WVDOH Standards Committee Meeting
Tuesday, April 7, 2026
Meeting Location: 190 Dry Branch Drive, Charleston, WV

Also meeting virtually via Google Meet. Email distribution includes instruction.

Old Business: Standards discussed at the February 2026 meeting are below.

ITEM	Champion
3rd time to Committee. Discussed in December, February, April • DD-644-*Asphalt Pavement* • DD-646-*Pavement Design Guide* • DD-647-*Life-Cycle Cost Analysis for Pavement Design* • DD-648-*Alternate Design and Alternate Bidding of Pavements* The revisions include updated links and reference documents, as well as adding new standards for pavement design. Revision reflects updates to AASHTO 93 and adjusts analysis periods. Meeting held outside committee to discuss directives. Updates are shown.	K. Welch
2nd time to Committee. Discussed in: Feb, April • DD811-*Accessability Standards, Curb Ramps and Sidewalks* The revision removes 2010 Standards language and replaces it with the governing standard for public right-of-way, the Public Rights of Way Accessibility Guidelines (PROWAG) and updates curb ramp attribute standards to reflect. The update also cleans up language and links, adding logistics and clarifying directions to the Exception Justification Report (EJR) form. Approval Expected.	R. Patrick

New Business: None

ITEM	Champion
1st time to Committee • DD-105-*Specification, Standards, Manuals, and Material Procedure Approval Process* The revision clarifies the work and standard operating procedures for the Publications Section following the Reorganization and other departmental changes.	S. Boggs
1st time to Committee • DD622- *Intersections on Rural Divided Highways* • DD625- *Interchange Warrants* The revision updates references to outdated 2011 AASHTO's A Policy on Geometric Design of Highways and Streets to the current 2018 edition, ensuring alignment with the latest national geometric design standards:	S. Boggs
1st time to Committee • DD662- *Guardrail* The revision reflects coordination between WVDOH and FHWA and is intended to ensure that adequate grading is completed prior to terminal installation so that these systems function as designed.	S. Boggs

WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS

DESIGN DIRECTIVE 644
ASPHALT PAVEMENT
April 7, 2026
Supersedes July 6, 2022

This Design Directive (DD) provides guidance on selecting asphalt pavement mix design methods and types of asphalt pavement. It also provides descriptions of situations that require polymer-modified asphalts, and methods for calculating quantities and types of materials that are to be used.

TYPES OF ASPHALT MIX DESIGNS

Marshall Asphalt Mix Design: Bruce Marshall developed the "Marshall" method of asphalt mix design in the late 1930's for the Mississippi Highway Department. This method has been used by the WVDOT since the 1970's.

Superpave Asphalt Mix Design: "Superpave" stands for Superior Performing Asphalt Pavements. It represents an improved system for specifying the components of asphalt concrete, asphalt mixture design and analysis, and asphalt pavement performance prediction. The Strategic Highway Research Program (SHRP) developed the Superpave asphalt pavement mix design method in the early 1990's.

ASPHALT PAVEMENT MIX DESIGN TYPE SELECTION

Superpave asphalt mixture types are to be used for the following type projects:

1. New construction of multilane divided highways where the mainline pavement is asphalt pavement.
2. Overlay or 3R type projects on existing multilane divided highways where the asphalt pavement overlay is 3 inches or more.
3. Overlay type projects on existing National Highway System (NHS) highways where the asphalt pavement overlay is 3 inches or more.
4. Projects on other highways were approved by the Deputy State Highway Engineer ~~Chief Engineer~~ of Development or Operations.

Marshall asphalt mixture types are permitted on all other projects with design ESALs less than 3,000,000.

SPECIFICATION SELECTION CRITERIA

There are three specifications available when identifying the asphalt requirement for projects. Specifications Sections 401, 402 and 410 shall be used based on project criteria.

- Section 401 is the standard asphalt pavement specification, covering most roadways.
- Section 402 is utilized for roadways needing polish resistant aggregates to promote skid resistance. Section 402 shall be used for the surface course on projects with a current ADT of 3000 or more vehicles per day.
  - Section 410, "Percent Within Limits", is a specification for use when there is a need

for performance related results. This Specification uses mathematical models to quantify relationships between quality characteristics and product performance. These characteristics include mat density, asphalt content, bond strength and others, with samples taken directly from the roadway. Acceptance according to Section 410 (PWL) shall be limited to the top two layers of the pavement, scratch and P&L do not count as ~~a~~ pavement layers. Other materials below the top two layers shall be accepted in accordance with ~~s~~Section 401.

Section 410 (PWL) of the Specification shall be used on the following project types:

1. New Construction where the mainline is asphalt pavement.
2. Overlay projects on existing multilane divided highways.
3. Overlay projects on any National Highway System (NHS) routes, as found on the Divisions website using the latest version of the "Annual Roadway Inventory Statistics"
4. Projects on other highways where approved by the Deputy State Highway Engineer ~~Chief Engineer~~ of Development or Operations.

Additionally, a project must meet all of the following specific requirements for the use of Section 410:

1. ~~Projects~~The layer exceed~~s~~ 5,000 tons ~~in either of the top two asphalt layers~~ (scratch and P&L do not count as layers)
2. The overall width of asphalt equals or exceeds 20 feet in width
3. Project paving is continuous for a minimum of 1500 feet
4. Posted speeds ~~equal to or~~ greater than 35-mph

Section 410 shall not be specified if cities or areas with a high density of utilities are within the project limits. The Specifications in Section 401 and 402 shall be used for all other projects.

DETERMINATION OF EQUIVALENT SINGLE AXLE LOAD (ESAL)

The "ESAL Calculator" program shall be used to calculate the ~~20-year~~ projected design ESALs for all projects unless one of the following applies.

1. The "ESAL Calculator" program produces a value exceeding 10,000,000.
2. When a traffic study has been performed. (i.e. When traffic movements or traffic counts are provided by the Traffic Modeling and Analysis Unit of the Planning Division.)
3. On roadway realignment projects that exceed 1000 feet of relocated roadway.
4. When there is an expected development in the area that may change or alter the nature or character of the expected traffic. (i.e. Shopping centers, schools, etc.)
5. The project is on the CRTS (Coal and Resource Transportation System).

The ESAL Calculator program can be obtained from the West Virginia Department of Transportation's ~~Engineering Publications and Manuals~~Materials Toolbox website at ~~http://www.transportation.wv.gov/highways/engineering/Pages/Manuals.aspx~~ https://transportation.wv.gov/highways/mcst/Pages/tbox.aspx, then under the "Pavement~~ing~~" heading choose "ESAL Calculator".

When the ESAL Calculator program cannot be used to calculate the ESALs, then the ESALs or the percentage of traffic in each of the 13 classes shall be obtained from the Traffic Monitoring Unit of the Performance Management Group. The Traffic Monitoring Unit can be emailed at TMATrafficMonitoring@wv.gov. The designer is cautioned that the development of appropriate data to establish accurate ESAL estimates should be requested prior to the Design Study Office Review (if there is one) or prior to the Preliminary Field Review (if there was not a design study~~.~~).

Projects shall show the projected design ESALs on the general notes and the typical section sheets showing the pavement details.

SURFACE PREPARATIONS

Milling is used to remove surface distresses, create a better bond for an overlay, restore cross slope, and maintain vertical geometric properties, such as bridge clearance, guardrail height, and grade with gutter area. Milling shall be the preferred method of correcting deviations to the road surface prior to resurfacing.

When milling is specified by the contract, the thickness of milling specified by the Designer shall be at least 1/4" into the layer just below the layer(s) being removed. The intent is to mill off entire layers, and not leave any partial layers.

Section 415 of the Specifications, *Milling of Asphalt Pavement Surfaces,* contains three (3) types of milling: Standard Milling, Fine Milling, and Micromilling. These are differentiated primarily by the carbide tooth spacing, typically 15, 8, and 5 mm respectively, resulting in finer textured surfaces. These milling types specify the final surface texture prior to any overlay. The following describes the conditions in which the designer should use each type of milling:

- Standard Milling: Used as the default milling of asphalt pavement. It is intended to be used when the Division plans to remove existing asphalt pavement to correct deviations less than one (1) inch, without a high level of profile and slope control.
- Fine Milling: Used when the Division intends to overlay the milled surface with a two (2) inch or less asphalt course. It shall also be used when the contract contains pay items from Section 410 of the Specifications, *Asphalt Base and Wearing Courses, Percent Within Limits (PWL).* It is intended to be used when control of the profile and slope of the milled surface is important. Fine milling shall only be used if there is a minimum of 5,000 SY of fine milling.
- Micro Milling: Used for smoothness correction, skid correction, bump and/or grade corrections on existing or newly paved surfaces. This milling is typically less than an inch. It is not intended to be used when additional asphalt will be placed on the milled surface.

If fine milling is needed and multiple milling passes are necessary, standard milling shall be used to cut down to one inch above the final prepared surface. The designer shall document in the plans the estimated thickness of each type of milling.

ASPHALT MATERIAL (TACK COAT)

Asphalt Material (Tack Coat) (Section 408) shall be specified for placement on all existing pavement prior to placing asphalt pavement. If the designer can anticipate phased construction where part of the base or intermediate course will be open to traffic prior to final lift placement additional Asphalt Material should be included.

SCRATCH

Scratch Course is normally used in rehabilitation or resurfacing projects that do not contain a milling item. Scratch should be used to correct rutting and other deviations up to about one inch when the milling operation will cause an unnecessary disruption to the traveling public. If milling is performed on the project, Scratch Course shall not be used.

Scratch Course can be placed over the entire project or to the limits established by the designer. If the Scratch Course is not to be placed over the full width of the project, it shall be specified full lane width increments. Although Scratch Course can be placed over the entire project, it is not a constant thickness layer. The term "Scratch Course" comes from the method of placement of this item. The paving equipment is set to drag on or "scratch" the high areas of the existing pavement, only depositing material in the low areas; thereby creating a smooth surface on which to place the next layer of asphalt pavement.

Scratch course may be specified as a 9.5 mm or a 4.75 mm mix. Scratch Course shall be shown on the plan typical sections as a line without a thickness or application rate. Scratch Course is not included in the structural design of the pavement.

Scratch Course shall not be used on new construction.

PATCH AND LEVEL

Patching and Leveling is to be placed at various locations throughout the project to remove irregularities in the existing pavement, such as dips, or to raise the outside edge of the existing pavement to provide a uniform template prior to placing a base or wearing course. Patching and Leveling shall not be specified as a continuous layer or course to be placed over the full width and length of the project.

Patching and Leveling shall be used only in resurfacing or rehabilitation projects, not in the construction of new pavements. It shall be specified when the deviations in the existing pavement are one (1) inch or greater in depth.

Patching and Leveling shall be shown on the plan typical sections as a layer with thickness specified as "variable - 2" maximum lift thickness. No application rate shall be shown. Patching and Leveling thickness is not included in the structural design of the pavement.

OVERBANDING LONGITUDINAL JOINTS

Longitudinal joint construction in asphalt pavements is a critical phase of construction. This affects structural integrity and results in premature failure of the asphalt pavements. Overbanding makes joints less susceptible to deterioration from water and other external factors.

