from Federal Highway Administration's Web site at:

http://www.fhwa.dot.gov/bridge/hydsoft.htm

NOTES AND COMMENTS

DR 1006-1 General Information

The Universal Soil Loss Equation (USLE) has been used extensively as an acceptable method of computing sheet erosion from farmlands. Modifications have been made in the USLE for determining construction site erosion. The revisions are referred to as RUSLE and are accomplished mainly through adjustments of "urban" vegetation conditions ("C" factors) and the urban best management factors ("P" factors). Soil erosion from rills and gullies is not included in this equation. If gullies are present or a potential problem, further computations may be made to determine additional soil erosion. This is an "estimation" of sheet soil erosion and is not interchangeable with sediment delivery or sediment yield.

The rate of sheet erosion depends on several factors:

- Rainfall energy and intensity
- Soil erodibility
- Land slope and length of slope
- Condition of the soil surface and best management practices in use
- Surface cover involved, such as grass, woodlands, crops, pavement, or no cover at all

These factors are assigned quantitative values to be used for computing soil loss and are found in the following tables.

The Universal Soil Loss Equation equation is A = R x K x (LS) x C x P, where

- A = The computed annual soil loss expressed in tons per acre

- R = The rainfall factor is the number of erosion index units in a normal year's rain. The average annual erosive rainfall factors (R values) for Kentucky are shown in **Table 1006-1-A.**

- K = The soil erodibility factor for selected soils of Kentucky is shown in **Table 1006-1-B.** K is the erosion rate per unit of erosion index for a specific soil.

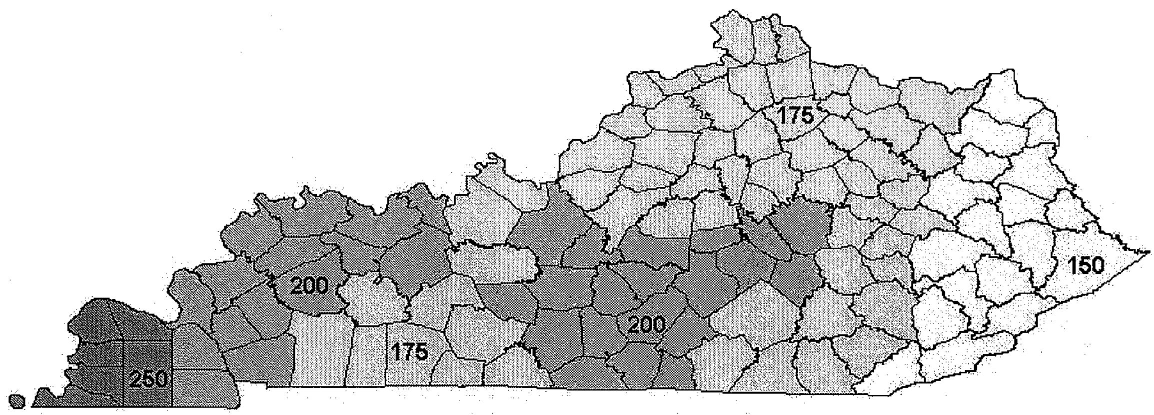
- LS = The slope length factor is the ratio of soil loss from a specific slope length to a 72.6-foot slope of the same soil on a 9 percent gradient. Refer to **Table 1006-1-C** for values of LS.

- C = The cropping management factor is the ratio of soil loss from a field with specified cropping management to that of the fallow condition on which the factor K is evaluated. Refer to **Table 1006-1-D** for crop management factors.

- P = The best management practice factor is the ratio of soil loss with certain conservation practices to that which results without such practices. Refer to **Table 1006-1-E** for best management practice factors. The annual soil loss in tons per acre may be reduced to cubic yards per acre by use of **Table 1006-1-F** and adjusted for the portion of the year that the soil is actually exposed to soil erosion by use of **Table 1006-1-G**.