Longitudinal joints shall be overbanded using PG 64S-22 binder, a minimum of six (6) inches in width (three (3) inches on each side of the joint), centered over the joint, at a thickness of 1/16 inch, in accordance to section 401.13.3 and 403 of the Specification. This overbanding shall be specified for placement on all longitudinal joints after the placement of the asphalt pavement surface layer.

PERFORMANCE GRADED (PG) BINDER TYPE SELECTION

Binder Selection will be based on the design ESAL estimate for all projects.

Binder	ESALs
PG64S-22	<20 million
PG64H-22	20 million — 30 million
PG64E-22 (Polymer Modified Binder)	>30 million (See PMA Section)

While rare, for colder areas of the state, a lower binder grade of PG 58S-28 may be appropriate. If unsure, the designer can contact the Asphalt Section ~~Group~~ of Materials Control, Soils, and Testing Division at DOHasphalt@wv.gov.

~~When using anything other than PG64S-22, t~~The binder grade shall be provided on both the general notes sheet and the typical section sheet(s) showing the pavement details.

PG 64S-22 binder may be used in asphalt placed below the top two lifts in any pavement section. Scratch course and patching and leveling are not identified as lifts. PG 64H-22 and PG64E-22 shall not be used in Marshall mix designs.

Polymer Modified Asphalts (PMA) or Non Standard Grade: The binder PG 64E-22, which is a polymer-modified binder, is required to be used in the following cases:

1. Projects estimating more than 30 million ESALs.
1.2. For the surface lift on roadways facilitating access to industrial parks, warehouses, production facilities, etc.
2.3. High Performance Thin Overlay (HPTO) asphalt pavement in accordance with Special Provision 496. Since PG 64E-22 is required by the Special Provision a plan note is not required.

A binder grade associated with a higher ESAL count may be used, at the discretion of the responsible eEngineer, on projects where the pavement exhibits severe rutting or shoving problems due to heavy traffic conditions, such as:

1. Intersections with very heavy truck traffic
2. Truck climbing lanes and ramps

PMAs have shown great success as being a long-term solution to severe rutting problems. Due to the additional cost of a PMA, it shouldn't be used on any project without first repairing base failures and removing excessively rutted pavement. PMA shall generally be used only in the skid surface mix (preferably a 12.5 mm mix) but may also be used in the underlying courses depending on the severity of the traffic conditions. Always use the preferred thickness from the Superpave asphalt pavement recommended lift thickness tables as a minimum thickness when using PMA. Any mix design to be used as a scratch course shall not be specified to use PMA.

PMA Pavement quantities shall be used in increments of 400 tons due to minimum requirements necessary for ordering of material.

PG 64S-22 binder should be used in asphalt placed below the top two lifts in any pavement section. Scratch course and patching and leveling are not identified as lifts.

PAVEMENT STRUCTURE

Bottom Courses: When developing the overall pavement thickness, it is recommended the designer use 25 mm mix as the bottom lifts. When a 25mm mix is to be used on a sSection 410 (PWL) project, acceptance of the 25mm layer(s) shall be in accordance with sSection 401.

Where Marshall is permitted, a Marshall Type 2 Base Course shall be specified instead of a Type 1 Base when the total base course thickness is less than or equal to 3.25 inches.

Intermediate Courses: On new construction or multi-lift projects a Superpave 19mm or Marshall Type 2 base mixture shall be utilized below the surface course to promote smoothness in the final pavement.

Surface Courses: The wearing course is a single constant thickness layer to be placed over the entire pavement surface. The wearing course is the riding surface on which traffic travels. A Superpave 4.75 mm, 9.5mm, or 12.5mm or Marshall Type 1 or Type 3 Wearing mixture is the mix type to be used as the surface course. PMA can also be used if traffic warrants. A Marshall Type 4 Wearing is intended for use in heavy truck traffic situations, note that a wearing 4 is a visually coarse mixture.

Section 402 shall be used for the surface course on projects with a current ADT of 3000 or more vehicles per day. Only Superpave 9.5mm and 12.5mm mixtures and Marshall Type 1 and

Type 4 wearing mixtures shall be specified as a skid resistant mix.

A Wearing 3 or 4.75 mm mix shall only be used for pavement preservation applications or as a surface course over an intermediate course in multi-lift applications. High performance thin overlays shallmay be used for pavement preservation on roads with ADT of 3000 or more vehicles per day.

SUPERPAVE MIX TYPELIFT THICKNESS RECOMMENDATIONS

The following table provides a list of Mix Type recommendations for the designer to use when preparing pavement lift thicknesses for the typical section. Pavement designs provide an overall thickness of asphalt pavement and the designer is generally left to make the decision on bottom, intermediate, and surface course thickness. The designer should use recommendations found in the Pavement Structure section, as well as minimum and maximum thicknesses from the table.

For Marshall Base Courses, it is recommended that in multi-lift pavements when Type 1 Base Course is used, an intermediate course (the top lift of base course) be a Type 2 to improve the smoothness of the finished pavement. This would eliminate the use of a Scratch Course prior to placing the surface course.

Recommended Lift Thickness for Asphalt Pavement

Marshall Mix Type	Superpave Mix Type (mm)	Minimum (inches)	Maximum (inches)	Preferred[Note1] (inches)
Wearing 3	4.75	5/8	1	5/8
Wearing 1	9.5	1.5	2.0	1.5[Note2]
-	12.5	1.5 2.0	2.5	2.0
Wearing 4/Base 2	19	2.25	3.5	2.5
-	25	3.0	4.0	3.5
Base 1	-	3.25	5.0	4.0

Note 1: Minimum Thickness with Polymer Modified Binders

Note 2: 1½ inch thickness on resurfacing projects where the Wearing Course is the only asphalt pavement material being placed exclusive of Patching & Leveling and Scratch Courses.

Recommended Lift Thickness for Superpave Asphalt Pavement

Mix Type (mm)	Minimum (inches)	Maximum (inches)	Preferred[Note 1] (inches)
4.75	5/8	1.0	5/8
9.5	1.5	2.0	1.5
12.5	1.5	2.5	2.0
19	2.25	3.5	2.5
25	3.0	4.0	3.5

Note 1: Minimum Thickness with Polymer Modified Binders

MARSHALL MIX TYPE RECOMMENDATIONS

A. **Marshall Bottom and Intermediate Courses (Base Courses):** It is recommended that in multi-lift pavements when Type 1 Base Course is used, an intermediate course (the

~~top lift of base course) be a Type 2 to improve the smoothness of the finished pavement. This would eliminate the use of a Scratch Course prior to placing the surface course.~~

~~Recommended Lift Thickness (inches) for Marshall Base Courses~~			
~~Mix Type~~	~~Minimum~~	~~Maximum~~	~~Preferred~~
~~2~~	~~2.0~~	~~3.0~~	~~2.0~~
~~1~~	~~3.25~~	~~5.0~~	~~4.0~~

~~B. **Marshall Wearing Courses:** The wearing course is a single lift constant thickness course to be placed over the entire pavement surface.~~

~~Recommended Lift Thickness (inches) for Marshall Wearing Courses~~			
~~Mix Type~~	~~Minimum~~	~~Maximum~~	~~Preferred~~
~~3~~	~~0.5~~	~~0.75~~	~~5/8~~
~~1~~	~~1.0*~~	~~1.5*~~	~~1.0*~~
~~4~~	~~2.0~~	~~2.0~~	~~2.0~~

~~* 1½ inch thickness on resurfacing projects where the Wearing Course is the only asphalt pavement material being placed exclusive of Patching & Leveling and Scratch Courses.~~

PLAN REQUIREMENT

Projects will show the 20-year projected design ESALs on both the general notes sheet and the typical section sheet(s) showing the pavement details. This includes new construction, reconstruction, AND resurfacing projects (including ALL bridge replacement projects regardless of the length of pavement placed). The design ESALs shall be shown for the mainline and all other affected roadways where more than 500 feet of pavement is being placed.

The aggregate used in asphalt mixtures can be either primarily stone and gravel, or slag. The aggregate used is up to the contractor, and typically depends on what the contractor has readily available that also meets mix requirements. Mixes with the two aggregate types have different densities; as such, estimated weight quantities will be different for mixes with each aggregate type. Alternates for these two shall be listed in the plans, and the contractor will bid appropriately.

The following is an example of how to list alternate asphalt pavement items in plans:

BB1 401001-042 SUPERPAVE ASPHALT BASE CRSE, SG, TY 25, TN
BB2 401001-043 SUPERPAVE ASPHALT BASE CRSE, S, TY 25, TN

~~**PLAN REQUIREMENTS WHEN USING MARSHALL MIX DESIGN**~~

~~In addition to the requirements listed above, projects using Marshall asphalt pavement, including District-designed projects, will designate the use of "Medium Marshall Mix Design" or "Heavy Marshall Mix Design" as well as the design ESALs on both the general notes sheet and the typical section sheet(s) showing the pavement details. The designer should note that the terms "Medium" and "Heavy" refer to Equivalent Single Axle Loads (ESALs), and not to the quality of the asphalt pavement. After determining the ESALs, the mix design type shall be determined from the following criteria.~~

~~Medium Marshall Mix Design: This design is intended for use on local service roads or rural resurfacing projects with a 20-year projected design ESALs of less than 3,000,000.~~

Heavy Marshall Mix Design: This design is intended for use on new construction projects and on projects with a 20-year projected design ESALs of equal to or greater than 3,000,000.

QUANTITY ESTIMATING

Asphalt Pavement: The quantity for asphalt pavement shall be estimated at 1.98 ton/cy for stone and gravel mixes, 1.89 ton/cy for slag mixes and 2.10 ton/cy for steel slag mixes.

Patching And Leveling: The quantity for Patching and Leveling Course shall be estimated by multiplying the nominal depth of the irregularity to be repaired plus 3/4 inch by the irregularity's surface area. Then the conversion rates of 1.98 ton/cy for stone and gravel mixes, 1.89 ton/cy for slag mixes and 2.10 ton/cy for steel slag mixes will be utilized.

Scratch Course: The quantity for Scratch Course shall be estimated at a thickness of one- half inch (0.028 ton/sy) for the entire area to be covered with Scratch Course. If the Specification allows, Scratch Course may alternatively be estimated by the square yard. Scratch Course shall not be used if there is Milling on the project, or if there are more than two lifts of asphalt being placed.

Asphalt Material (Tack Coat): The quantity for Asphalt Material (Tack Coat) shall be estimated using the undiluted rates as indicated in Table 408.11 in the Specifications. No application rate will be shown on the typical sections.

Smoothness: If a project meets the requirements of subsection 720.6 of the Specifications, smoothness testing shall be requested by the designer through the Request Form available at MCS&T's Tool Box at https://transportation.wv.gov/highways/mcst/Pages/tbox.aspx. If the test results are available, the results shall be included in the PS&E submittal. If not available, then the request for testing shall be included in the PS&E submittal. If the results arrive before letting, then the results shall be included in an amendment. If too late for an amendment, then the results shall be provided to the District Construction Engineer.

SPECIAL SITUATIONS

General: The Specifications have been written to account for the majority of the situations that would occur during construction. However, there are always special situations that require the designers' attention.

Specification requirements shall only be altered after careful consideration and when, in the opinion of the designer, there is no practical way for the work to be performed in accordance with the Specifications and a project specific special provision shall be developed as outlined in DD-105.

Compaction: The specification density requirement in the of the Specifications shall not be modified when asphalt pavement is placed at normal paving widths. It is possible that asphalt pavement will be placed in certain areas of the project where densities of this magnitude cannot be obtained. These areas usually have an irregular shape, which will not allow the proper use of compaction equipment. Listed below is a situation where the density specification may be modified by plan note and the plan note to be used.

Situation	Plan Note
Concrete pavement repair Note3	Compaction testing shall be in accordance with the Lot-by-Lot method and the rollerpass method shall not be used for acceptance testing for compaction. The eEngineer may reduce the target density requirement if the contractor has made every reasonable effort at obtaining the required density.

Note3: If the proper density is not obtained during placement, traffic will continue to compact the asphalt pavement in the pavement repair area, causing additional settlement. This will be very noticeable because the surrounding overlay will be placed on the existing concrete pavement, which is rigid and will not settle.

When overlaying Portland Cement Concrete Pavement (PCCP) the concrete is sometimes in need of repair. Whether this is an initial overlay or a subsequent overlay, the designer shall examine the extent of the needed PCCP repairs and evaluate whether to repair with Patch and Level, to perform proper concrete pavement repairs, or to remove the PCCP through rubblization or another process prior to the asphalt overlay. The use of Patch and Level is restricted to those projects with a few shallow repairs when the cost of mobilization for concrete repairs is high. PCCP removal should be considered only when the existing pavement is extremely distressed. In addition to compaction, consideration shall be given to smoothness, temporary traffic control, and long term impacts to the traveling public.

DRAFT

WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS

DESIGN DIRECTIVE 646
PAVEMENT DESIGN GUIDE
April 7, 2026
Supersedes September 6, 2026

A pavement design will be completed for all projects requiring pavement (excepting certain Resurfacing, Restoration, and Rehabilitation projects), in accordance with the Division of Highways' Design Directive 641, *Pavement Type Selection Guide.*

This Design Directive (DD) provides a means to standardize the process to design and evaluate pavement designs throughout all development units of the West Virginia Division of Highways (WVDOH).

10. INTRODUCTION

Pavement design is a combination of engineering and economic analyses, which provides data to assist in choosing a cost-effective pavement structure and thickness. The engineering analysis consists of a pavement structural design procedure with consideration of "other factors" which may influence the thickness of the pavement section. The 1993 AASHTO *Guide for the Design of Pavement Structures and 1998 Supplemental* allows for these "other factors", both principal and secondary, which will be considered along with the engineering and economic data to select the pavement section for the project. The principal factors have a major influence on the thickness of the pavement section. The secondary factors will be used to evaluate the designed thickness.

This Guide outlines the process for pavement design for new or reconstructed pavement structures and rehabilitation projects. It provides guidance in the design approach for the cost comparison, the use of design parameters and discusses principal factors to be utilized in making a selection of a pavement type for design. This guide is provided in compliance with Title 23, Code of Federal Regulations Part 626. The following list provides other sources of information related to this DD:

- *West Virginia Division of Highways Pavement Design Manual,* 1997
- *AASHTO Mechanistic-Empirical Pavement Design Guide,* 2000 (and associated software)
- Westergaard Equations (for design of concrete slabs)
- Asphalt Pavement Alliance *PerRoad* software

The *designer* may also use engineering judgment based on past performance of other pavements in the project area, provided the pavements are of the same type, the geotechnical data, traffic characteristics, etc. are similar. Coordination with the Pavement Management System Section in the Operations Division is essential to gather information on past performances of differing types of pavement and rehabilitations in the different geological regions of the State.

If the criteria listed below are true then consider an *analysis period* of 50 years or more along with the design of a "perpetual pavement" or a "long-life pavement". Additionally, the *Mechanistic-Empirical Pavement Design Guide* (M-E PDG) software should be used to verify the results of the *DARWin* analysis when the following situations are true:

- ESAL values are greater than 30,000,000
- *DARWin* software indicates that an asphalt pavement is greater than 13 inches
- When Plain Jointed Portland Cement Concrete Pavement (PCC) is 10 inches or thicker.

NOTE: The *M-E PDG* is not yet approved by AASHTO; however, it may be used if the designer is both familiar with it and can obtain the required material property values.

The *PerRoad* software from the Asphalt Pavement Alliance gives the thickness of an asphalt pavement known as a "Perpetual Pavement", which is a pavement with a structural performance period greater than 50 years. Ride-ability overlays still must be considered with a perpetual pavement. These overlays are "mill and fill" overlays where the thickness milled out is replaced with an identical thickness of asphalt. PCC pavements with a structural performance period more than 50 years are known as "long-life pavements" and thicknesses are given by the Westergaard Equations. While the thicknesses are given by these equations, PCC pavements designed by this method must have full-depth, tied PCC shoulders for lateral support, as the equations assume that the edge of the PCC pavement has adequate lateral support so the slabs do not spread apart. These PCC pavements also require ride-ability rehabilitation techniques to be performed throughout the 50-year lifespan of the pavement.

In general, a minimum 40-year *analysis period* shall be used unless the conditions for a "perpetual pavement" or "long-life pavement" are met. In this case, an analysis period of at least *50 years* will be considered. The conditions for the use of a 50-year analysis period are listed in paragraph four of "Section 10" of this DD.

20. PAVEMENT DESIGNS

Pavement designs shall be required for all pavement types with LCCA when more than one type of pavement is to be considered in the pavement type selection procedure. See DD-641, *Pavement Type Selection Guide,* for the criteria to be used for this determination.

An LCCA is not required on projects where pavement replacement or reconstruction is less than 1,000 feet on a single roadway segment or less than 500 feet of each bridge approach roadway. In these cases, the pavement design process can be based on engineering judgment; however, *pavement designs* shall be *required* on all other project types, with the exception of rehabilitation projects. The project manager shall give due consideration to selected *pavement segments,* considering in-kind replacement, adjacent pavement type and condition, past pavement performances as described in "Section 10" above, and future improvements when exercising judgment during the design process.

The asphalt overlay thickness for rehabilitation projects is to be based on historic practices utilized by the West Virginia Division of Highways, engineering judgment supported by a field review of the existing pavement and the past performance of asphalt overlays on similar projects, or if necessary a pavement design in accordance with this DD.

1. PRINCIPAL FACTORS

"Principal factors" are those which can have a major influence on the design. Some of these factors are included in the basic design procedures as they influence the structural requirements of the pavement design or sub-grade or the embankment treatments. In such cases, they are assigned an economic value for comparative purposes. The following discussion documents Division policies and practices for principal factors not considered in basic design procedures.

a. Traffic

Shifts occur in the economic activity of manufacturing and service industries throughout the state. These activities should be considered as factors affecting the proposed alternative and required method for construction of the selection. In urban areas or on roadways with heavy traffic, the need to minimize disruptions may be a major consideration.

b. Soils Characteristics

The design is to give full consideration to any unusual soils characteristics. Subsurface exploration is an essential part of the design process which includes investigation, sampling and testing, identification of materials types and the distribution of soils materials throughout the project. Based on past experience, the characteristics of the roadbed soils have been found to have a major influence on pavement performance.

c. Recycling

It is the Division's policy to promote recycling of existing roadway materials. The current edition of the *West Virginia Division of Highways Standard Specifications, Roads and Bridges* allows recycled materials to be incorporated in the pavement section.

30. RESPONSIBILITIES AND SELECTION PROCEDURES

The project manager will perform the design analysis utilizing appropriate software for all pavement alternates, when applicable. The analysis period shall be the same for each type of pavement with pavement rehabilitation strategies developed to give an equivalent performance.

The project manager will document the "principal factors" as they relate or apply to the project. Weighing the factors and any related costs along with the costs of alternates from the LCCA, a pavement design and bidding method will be submitted to the Deputy State Highway Engineer ~~Chief Engineer~~ of Development for approval. Refer to DD-647, *Life-Cycle Cost Analysis for Pavement Design,* for more information concerning LCCA.

40. SAFETY

All projects, whether new construction, reconstruction or rehabilitation, will have skid resistant properties suitable for the needs of traffic. Refer to DD-644, *Asphalt Pavement,* for related criteria.

50. GENERAL TYPES

Consider the following types of pavement alternates:

A. Rigid

The pavement will be jointed Portland Cement Concrete (PCC) as required by the design parameters, current design policy, or as selected by use of DD-641, *Pavement Type Selection Guide.* Joint spacing shall be in accordance with details set forth in the current edition of the *WVDOT/DOH Standard Details, Volume 1.*

B. Flexible

Flexible pavement will be asphalt. *Applications* and asphalt *mix types* shall be in accordance with DD-644, *Asphalt Pavement.*

C. Base Courses

Base course(s) will be specified as per DD-643, *Use of Aggregates and Filter Fabric.*

D. Shoulders

Joint spacing on PCC shoulders shall match the spacing of the mainline pavement. For both PCC and asphalt pavements, the paved shoulder thickness shall match the mainline pavement section for:

- Urban arterials
- Projects with an ADT of 6,000 and truck traffic of 15% or greater
- Projects with an ADT greater than 15,000

60. PERFORMANCE PERIOD ~~- NEW PAVEMENTS~~

Performance periods are a determined time during which condition and performance are measured and evaluated. The recommended performance period for Flexible Pavement is twenty (20) years and twenty-two (22) years for Rigid Pavement. Recommended values from Table 1 of this DD are to be used unless project-specific information is available and approved by the Deputy State Highway Engineer of Development.

~~Performance periods for new pavements will be selected based on past design practices, experiences, and a review of pavement data.~~

~~The WVDOH's current historical data regarding the initial performance period of original asphalt pavements indicates an average of 18 years to the first rehabilitation. This may be extended by as much as 4 years if one of the following is true:~~

- ~~The initially constructed asphalt pavement utilized a polymer binder in at least the top 4 inches of the asphalt mix.~~
- ~~A rut-resistant base (such as a Superpave 19 mm, 25 mm, 37.5 mm mix, or a combination of these) was used to the elevation of the bottom of the surface course and the surface course utilized has a polymer binder.~~

~~The WVDOH's current historical data indicates an average initial performance period of 22 years for original PCC pavements.~~

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~~70. PERFORMANCE PERIOD - REHABILITATION~~

~~Rehabilitation projects are to be based on performance periods as described below. These performance periods vary by rehabilitation techniques (asphalt overlays vs. Concrete Pavement Restoration (CPR)) as well as original pavement types (asphalt vs. PCC).~~

~~Performance periods of subsequent asphalt overlays over asphalt pavements vary from 8 to 12 years (based on WVDOH historic data), which may be extended by up to 4 years when a polymer binder is used in at least the top 4 inches of the final pavement thickness.~~

~~Performance periods of subsequent rehabilitations over PCC pavements range between 10 and 14 years for Concrete Pavement Restoration techniques (based on national experience), and 6-10 years for asphalt overlays (based on WVDOH historic data), which may be extended by up to 4 years when a polymer binder is used for the entire thickness of the asphalt overlay mix. An additional four years should not be anticipated with minimal thickness polymer wearing course overlays.~~

~~The designer is cautioned to investigate all available historical data regarding past pavement performance, including overlays, when determining pavement rehabilitation schemes for the LCCA of newly constructed pavements. This is also true when considering rehabilitation schemes for existing pavements. The Pavement Management Systems Section of Operations Division is to be consulted for guidance in this matter.~~

7~~8~~0. TRAFFIC DATA

Traffic factors for growth rates, equivalent single axle loads (ESAL), and directional distribution percentage are to be obtained from the Traffic Modeling and Analysis Unit of the Planning Division.