Table 1006-1-A

RAINFALL FACTOR, R by COUNTY



Counties with 150 R Factor				
Bell	Elliott	Johnson	Letcher	Morgan
Boyd	Floyd	Knott	Magoffin	Perry
Breathitt	Greenup	Lawrence	Martin	Pike
Carter	Harlan	Leslie		
Counties with 175 R Factor				
Allen	Clay	Kenton	Nelson	Shelby
Anderson	Estill	Knox	Nicholas	Simpson
Bath	Fayette	Laurel	Ohio	Spencer
Boone	Fleming	Lee	Oldham	Todd
Bourbon	Franklin	Lewis	Owen	Trimble
Bracken	Gallatin	Logan	Owsley	Warren
Breckinridge	Grant	Mason	Pendleton	Washington
Bullitt	Grayson	McCreary	Powell	Wayne
Butler	Harrison	Meade	Pulaski	Whitley
Campbell	Henry	Menifee	Robertson	Wolfe
Carroll	Jackson	Mercer	Rowan	Woodford
Christian	Jefferson	Montgomery	Scott	
Clark	Jessamine	Muhlenberg		
Counties with 200 R Factor				
Adair	Cumberland	Hart	Madison	Rockcastle
Barren	Daviess	Henderson	Marion	Russell
Boyle	Edmonson	Hopkins	Marshall	Taylor
Caldwell	Garrard	Larue	McLean	Trigg
Calloway	Green	Lincoln	Metcalfe	Union
Casey	Hancock	Livingston	Monroe	Webster
Clinton	Hardin	Lyon	Ohio	
Crittenden				
Counties with 250 R Factor				
Ballard	Fulton	Graves	Hickman	McCracken
Carlisle				

Table 1006-1-B
ERODIBILITY (K FACTORS) AND TEXTURES OF B AND C HORIZONS FOR SELECTED KENTUCKY SOIL SERIES

Soil Series	B Horizon		C Horizon	
	Tex.	K Value	Tex.	K Value
Armour	sicl	0.37	sicl	0.43
Ashton	sil	0.43	sil	0.43
Avonburg	sil	0.43	sic	0.32
Beasley	sic	0.28	c	0.28
Brandon	sicl	0.28	vgrsl	0.17
Brashear	sic	0.28	c	0.28
Braxton	sicl	0.28	sicl	0.28
Calloway	sic	0.43	sic	0.43
Crider	sicl	0.32	sic	0.28
Cynthiana	sic	0.28	rock	----
Donerail	sicl	0.28	c	0.28
Eden	flsic	0.28	vflsic	0.17
Elk	sicl	0.28	sicl	0.28
Fairmont	sic	0.28	rock	----
Faywood	sic	0.28	sic	0.28
Grenada	sicl	0.49	sil	0.64
Lakin	fsl	0.17	ls	0.17
Lanton	sic	0.43	c	0.32
Lax	sicl	0.43	grcl	0.32
Loradale	sic	0.28	c	0.28
Loring	sicl	0.49	sicl	0.43
Lowell	sic	0.28	c	0.28
Maury	sic	0.28	c	0.28
McAfee	sic	0.28	c	0.28
Memphis	sicl	0.49	sil	0.49
Mercer	sicl	0.43	c	0.28
Muskingum	sil	0.28	cnsil	0.17
Nicholson	sicl	0.43	c	0.37
Russellville	sicl	0.43	c	0.37
Shelbyville	sicl	0.28	sic	0.28
Wheeling	cl	0.24	fsl	0.24
Woolper	sic	0.28	c	0.28
Zanesville	sicl	0.28	l	0.28

(The K value may be increased or decreased as much as 20 percent to adjust for local soil series variations.) Abbreviations of Soil Textures are as follows:

c—clay
cl—clay loam
cnsil—channery silt loam
fsl—fine sandy loam
grsl—gravelly clay loam
ls—loamy sand
sic—silty clay
sicl—silty clay loam
sil—silt loam
vflsic—very flaggery silty clay
vgrsl—very gravelly sandy loam

Table 1006-1-C
Soil Loss, LS, Along a Slope

$LS = (\lambda / 72.6)^m * (430 * x^2 + 30 * x + 0.43) / 6.613$

Where λ = slope length (λ = horizonal length/cos θ or = fill height/sin θ)

θ = slope angle; $x = \sin \theta$

^{m} = 0.3 for slope < 3%, 0.4 for slope = 4%, or 0.5 for slope > 5%

LS Based on Horizontal Length (feet)