8~~9~~0. ROADBED SWELLING AND FROST HEAVE

Recommended values from Table 1 of this DD are to be used unless project-specific information is available and approved by the Deputy State Highway Engineer ~~Chief Engineer~~ of Development.

9~~10~~0. SERVICEABILITY

Recommended values from Table 1 of this DD are to be used unless project-specific information is available and approved by the Deputy State Highway Engineer ~~Chief Engineer~~ of Development.

10~~1~~0. MATERIALS PROPERTIES

~~Effective roadbed soil resilient modulus data are to be obtained from Materials Control, Soil and Testing Division.~~ Soil samples are normally obtained during the design phase.~~; however, if a paving project is to be bid after the grading has been completed and enough time is available to perform in-place testing of the sub-grade, the Designer should request the Materials Control, Soils, and Testing Division to re-test the sub-grade prior to designing the final pavement section.~~
Recommended values from Table 1 of this DD are to be used unless project-specific information is available and approved by the Deputy State Highway Engineer ~~Chief Engineer~~ of Development. The designer may choose to obtain the effect roadbed soil resilient modulus date themselves or

utilize the information found in the 1993 AASHTO Pavement Design Guide.

1120. PAVEMENT STRUCTURAL CHARACTERISTICS

Recommended values from Table 1 of this DD are to be used unless project-specific information is available and approved by the Deputy State Highway Engineer Chief Engineer of Development.

1230. PAVEMENT THICKNESS

The final pavement thickness will be based on the structural analysis. The minimum layer thickness will be consistent with standard construction methods and/or material requirements. For all pavement types, the total design thickness shall be rounded up to the nearest half-inch. Refer to DD-644, *Asphalt Pavement,* for information on pavement layer thickness criteria for asphalt pavements.

130. REHABILITATION PROJECTS

The Division recognizes that there are a variety of rehabilitation methods and strategies available to restore pavements. As all factors that influence pavement performance and life expectancy have not been quantified, the latest information and recommendations from the Pavement Management System Section of Operations Division should be considered in the selection type and process outlined herein.

The asphalt overlay thickness for overlay types of rehabilitation projects is to be based on historic practices utilized by the West Virginia Division of Highways, engineering judgment supported by a field review of the existing pavement and the past performance of asphalt overlays on similar projects, or if necessary a pavement design in accordance with this DD.

In situations where the use of an asphalt overlay as the rehabilitation method is questionable, the following process can be used to select the rehabilitation method best suited to the project:

A. Project Evaluation

The type of pavement rehabilitation to be considered begins with an evaluation of pavement distress, smoothness or ride-ability and consideration of general conditions within the proposed project area. For asphalt pavement, distress evaluations are based on the amount of rutting, longitudinal cracks, transverse cracks, alligator cracks, and smoothness. For concrete pavements, the distress will be measured on the basis of the amount of faulting, longitudinal cracking, transverse cracking, pumping, joint deterioration and smoothness. This information will normally be available from pavement management inventories collected by the Pavement Management Section of Operations Division. Project conditions will be gathered based on a field review by the project manager.

B. Project Analysis

Upon completion of evaluations, alternative solutions will be considered for the project. The following alternates considered by the designer may vary with the type of pavement being overlaid, the amount of distress and smoothness values. The alternates will be analyzed as to their constructability, performance period, initial agency costs, and life cycle costs. The performance periods may be chosen by the designer from the ranges given below, considering project specific information. ~~input from other Division and District personnel, and the Pavement Management Section of Operations Division will consider the vertical clearances, traffic control, and construction conflicts.~~

NOTE: Full and partial depth patching are normally considered maintenance and occur prior to rehabilitation. Maintenance performed at a separate time and under a separate contract is not included in rehabilitation; however, full and partial patching performed in conjunction with an overlay *is* included in the LCCA and the rehabilitation project.

1. Original PCC Pavements

a. All Phases of Rehabilitation

i. Concrete Pavement Restoration Techniques

~~A performance period of up to 14 years may be considered when Concrete Pavement Rehabilitation (CPR) techniques are selected.~~ These techniques may be as follows:

a) Joint and crack repair (full and partial depth) for spalling or faulting joints
b) Diamond grinding for IRI improvement

More information for the designer concerning joint repair and diamond grinding can be obtained at the Federal Highway Administration's website at the following address: http://www.fhwa.dot.gov/pavement/guid.cfm. This page conveys links to technical guidance papers for all types of pavements, rehabilitation techniques and materials, among other pertinent information.

If reconstruction is determined to be the preferred design after a thorough field evaluation of the existing pavement and consultation with the Pavement Management System Section, then the required initial performance period shall be as described in "Section 70" of this DD for the type of pavement selected.

ii. ~~Superpave and Marshall Mix Designs~~

~~If reconstruction is determined to be the preferred design after a thorough field evaluation of the existing pavement and consultation with the Pavement Management System Section, then the required initial performance period shall be as described in "Section 70" of this DD for the type of pavement selected.~~

iii. Concrete Overlays

~~The service life of a concrete overlay is up to the designer and can range from 10-40 years and is designed to provide the selected extended performance.~~ The overlay can be either bonded or unbounded depending on the pavement condition and desired service life. More information for the designer can be obtained from the following web address: http://www.fhwa.dot.gov/pavement/concrete

iv. Asphalt Pavement on Rubblized PCC pavement

Asphalt pavement on rubblized PCC pavements should be designed as new, full-depth pavements. It is critical to properly assess the conditions under the concrete slabs and the uniformity of the rubblized layer to ensure the desired performance of the asphalt pavement. Based on the subsurface exploration, specify the technique location, and dimensions of subgrade stabilization in the plans. If required, proper subgrade stabilization will guarantee a constructible pavement, improve performance, and reduce expensive change orders.

2. Original Asphalt Pavements

a. All Phases of Rehabilitation

i. Superpave and Marshall Mix Designs

The asphalt overlay thickness for these types of rehabilitation projects is to be based on historic practices utilized by the West Virginia Division of Highways engineering judgment supported by a field review of the existing pavement and the past performance of asphalt overlays on similar projects, or if necessary a pavement design in accordance with this DD.

~~An 8 to 12 year performance period is appropriate and may be extended up to 4 years if the top 4 inches of the final pavement thickness (after the overlay is applied) has a polymer binder in the asphalt mix(s), or a large stone rut-resistant base (such as a Superpave 19 mm, 25 mm, 37.5 mm mix, or a combination of these) was used to the elevation where the surface course was applied.~~

~~If reconstruction is determined to be the preferred design after a thorough field evaluation of the existing pavement and consultation with the Pavement Management System Section, then the required initial performance period shall be as described in "Section 70" of this DD for the type of pavement selected.~~

ii. Whitetopping (Overlaying with Concrete Pavement)

No "ultrathin" whitetopping will be permitted. Only unbonded whitetopping overlays with a 5-inch minimum thickness will be permitted.

Whitetopping overlays may be designed for a 10 to 20-year service life.

The following FHWA publication provides guidance and references for use of whitetopping on asphalt pavements: http://www.fhwa.dot.gov/pavement/concrete

C. Project Design

The design strategy will be to bring the Present Serviceability Index up to near the initial value of 4.2. The design of overlays will be in accordance with methods previously outlined.

D. Project Implementation

Rehabilitation projects will be initiated on an annual program in accordance with pavement management data and the budget.

Table 1 - Pavement Design Inputs

Input		Range of Input	Recommended for West Virginia
Design Variables			
Analysis Period (Years)			50 ~~(See Note 1)~~
Initial Performance Period (Years)		0.1 to Analysis Period	Flexible Pavement: 20~~18~~ (~~if polymer binder used add 4 years)~~ Rigid Pavement: 22
Traffic Variables			
Growth Rate/Year		-9.99 to 99.99%	Data from the Traffic Modeling and Analysis Unit of the Planning Division
Type of Growth Rate		Simple or Compound	Compound
Initial Yearly 18-kip ESAL's (Both Directions)			Data from the Traffic Modeling and Analysis Unit of the Planning Division
Directional Distribution Factor		1% - 100%	50%~~100~~% ~~(See Note 2)~~
Lane Distribution Factor		1% - 100%	Number of Lanes in Each Direction / Percent in Design Lane 1 / 100 2 / 80-100 3 / 60-80 4 / 50-75
Overall Standard Deviation		0.001 - 0.999	Flexible Pavement: 0.45 Rigid Pavement: 0.35
Reliability		50% - 99.99%	<3000 ADT ~~& Low Truck Traffic~~: 85% 3000 - 6000 ADT: 90% >6000 ADT: 95%
In-Situ Variables			
Roadbed Swelling:			
	Vertical Rise	0.00 - 99.99"	0
	Probability	0 - 100%	0
	Rate Constant	0 - 0.30	0
Frost Heave:			
	Serviceability Loss	0 - 5	0.5
	Probability	0 - 100%	100% (See **Note 1~~3~~**)
	Rate per Day	0 - 50 mm	2.5 mm (See **Note 1~~3~~**)
Performance Criteria - Present Serviceability Index			
Initial		0 - 5.0	4.2
Terminal		0.01 - 3.99	<3000 ADT: 2.3 >3000 ADT: 2.5 ~~<3000 ADT: 2.3~~

~~**Note 1:** A minimum **40-year** ***analysis*** *period* shall be used unless the conditions for a 50-year *analysis period* are met. These conditions are described in paragraph 4 of "Section 10" of this DD.~~

~~**Note 2:** The Traffic Analysis Section of the Program Planning and Administration Division has applied the Directional Distribution Factor when the traffic data is submitted.~~

Note 1~~3~~: Use for frost-susceptible conditions. Other values are appropriate when conditions warrant.

Table 1 (Continued)

Input	Range of Input	Recommended for West Virginia
Material Properties		
Effective Roadbed Soil Resilient Modulus	2700 – 7300 psi	~~Data from Materials Control, Soils, and Testing Division~~ 4500 psi
Effective Modulus of Subgrade Reaction		Calculated in DARWin software
Pavement Layer Characteristics		HMA Elastic Modulus = 450,000 psi
		PCC = 4,200,000 psi
		Crushed Agg. Base Course = 36,000 psi
		Free-Draining Base = 200,000 psi
PCC Modulus of Rupture		660 psi
Flexible Pavement Layer Coefficients	Wearing Courses:	w/ PMA (PG 64E-22): Superpave: 4.75, 9.5, 12.5mm; Marshall: Type 1, 3, 4 — 0.54 **(Note 3)**
		All mixes without PMA: 0.44 (**Note 3~~5~~**)
	Base Courses:	Superpave:19mm Marshall: Type 2 — 0.44 **(Note 3)**
		Superpave: 25mm Marshall: Type 1 — 0.4 **(Note 3)**
		Crushed Agg. Base Course: 0.14
		Free-Draining Base: 0.30 (See **Note 2~~4~~**)
		Rubblized Concrete: 0.22
		Broken/Seated Concrete Pavement: Good Condition: 0.35 Poor Condition: 0.14
Pavement Structural Characteristics		
HMA Pavement:		
Drainage	0.40 - 1.40	1.00
Free-Draining Base	0.40 - 1.40	1.20
Rigid Pavement:		
Drainage	0.70 - 1.25	1.00
Free-Draining Base	0.70 - 1.25	1.20
Load Transfer with tied shoulders	2.30 - 2.90	2.60
Load Transfer without Tied Shoulder	2.9 - 3.2	3.20
Loss of Support	0.00 - 3.00	0.00
Base Course Thickness		
Crushed Agg. Base Course	4 - 12 in	6.0"
Free-Draining Base Course	4 - 8 in	4.0"

Note 24: 2% Asphalt content or Type I cement with a minimum of 150 pounds per cubic yard.
Note 35: The designer may choose to evaluate the pavement condition and utilize layer coefficients found in the 1993 AASHTO Pavement Design Guide.

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WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS

DESIGN DIRECTIVE 647
LIFE-CYCLE COSTS ANALYSIS FOR PAVEMENT DESIGN
April 7, 2026
Supersedes September 6, 2023

This Design Directive (DD) gives guidance for the Division of Highways' (DOH) policy on Life-Cycle Cost Analysis (LCCA) for pavements.

This DD provides a means to standardize the process required to analyze and report the pavement design Life-Cycle Costs throughout all development units of the DOH. The general procedure for performing the LCCA is detailed herein. References for more in-depth LCCA analyses are also given.

10. General

The purpose of an LCCA for a particular pavement design within a defined *pavement segment* is to evaluate the overall long-term economic efficiencies of competing design alternates. Initial (construction) and discounted future (future rehabilitations, user, etc.) costs over the projected life of the pavement are added together to obtain a Net Present Value (NPV) for each *pavement type* selected. This process improves decisions concerning the utilization of limited funding for pavement in a construction project within a *pavement segment.*

20. Life-Cycle Cost Analysis (LCCA)

The WVDOH generally follows the LCCA methodology recommended in the FHWA Pavement Division's interim technical bulletin *Life-Cycle Cost Analysis in Pavement Design — in Search of Better Investment* Decisions, 1998. The publication number for this document is *FHWA SA-98-079* and is available electronically at https://www.fhwa.dot.gov/pavement/lcca/lccafact/ ~~isddc.dot.gov/OLPFiles/FHWA/013017.pdf~~. It contains standard procedures for estimating and comparing the long-term costs of *asphalt* and *Plain Jointed Portland Cement Concrete* (PCC) pavements over an analysis period under specified traffic and environmental conditions. The WVDOH uses an analysis period of at least ~~40~~ fifty (50) years for both the asphalt and PCC pavements. See *DD-641, Pavement Type Selection Guide,* for more information regarding pavement type selection parameters, and *DD-646, Pavement Design Guide,* for information concerning the design of the pavement structure itself.

The WVDOH generally follows the FHWA's recommendations for LCCA input data unless local data is available. Local input data includes, but is not limited to, traffic characterization, duration of construction, and construction costs. It is important to note that only differential costs are considered between alternates in the LCCA.

The Life Cycle Cost Analysis, if required per DD-641, will be performed on each *pavement segment* upon receipt of necessary soils data, existing pavement cores, and traffic data.

The base bid quantities for grading will be for the thicker pavement section. The *designer* may allow a lower profile grade but hold the cross-section to avoid additional earthwork. The profile grade can be lowered by using a straight horizontal taper rate of 0.25%. This will occur at, but not be limited to, the ends of structures and at tie-ins to existing pavements. If the *designer* does not allow a lower profile grade, bid items for adjusting the grade must be added to the contract and included in the LCCA for that particular alternate; however, the contractor will not be permitted to raise the profile grade above that shown for the thickest pavement alternate. Costs common to each pavement alternate such as mobilization, signing/pavement marking, grading, drainage, rights-of-way, utility relocation, etc. are not included.

User delay costs are another important element in LCCA. Estimation of user delay costs follows the procedures in *Life-Cycle Cost Analysis in Pavement Design — In Search of Better Investment Decisions,* 1998. The user delay costs considered are the differential costs between competing alternates such as work zone costs including duration, setting traffic control, resetting traffic control for construction phasing, etc. User delay costs can differ by pavement type. The designer must carefully examine all facets of the planned work to accurately estimate user delay costs. Routine maintenance is not included in this analysis.

User costs are further divided into the *working day* and *non-working day* daily user costs. In most cases, the travel capacity of a construction zone on a *working day* is less than the capacity on a *non-working day.* For the purposes of this Directive, a *non-working day* is any day throughout the course of construction that traffic is not impeded in any way by lane/shoulder closures. User costs associated with *non-working days* are excluded from the analysis.

If the LCCA is performed on an entire pavement segment and the segment is not being fully constructed in one contract, then the result of the analysis will be pro-rated using the contract length divided by the entire *pavement segment* length. See *DD-648, Alternate Design Alternate Bidding of Pavements,* for more information on this matter.

30 Alternate Design Alternate Bid (ADAB)

The ADAB bid process is described in greater detail in *DD-648.*

40 Steps in LCCA

A standard procedure has been developed to perform the LCCA analysis. The *project manager* is responsible for the LCCA, using software that is specifically designed for use with *Life-Cycle Cost Analysis in Pavement Design — In Search of Better Investment Decisions,* 1998. The following steps are to be followed:

40.1 Project Selection

Criteria to be used for evaluating projects for inclusion in the LCCA process are described in DD-641.

40.2 Alternative Pavement Design Strategies

See DD-646 for selection of alternate design strategies and for information on the pavement design and rehabilitation process itself. The analysis period shall be at least 50 years.

The designer will develop reasonable design strategies for each alternative based on past pavement performance; that is, an initial pavement structure followed by a series of rehabilitations to cover the analysis period. The analysis period will be the same for each alternative considered.

40.3 Performance Period

Performance periods for new pavements will be selected based on past design practices, and a review of pavement data. WVDOH's current historical data regarding the initial performance period of original asphalt pavements indicates an average of twenty (20) years to the first rehabilitation. WVDOH's current historical data indicates an average initial performance period of twenty-two (22) years for original PCC pavements.

Rehabilitation projects are to be based on performance periods as described below and vary by rehabilitation techniques and original pavement types:

- Asphalt overlays over asphalt pavements have performance periods ranging from eight (8) to twelve (12) years based on historical data.
- Concrete pavement restoration (CPR) techniques on concrete pavements have performance periods ranging from ten (10) to fourteen (14) years based on national experience.
- Asphalt overlays on concrete pavements have performance periods ranging from six (6) to ten (10) years based on historic data.

~~Rehabilitation projects are to be based on performance periods as described below. These performance periods vary by rehabilitation techniques (asphalt overlays vs. concrete pavement restoration (CPR). Performance periods of subsequent asphalt overlays over asphalt pavement vary from 8 to 12 years based on historical data. Performance periods of subsequent rehabilitations over PCC pavements range between 10 and 14 years for concrete pavement restoration techniques (based on national experience), and 6-10 years for asphalt overlays (based on WVDOH historic data).~~

The designer is cautioned to investigate all available historical data regarding past pavement performance, including overlays, when determining pavement rehabilitation schemes for the LCCA of newly constructed pavements. This is also true when considering rehabilitations schemes for existing pavements. The Pavement Management Systems Sections of Operations Division is to be consulted for guidance in this matter.

~~40.3~~40.4 Estimate Agency Cost

Initial agency costs of the pavement section are the construction costs incurred by the WVDOH. These are official estimates prepared by the Division's *designer* or *project manager.* See the latest issue of DD-707, Development of Engineer's Estimate, for more information regarding the development of the official cost estimate.

Future agency costs are the costs incurred by the WVDOH to overlay, rehabilitate, or reconstruct the roadway in the ~~40~~ fifty (50) year (or longer) analysis period specified. All of these future costs must be considered in the LCCA for each pavement type considered for use.

~~40.4~~40.5 Estimate User Costs

User costs are estimated according to the recommendations made in *Life-Cycle Cost Analysis in Pavement Design — In Search of Better Investment Decisions,* 1998. As stated above, only work zone user costs are estimated in the LCCA process. Estimation of user costs requires three steps: calculate the appropriate daily user costs, determine the duration of the construction activities and apply the daily user costs to the expected duration of the construction.

Data used for computation of LCCA user delay costs will be obtained from the Traffic Engineering Division and the Planning Division. The *designer* will be responsible for compiling all the required information from these sources and running the aforementioned program.

~~40.5~~40.6 Compute Net Present Value (NPV)

In the broadest sense, LCCA is a form of economic analysis used to evaluate the long-term economic efficiency between investment options; therefore, the NPV of cash flow is calculated.

Economic analysis focuses on the relationships between costs, timings of costs, and discount rates employed. Once all costs and their timings have been developed, future costs must be discounted to the year of initial construction (the "base year") and added to the initial cost (the construction estimate cost) to determine the NPV for each LCCA alternate. Again, more information on the calculation and use of NPV is available in *Life-Cycle Cost Analysis in Pavement Design,* 1998. The designer is encouraged to consult this publication. Software designed from this publication will be used to determine the NPV of all cash flows.

Once completed, all LCCA's should be subjected to a sensitivity analysis. Sensitivity analysis is a technique used to determine the influence of major LCCA inputs, assumptions, projections, and estimates on the various LCCA results. In a sensitivity analysis, major input values are varied over a reasonable range of values, while all of the other variables remain constant. The input variables may then be ranked according to their effect on the results. This allows the designer to subjectively get a feel for the impact of the variability of individual inputs on overall LCCA results.

Sensitivity analyses, at a minimum, evaluate the influence of the discount rate on LCCA results. The discount rate accounts for the time value of money. It takes into account fluctuations in the inflation and interest rates to show the actual rate of increase in the value of money over time. Using the discount rate allows the designer to use today's dollars in the LCCA. The higher the discount rate, the lower the present value of future cash flows. The discount rate to be utilized in all LCCA's will be the~~-~~ average of the five (5) most recent ~~latest~~ effective thirty (30)~~-~~ year value of *real treasury interest rates or treasury notes* and *bonds of specified maturities* as given in the United States' Office of Management and Budget's *Circular A-94,* Appendix C. Averaging five (5) interest rates reduces the impacts of short-term volatility and creates a more stable, reliable valuation. A table summarizing the past history of and giving the latest years' rate can be found on the current United States Office of Management and Budget website.~~is available at http://www.whitehouse.gov/omb/circu1ars/a094/dischist.pdf~~.