Slope H : V	10	20	30	40	60	80	100
50 : 1	0.100	0.123	0.139	0.152	0.172	0.187	0.200
40 : 1	0.121	0.149	0.168	0.183	0.207	0.226	0.241
30 : 1	0.159	0.196	0.221	0.241	0.272	0.297	0.317
25 : 1	0.193	0.238	0.269	0.293	0.331	0.361	0.386
20 : 1	0.205	0.271	0.319	0.358	0.421	0.472	0.516
10 : 1	0.432	0.610	0.748	0.863	1.057	1.221	1.365
8 : 1	0.607	0.858	1.051	1.213	1.486	1.716	1.918
6 : 1	0.960	1.357	1.662	1.919	2.351	2.714	3.035
4 : 1	1.880	2.659	3.257	3.761	4.606	5.318	5.946

LS Based on Fill Height (feet)

Slope H : V	5	10	20	40	60	80	100
6 : 1	1.662	2.351	3.325	4.702	5.758	6.649	7.434
4 : 1	2.659	3.761	5.318	7.521	9.212	10.637	11.892
2 : 1	5.925	8.379	11.850	16.759	20.525	23.700	26.498
1 : 1	11.168	15.794	22.336	31.587	38.687	44.671	49.944

Table 1006-1-D ESTIMATED C FACTORS FOR PROTECTIVE GROUND COVER ON CONSTRUCTION SITES		
Type of Cover	**Application Rate**	**C Factor**
None (Fallow Ground)	-	1.0
Temporary Seeding (90% Stand):		
Ryegrass (Perennial Type)	-	0.05
Ryegrass (Annuals)		
Small Grain	-	0.05
Millet or Sudan Grass	-	0.05
Field Bromegrass	-	0.03
Permanent Seedings (90% Stand):	-	-
(Bluegrass, KY 31 Fescue, etc.)	-	0.01
Sod (Laid Immediately)	-	0.01
Mulches:		
Straw or Hay	2 Tons/acre	0.25
	4 Tons/acre	0.13
	6 Tons/acre	0.07
	10 Tons/acre	0.02
Wood Chips	30 Tons/acre	0.06
Wood Cellulose	9 Tons/acre	0.10
Fiberglass	2 Tons/acre	0.05
Asphalt Emulsion	40 Cubic Yards/acre	0.02
(Fiber matting, excelsior, gravel, and stone may also be used as protective ground cover with an estimated C factor of 0.02 to 0.10 depending upon the amount applied.)		

ESTIMATED C FACTORS FOR SURFACE CONDITIONS WITH NO COVER	
Type of Cover	**C Factor**
Compact and smooth, scraped with bulldozer or scraper up and downhill	1.3
Same condition, except raked with bulldozer root rake up and downhill	1.2
Compact and smooth, scraped with bulldozer or scraper along the slope	1.2
Same condition, except raked with bulldozer root rake along the slope	0.9
Loose as a disked layer	1.0
Rough irregular surface equipment tracks in all directions	0.9
Loose with rough surface greater than 1 foot deep	0.8
Loose with smooth surface greater than 1 foot deep	0.9

Table 1006-1-E ESTIMATED BEST MANAGEMENT PRACTICE P FACTORS FOR SEDIMENT BASINS AND SEDIMENT CONTROL SYSTEMS	
Situation	**P Factor**
Sediment basin – small, on site	
- Receiving sediment from 70% of the site	0.50
- Receiving sediment from 100% of the site	0.20
Sediment basin – large, off site	
- Downstream below construction site	0.15
System of diversions and waterways	
- Seeded, sodded, riprap as needed	0.45

Table 1006-1-F FACTORS FOR CONVERTING TONS PER ACRE TO CUBIC YARDS PER ACRE	
Texture	**Factor**
Sands, loamy sands, sandy loams	0.70
Sandy clay loams, silt loams, loams, and silty clay loams	0.87
Clay loams, sandy clays, clay, and silty clays	1.02

Table 1006-1-G RAINFALL DISTRIBUTION TABLE				
Month	**Western Half of Kentucky[1]**		**Eastern Half of Kentucky[1]**	
	Per Month	**Accumulative**	**Per Month**	**Accumulative**
January	3	3	3	3
February	6	9	4	7
March	7	16	6	13
April	9	25	6	19
May	12	37	8	27
June	12	49	13	40
July	15	64	20	60
August	13	77	20	80
September	7	84	9	89
October	6	90	4	93
November	5	95	3	96
December	5	100	4	100
SUM	100		100	

[1] Division line is approximately a north/south line from Owenton to Albany.

NOTES AND COMMENTS

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