If the *designer* finds that any LCCA is sensitive to a particular input, then the *designer* is to perform LCCA's utilizing a reasonable range of that input, and submit these results to the Deputy State Highway Engineer ~~Chief Engineer~~ of Development in the package required by DD-641.

50. Comments

As projects utilizing LCCA are *let to construction,* their associated unit bid prices will be monitored to determine any trends in costs. Also, salvage values will not be considered in the LCCA's.

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WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS

DESIGN DIRECTIVE 648
ALTERNATE DESIGN AND ALTERNATE BIDDING OF PAVEMENTS
April 7, 2026
Supersedes September 6, 2023

This Design Directive (DD) gives guidance on the West Virginia Division of Highways' (WVDOH) policy on *alternate design and alternate bidding* (ADAB) of pavements.

Use of this DD provides a means to standardize the process required to utilize ADAB for pavements throughout all development units of the DOH; however, this DD does not detail the procedure for designing pavements and performing life-cycle cost analyses (LCCA), but references to publications written in detail concerning these subjects are given for the *designer's* use.

10. General

The objective of the ADAB process is to promote more cost-effective usage of highway construction funds. This is achieved by allowing contractors to select the *pavement type* constructed through the bidding process; consequently, increasing competition as well as making that competition more equitable. The Federal Highway Administration's (FHWA) Technical Advisory: "Use of Alternate Bidding for Pavement Type Selection, T 5040.39 December 20, 2012 can be accessed at: https://www.fhwa.dot.gov/pavement/t504039.cfm.~~Memorandum: *Clarification of FHWA Policy for Bidding Alternate Pavement Type on the National Highway System,* November 13, 2008, can be accessed at: http://www.fhwa.dot.gov/pavement/081113.cfm.~~

The ADAB process requires the WVDOH to consider future roadway rehabilitation, traffic control associated with that rehabilitation, and user delay costs. The process utilizes traditional *life-cycle cost analysis* (LCCA) concepts to model the cost of pavement section alternatives over a selected performance period. The selection process is then accomplished through an ADAB procedure, which essentially allows the bidder with the lowest *life-cycle costs* (LCC) to determine which pavement type will be constructed. See DD-647, *Life-Cycle Cost Analysis of Pavements,* for more information concerning LCCA.

To accomplish the ADAB process, the "A + B + C" bidding method is utilized for all bids submitted. Factor "A" is the contractor's bid, factor "B" is the time *in days* to construct the initial pavement, and factor "C" is the *net present value* (NPV) of all future rehabilitation costs, plus the NPV of *present* and *future* user costs for the pavement's analysis period. The lowest bidder is identified by adding "A + C".

The time factor "B" is not normally added to the contractor's bid. This factor may be used on projects that consist of total pavement reconstruction in order to capture the user costs associated with the initial construction. This *time factor* is usually zero (0) because most projects are on new alignments, and traffic is not impeded during the initial construction of a project.

If a particular project is not approved by the Deputy State Highway Engineer ~~Chief Engineer~~ of Development or the FHWA's *Special Experimental Projects No. 14 — Alternative Contracting* (SEP-14) for the ADAB process, then the *designer* is to consider the following to recommend a *pavement type only* for approval:

- The LCCA
- *Secondary factors* as described in DD-641, *Pavement Type Selection Guide,* Section 40
- Sound engineering judgment

If the ADAB process is approved on any particular project, the *designer* may be required to submit a request to the FHWA headquarters, through the local office, to approve the use of ADAB on a project-by-project basis under the FHWA's SEP-14.

The following FHWA website contains additional information concerning SEP-14 submittals:www.fhwa.dot.gov/programadmin/contracts/sep_a.cfm

20. Criteria for Selection of Projects for the ADAB Procedure

Section 30 of DD-641 describes the criteria to be followed for selection of projects that will use the ADAB procedure for bidding of alternate pavement types.

30. Alternate Design and Alternate Bid (ADAB)

The ADAB bid model is accomplished by adding a factor "C" to each contractor's base bid factor "A". Factor "C" represents future rehabilitation and user delay costs for a particular pavement alternate. The implementation of ADAB, in general, may result in comparing multiple competing pavement structures with differing total thicknesses between the top of the sub-grade and the final pavement surface. A threshold of 20 percent in the difference of the NPV of the LCCA is a reasonable zone within which pavement types can compete.

In a contract in which the pavement is bid by the ADAB procedure, both the *asphalt* and the *Jointed plain concrete* pavements shall be bid as a *pavement system* in square yards (sy). The *pavement system* is the entire pavement section, including fine grading, sub-grade, base and pavements. This approach allows an equal bidding process.

Note: The contract documents will include price adjustment factors for fuel, asphalt, and cement.

40. Steps in ADAB

A standard procedure has been developed to perform the ADAB analysis. This procedure has the following steps.

40.1 Project Selection

Criteria to be used for evaluating projects for inclusion in the ADAB process are described in DD-641, as mentioned in "Section 20" above.

40.2 Alternative Pavement Design Strategies

Refer to DD-641 for selection of alternate design strategies for the chosen analysis period, and DD-646, *Pavement Design Guide* for information regarding the pavement design process.

40.3 Estimate Agency Costs

Initial agency costs are the construction costs incurred by the WVDOH. These are official estimates prepared by the Division's *designer* or *project manager.* See the latest issue of DD-707, *Development of Engineer's Estimate,* for more information regarding the development of the official cost estimate.

Future agency costs are the costs incurred by the WVDOH to overlay, rehabilitate, or reconstruct the roadway in the ~~40~~ fifty (50) year (or longer) *analysis period* specified. All of these future costs must be considered in the LCCA for each pavement type considered for use.

40.4 Estimate User Delay Costs

See DD-647 for more information concerning computation of user delay costs.

40.5 Compute Net Present Value (NPV)

Refer to DD-647 for more information concerning computation of the NPV for each pavement alternate considered.

40.6 Analyze Results And Calculate Life-Cycle Cost Adjustment Factor "C"

After the total NPV for each alternate is computed, the results are then compared. If the difference in the total NPV between the lowest two alternates is greater than twenty (20) percent, the alternate with the lower total NPV only is selected for bidding. The *designer* shall eliminate any pavement alternate that is considered, in the *designer's* judgment, to be impracticable for the project. Otherwise, alternate pavement designs will be included in the bidding documents and a *life-cycle cost* adjustment factor "C" will be included in the *schedule of prices* for each alternate.

The *life-cycle cost adjustment* factor, "C", is calculated as ***C = total NPV of the LCCA — construction cost****.* As part of the ADAB process, this "C" factor will be added to the contractors' bid. The lowest bidder identified by adding the "C" factor to the contractors' base bid "A" factor; thus, the lowest total is then selected.

If the LCCA is performed on an entire *pavement segment* and the *segment* is not being fully constructed in one contract, then the "C" factor will be pro-rated using the project length divided by the entire *pavement segment* length.

If the "C" factors are essentially equal (1% or less of the lowest cost initial *pavement section)* for all of the paving alternates considered, then "C" factors do not need to be added to the contractor's bids in order to determine the low bid.

Refer to "Section 30" of this DD for information on the handling of multiple pavement types in both the LCCA and bidding processes.

50. Comments

As Projects utilizing LCCA are *let* to construction, their associated unit bid prices are monitored to determine any trends in costs. Also, salvage values are not to be considered in the LCCA's.

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WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS

DESIGN DIRECTIVE 811
ACCESSIBILITY STANDARDS, CURB RAMPS AND SIDEWALKS
April 7, 2026
Supersedes November 1, 2023

This Design Directive defines the West Virginia Department of Transportation, Division of Highways' policy concerning curbs and sidewalks, and further compliance with the Americans with Disabilities Act of 1990 (ADA) and the ~~U.S. Department of Justice (DOJ) 2010 ADA Standards~~ 36 CFR Part 1190 – Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way Final Rule. Other references will be given to assist the Designer/Project Manager during the assessment of a project for ADA requirements, as well as details and criteria that are to be used when ADA requirements must be met.

Attached to and made a part of this Design Directive is an ADA Exceptions Justification Form. See Section ~~50~~ 60 of this DD for more information.

The policies described herein will apply to all projects, whether designed at the District level, in the Central Office, or the Special Projects Section.

10. General

In compliance with the Americans with Disabilities Act of 1990 and ~~the U.S. Department of Justice 2010 ADA Standards for Accessible Design~~ 36 CFR Part 1190 – Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way Final Rule, curb ramps as per DOH Standard Details shall be provided at all existing marked and unmarked crosswalks for which the Division of Highways has responsibility. Existing ADA features that are within the limits and scope of work of the project are to be checked for conformity with ~~the DOJ 2010 ADA Standards for Accessible Design~~ 36 CFR Part 1190 – Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way Final Rule and are to be reconstructed if they do not comply. All curb ramps are to have Detectable Warnings installed. In addition, the existing condition of a sidewalk will not affect the decision of whether to add a curb ramp or not.

The following information is to be used to determine, for ADA applicability purposes, whether a project is considered a "Maintenance Project" under which curb ramps are NOT required to be incorporated into the project, or an "Alteration Project" under which curb ramps MUST be incorporated into the project. See the following web page for a more precise definition of some of the terms in the lists below: https://highways.dot.gov/civil-rights/programs/ada/glossary-terms-dojfhwa-joint-technical-assistance-ada-title-ii
~~www.fhwa.dot.gov/civilrights/programs/doj_fhwa_ta_glossary.cfm~~

A. Roadway Maintenance
1. Crack filling and sealing
2. Surface sealing
3. Chip, Slurry, and Fog seals
4. Scrub sealing
5. Joint crack seals
6. Joint repairs

7. Dowel bar retrofit
8. Spot high-friction treatment
9. Diamond grinding
10. Pavement patching
11. Shoulder repairs
12. Pipe and inlet repairs
13. Pulling and restoration of ditches
14. Guardrail repair and installation
15. Re-striping

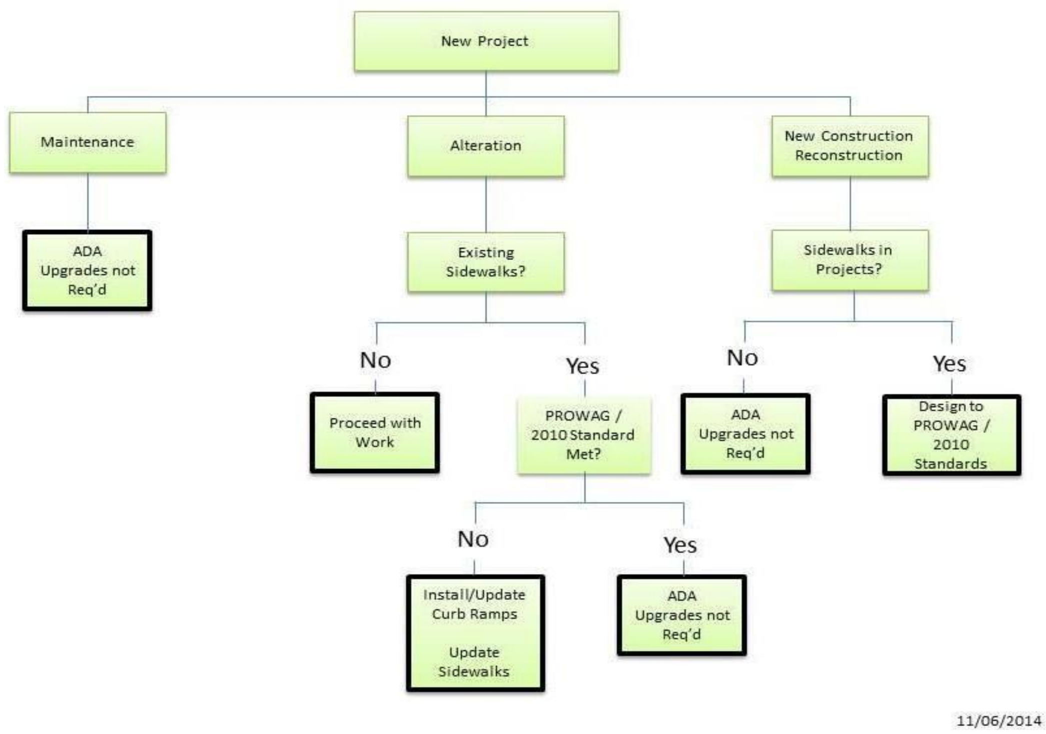
B. Roadway Alteration
1. Open-graded surface course
2. Cape seals
3. Mill and fill / Mill and overlay
4. Hot in-place recycling
5. Micro Surfacing / Thin-lift overlay
6. Addition of new layer of asphalt
7. Asphalt and concrete rehabilitation and reconstruction
8. New construction
9. Widening of the existing pavement typical section
10. Addition of turning lanes
11. Pavement rubblizing
12. Installation of new drainage structures to improve existing drainage characteristics

C. Bridge Maintenance
1. All painting of bridge members
2. Scour Countermeasure Activities
3. Expansion Joint Repairs and Replacement
4. Concrete Crack Repairs
5. Refurbishing or restoration of existing bridge bearings
6. Deck drainage system repairs
7. Seismic retrofit activities that do not include replacement of bearings or structural members

D. Bridge Alteration
1. Bridge deck overlay projects
2. Repairs to structural members for the purpose of restoring or enhancing structural capacity
3. Strength repairs to substructure elements
4. Bearing replacement
5. Bridge deck replacement
6. Superstructure replacement

Alteration projects administered by a municipality on WVDOH R/W, such as a streetscape, involve funds expended on a public right of way. The alteration requires the municipality and the WVDOH to meet full compliance with all federal laws and regulations during the development of plans and construction. As part of the development of plans for construction, where full design criteria for pedestrian access is not feasible, the designer (the municipality or their consultant) shall prepare an ADA Exception Justification Form, included in this DD, and submit with the plans for review and approval to the WVDOH. All exceptions approved by the Division shall be filed as required for all projects.

ADA Requirements Flowchart



20. Existing Sidewalks

Projects considered an alteration by the Department of Justice (DOJ) as described in Section 10 of this DD will require all curb ramps within the project limits to meet the requirements of the Americans with Disabilities Act (ADA). This will also require installing curbs ramps where presently a curb ramp does not exist to make the sidewalk ADA accessible. Detectable warning systems will be required on all existing curb ramps that otherwise meet the ADA criteria. Existing sidewalks shall be evaluated for ADA Compliance using ~~the DOJ 2010 ADA Standards for Accessible Design~~ 36 CFR Part 1190 – Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way Final Rule. These Standards are available at: https://www.access-board.gov/prowag/ ~~www.ada.gov/regs2010/2010ADAStandards/2010ADAstandards.htm. The 2010 ADA Standards for Accessible Design consists of the U.S. DOJ TITLE 28 CFR Parts 35.151 from the Code of Federal Regulation combined with the 2004 ADA Accessibility Guidelines~~.

Within the project limits the evaluation of the sidewalks and any curb ramps which may exist within a project's limits is to be a field evaluation. An evaluation from remote sources such as Google Earth or the Division's pavement video records is not sufficient.

~~For sidewalks located outside of a municipality, the District/Division shall evaluate and fully document the entire sidewalk within the project limits for ADA Compliance. A cost estimate for the renovation and a copy of the ADA evaluation shall be forwarded for review to the District/Division ADA Coordinator. During project development, the District/Division shall~~

consider incorporating side walk renovations into the project. If there is significant scope creep, the District/Division may request, through the District ADA Coordinator, that sidewalk renovations not be incorporated into the project, and be included in the WVDOH ADA TransitionPlan. The ADA Coordinator shall obtain approval for this request from the Deputy Commissioner of Highways. Regardless of when the sidewalks are renovated, Curb ramp work to make the sidewalk ADA compliant must be incorporated into the alteration project, or completed prior to the alteration project.

For Sidewalks located on the WVDOH Right of Way within a municipality where the municipality is responsible for the sidewalk maintenance, the District/Division ADA Coordinator shall contact the municipality to inform them that the existing sidewalks need to be evaluated for ADA Compliance. Non-compliant sidewalks should be added to municipality's ADA Transition Plan. Regardless of sidewalk maintenance responsibility, curb ramp work must be incorporated into the project.

30. Curb Ramps on Resurfacing Projects in Urbanized Areas with Sidewalks

Alteration projects must include curb ramp installation if none previously existed where there is a pedestrian walkway with a prepared surface for pedestrian use within the scope of the project. Where a non-compliant curb exists within the pedestrian walkway, upgrading of the curb ramp to meet the Proposed Accessibility Guidelines for Pedestrian Facilities in the public Right-of-Way (PROWAG), dated July 26, 2011, 36 CFR Part 1190 – Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way Final Rule is required.

When performing roadway activities at intersections and adjoining streets, the limits of resurfacing is to be the curb or gutter line of the street being altered.

The WVDOH recommends not paving to the end of the radius return on side street or alleys where crosswalks are in disrepair. and impacting the existing curb ramps of the adjoining street. If flaring of the resurfacing project into an adjoining street is necessary, If flaring of the resurfacing project into an adjoining street is deemed necessary, curb ramps that are compliant shall remain compliant after the resurfacing and curb ramps that are not compliant shall be assessed for ADA compliance and addressed within the scope of the project.

Curb ramps are to be assessed for compliance with PROWAG, dated July 26, 2011 36 CFR Part 1190 – Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way Final Rule, or constructed on resurfacing projects when:

A. Limits of the resurfacing project encroach into the boundary of the curb ramp detail;
B. Pedestrians may reasonably conclude that they would cross the resurfacing project from one curb ramp to another, even if the curb ramp is outside the limits of resurfacing;
C. Construction activities expand beyond the original limits and encroach into the curb ramp area; and
D. Curb ramps aren't present in sidewalks at signals, stop signs or yield signs (they must be constructed with the resurfacing project on each side of the pedestrian access route).

Additionally, when existing Type II (diagonal) curb ramps meet any of the above conditions, they must be assessed to determine if two separate ramps can be provided at the corner.

40. New Sidewalks and Replacement of Existing Sidewalks

The Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right of Way (PROWAG), dated July 26, 201136 CFR Part 1190 – Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way Final Rule, should be considered as minimum criteria for the design of any new sidewalk or the replacement of an existing sidewalk. The complete PROWAG document is available at the following web address: https://www.access-board.gov/prowag/ Certain sections will be referenced for the designer in Section 40 of this DD. Currently, PROWAG is still in the rule making process and the 2010 ADA Standards for Accessible Design is being enforced by the Department of Justice. Therefore, new sidewalks shall also be checked for compliance with the 2010 ADA Standards for Accessible Design. If sidewalks do not meet the requirements of the 2010ADA Standards for Accessible Design36 36 CFR Part 1190 – Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way Final Rule an ADA Exception Justification Report (attached found in section 60) shall be submitted to the District/Division ADA Coordinator for review and concurrence

50. Technical Guidance and References

2010 ADA Standards (Existing Sidewalks)

The 2010 ADA Standards are to be used to evaluate existing sidewalks for ADA compliance. If the existing sidewalk is to be replaced, The Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right of Way dated July 26, 2011 36 CFR Part 1190 – Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way Final Rule shall be used in the design of the new sidewalk.

A technical assistance "tool kit" which includes checklists and information on conducting assessments of existing facilities is available for use by Designers at the following web address: http://www.ada.gov/pcatoolkit/toolkitmain.htm. Chapter 6 of this resource provides the technical assistance, and Appendices 1 and 2 provide instructions and a survey form to use to analyze existing sidewalks. The WVDOH PVT-7 Revised Standard Detail for Sidewalk Ramps and Specification Section 609 Sidewalks is available and shall be used by Designers in WVDOH projects. The Above-mentioned publications include the following items (this listing is NOT all-inclusive)

In short, the above-mentioned checklist includes the following items (this listing is NOT all-inclusive).

A. Sidewalks shall be at least 3 4 ft. wide. 5 ft. wide in WVDOH projects.

B. The cross slope shall not exceed 2% 2.1%.

C. When sidewalks are less than 5 ft. in width, passing spaces with a minimum clear space of 5 ft. x 5 ft. shall be provided at intervals not to exceed 200'. Driveways, building entrances, and public sidewalk intersections may be used for passing spaces.

D. Where an obstacle (example: utility pole or fire hydrant) is considered immovable, a minimum 32" of sidewalk width (excluding curb width from measurement) must be provided for the pedestrian. Reduction of sidewalk width from 36" (3') 48" due to an obstacle requires an ADA Exception Justification Report design exception. When developing sidewalk widths, the Roadside Design Guide (RDG) requirements of clear zone (RDG Section 3.1) and minimum lateral offset behind the curb (RDG Section 3.4.1) must also be considered.

E. Curb ramps shall not exceed a running slope of 1:12 or 8.33% (maximum 1:10 is permitted at existing sites where it is not feasible to provide the 1:12 requirement due to space limitations and the rise is less than 6 inches).

F. A level landing should be provided at the top of a perpendicular curb ramp.

G. The transition from curb ramp to gutter should shall be flush; lips are not permitted.

H. The foot of a curb ramp should be contained within the crosswalk markings.

I. Gratings such as tree well covers, valve boxes with vent holes, manhole covers, etc. in the path of travel may not have an opening with a dimension of greater than ½" in any direction. Drainage inlets or any other item with openings greater than ½" in any dimension shall be located out of the path of travel.

J. Drainage is to be provided upstream of the foot of the ramp to ensure flow depth is at a minimum.

K. Positive drainage on the curb ramp surface and abutting roadway shall be maintained. No ponding.

L. The surface of the curb ramp shall be firm, stable, slip resistant and generally planar.

The Designer is cautioned to fully review the requirements contained in the Guide and consult the Checklist for complete information. 36 CFR Part 1190 – Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way Final Rule and the identified documents for complete information.

Accessibility Guidelines for Pedestrian Facilities in the Public Right of Way (PROWAG) (New Designs)

These standards shall be used in the design of all new sidewalks and the replacement of any existing sidewalks:

A. The pedestrian access route shall have a minimum width of 4 ft. excluding the width of the curb.

B. A level landing shall be provided at the top of a perpendicular curb ramp. The landing at the top of the curb ramp shall be a minimum 4 ft. wide when no obstructions exist at the backside of the landing and a minimum 5 ft. wide when obstructions exist such as a building, pole etc.

C. All other requirements described for Existing Sidewalks above shall apply, noting that the list is NOT all-inclusive.

Additional guidance may be found at the following web site concerning Public Rights-of-Way Access from the United States Access Board (generally referring to facilities in public rights-of-way): http://www.access-board.gov/guidelines-and-standards/streets-sidewalks/public-rights-of-way. A manual entitled "Special Report: Accessible Public Rights-of-Way Planning and Design for Alterations", dated August 2007, is available for technical assistance to the Designer, generally providing guidance for alterations of existing facilities at http://www.access-board.gov/guidelines-and-standards/streets-sidewalks/public-rights-of-way/guidance-and-research/accessible-public-rights-of-way-planning-and-design-for-alterations.

Technical guidance, including sample details, is available for the proposed DOJ rules at the address given heretofore in Section 20 of this Design Directive (the DOJ 2010 ADA Standards for Accessible Design (www.ada.gov/regs2010/2010ADAStandards/2010ADAstandards.htm.) Chapter 2 of this resource includes Scoping Requirements, while Chapter 4 "Accessible Routes", include requirements and sample details for sidewalks and curb cuts.

Where a sidewalk which is being constructed or reconstructed along a State highway is carried around a radius, and ended, the surface of the sidewalk will smoothly meet the existing ground or adjacent sidewalk where conditions permit. If the sidewalk being constructed or reconstructed extends through the crosswalk on the intersecting street, curb cuts or ramps shall be provided.

The Checklists found in Design Directive 202, *Field and Office Reviews for Initial Engineering, Preliminary Engineering and Final Design* include lines for the Designer/Consultant Project Manager to initial for compliance when submittals are made.

60. ADA Exception Justification Report

If a requirement of the DOJ 2010 ADA Standards 36 36 CFR Part 1190 – Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way Final Rule is deemed technically infeasible, the reasons for the exception must be fully documented and approved. Some reasons why an ADA requirement cannot be implemented include historical considerations, limited right-of-way, or problems with geometry (both horizontal and vertical). It is up to the Designer to determine feasibility. If an ADA exception is granted for technically technical infeasibility, the Designer should make every effort to mitigate the requirement and design the feature to the greatest extent feasible in the effort to meet the established guidelines. Specifically, Sections 201, 202, and 206 of the adopted DOJ 2010 ADA Standards discuss scoping, structural impracticality and technical Section 406 discusses Curb Ramps.

Attached to and made a part of this Design Directive is an ADA Exceptions Justification Form which is to be completed by the Designer/Project Manager for all projects which have exceptions to any ADA requirements. A copy of the proposed ADA Exception Justification Report with the recommended signatures shall be mailed sent to the EEO Civil Rights Compliance Division ADA Coordinator to be forwarded to the ADA Board Chairman for approval. The completed Form is to be included in the Final Office Review and PS&E submittals.

West Virginia Division of Highways
EEO Civil Rights Compliance
Division ADA Coordinator 1900
Kanawha Boulevard, East Building
5, Room 618 550
Charleston, West Virginia 25305-0430

The District/Division ADA Coordinator shall maintain a copy of all approved ADA Exception Justification Reports and Sidewalk Evaluations for future reference.

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DD-811

SHEET 1 OF _____

Curb Ramp Number as identified in the WVDOH ADA Data Set (if applicable) - ____________

AMERICANS WITH DISABILITIES ACT EXCEPTIONS JUSTIFICATION REPORT

PROJECT DATA

State Project No. ______________________________ **Date:** __________________________

Federal Project No: ______________________________ **County:** ________________________

Project Name: ____

Project Description: ____

____

____

Special Project Sponsor Name and Address: ____

____

____

WVDOH Representative: _ **FHWA Representative:**

____

(Note: Project Description in above table should be the complete scope of the project: i.e. major or minor construction, urban or rural, reconstruction, rehabilitation, pavement overlay, etc. using the descriptions given in DD-803 as a guide)

HIGHWAY ROUTE DATA

AASHTO Functional Classification

1. ☐ Urban ☐ Rural
2. ☐ Arterial ☐ Collector ☐ Local Road
3. ☐ Freeway ☐ Divided/Arterial ☐ Two-Lane Arterial
4. ☐ Interstate
5. ☐ Other (i.e. school property)

TERRAIN TYPE ☐ Level ☐ Rolling ☐ Mountainous

SHEET 2 OF _____

ADA REQUIREMENTS (Document Only Exceptions)

	ADA Requirements Triggered	Existing Condition	Design Criteria	Proposed Action	Criteria Source
1.	Sidewalk	________	________	________	________
2.	Curb Ramps	________	________	________	________
3.	Detectable Warnings	________	________	________	________
4.	Accessible Signals	________	________	________	________
5.	Accessible Parking	________	________	________	________
6.	Van Accessible Spaces	________	________	________	________
7.	Path of Travel	________	________	________	________
8.	Bridge	________	________	________	________
9.	Other	________	________	________	________

(Note: references to the appropriate Section number of the 2010 ADA Standards for Accessible Design and proposed PROWAG Standards are to be used as the Design Criteria and the Criteria Source in the above table and in the Exception Report)

APPROVAL SIGNATURES

RECOMMENDED:

1. ______________________________
Consultant

2. ______________________________
Project Engineer

3. ______________________________
District/Division ADA Coordinator

APPROVED:

____
ADA Board Chairman

REVIEWED:

____
Federal Highway Administration

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SHEET ____OF _____

NARRATIVE DISCUSSION OF ADA EXCEPTION(S): Attach appropriate Photos, design drawings, or other documentation ~~as needed~~ to support the Exception Justification request

SECTION BREAK

NEW BUSINESS ITEMS

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WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS

DESIGN DIRECTIVE 105
PUBLICATION DEVELOPMENT AND APPROVAL PROCESS
Approval Date
Supersedes November 6, 2024

1. PURPOSE

This Design Directive establishes procedures for preparing, reviewing, approving, and publishing West Virginia Division of Highways (WVDOH) Specifications, Special Provisions (SPs), Standards, Manuals, and Material Procedures (MPs). These publications define the technical requirements, procedures, and policies used by the Division for planning, design, construction, maintenance, and materials management.

The directive applies to the following publication types:

- Specifications & Special Provisions
- Standards & Manuals
- Material Procedures

2. ADMINISTRATIVE AUTHORITY

All WVDOH publications shall be administered by the Materials Control, Soils & Testing Division (MCS&T). MCS&T is responsible for:

- Coordinating review of proposed publications and revisions
- Administering the applicable review committees
- Coordinating approval through the Division and review with the Federal Highway Administration (FHWA), when applicable
- Publishing approved documents on the Division's webpage

3. CHAMPION RESPONSIBILITIES

A Champion is responsible for developing and presenting proposed publication(s) or revision(s), including:

- Preparing the draft and electronically submitting it to the Committee Chairperson, along with information on the provision and a brief description of the proposed revision for inclusion in the agenda packet.
- Coordinating with subject matter experts, internal staff, industry, and public comments and updating the draft as necessary. The Champion may need to work outside of committee meetings to address comments and progress the item through the review process.
- Presenting it to the committee for review and approval. The Champion may designate a knowledgeable proxy to attend meetings if unavailable.

Failure to participate or provide required updates in a timely manner may result in removal of the item from the committee agenda.

4. COMMITTEE STRUCTURE

Each publication type is reviewed by its designated committee.

- Specification Committee
- Standards and Manuals Committee
- Materials Procedure Committee

Voting Members: One representative from:

- Contract Administration Division
- Engineering Division
- Materials Control, Soils and Testing Division
- Operations Division
- Traffic Engineering Division

Quorum: Minimum of three (3) voting members present.

Approval: Majority vote of present voting members; Chairperson may break tie votes.

Non-Voting Members: May include FHWA, industry representatives, contractors, and technical experts.

Open Government Compliance: All committees shall operate in accordance with the West Virginia Open Government Meeting Act. Meetings shall be properly noticed, agendas published in advance, votes recorded, minutes maintained, and open to the public.

5. COMMITTEE REVIEW PROCESS

5.1 Two-Meeting Minimum: Proposed items shall normally be presented at a minimum of two (2) committee meetings before being voted upon. Depending upon their complexity, controversy, or the level of comments, items may be held for additional review and updates as needed to address comments, revisions, or other required steps to ensure proper committee review.

5.2 Minor or Editorial Changes: Changes determined to be minor or editorial may be approved after one (1) meeting. Minor changes do not alter technical intent and include:

- Editorial corrections (spelling, grammar, formatting)
- Updated references, links, or organizational titles
- Clarifications that do not change technical intent

Any voting member or FHWA representative may request that a minor change be treated as substantive, requiring two (2) meetings.

5.3 Chairperson Authority: The Committee Chairperson manages meetings, determines readiness for vote, and may designate changes as minor or substantive. The Chairperson ensures the review process remains efficient while maintaining compliance with policy.

5.4 Comment Deadlines: Committee members shall review proposed items prior to the scheduled meeting. Comments must be submitted to the Chairperson in advance to allow the Champion time to address them. Late comments may be addressed during the meeting at the Chairperson's discretion, and, if appropriate, may be subject to a vote.

6. FHWA COORDINATION

FHWA is invited to participate in committee meetings and is provided meeting notices and agenda packets for review. FHWA may attend meetings and provide comments as part of the review process.

Following committee action, the publication is forwarded through the Division and submitted to FHWA for approval, as applicable.

7. EMERGENCY OR EXCEPTIONAL APPROVAL PROCESS

When urgent circumstances or project needs do not allow sufficient time for the committee review process, as defined in subsection 5 of this DD, a proposed item may be submitted through the Division chain of command to the State Highway Engineer for approval.

This process should be used only in exceptional circumstances when delaying the change would negatively impact project delivery, safety, or operations.

The submission shall include:

- Description of the proposed change
- Reason the standard committee process cannot be followed
- Project(s) affected
- Draft language of the proposed provision or revision
- Supporting background or justification

Items approved through this process should be presented by the Champion at the next meeting for information and record and may be incorporated into the next formal revision.

Emergency or exceptional approval process items are to be used only for the singular project for which it was approved. If the emergency or exceptional approved item is desired to be used among other projects, it must pass through the normal committee processes.

8. PUBLICATION AND DISTRIBUTION

Approved publications will be posted to the appropriate WVDOH webpages and distributed to district offices and impacted stakeholders. Materials Control, Soils & Testing Division shall maintain current electronic access to all publications.

WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
~~**DESIGN DIRECTIVE**~~

DESIGN DIRECTIVE 622
INTERSECTIONS ON RURAL DIVIDED HIGHWAYS
INSERT NEW DATE
Supersedes October 3, 2012

~~Attached is the West Virginia Department of Transportation, Division of Highways' Intersections on Rural Divided Highways guide. It shall be used on all applicable projects.~~

~~Attachment~~

INTERSECTIONS ON RURAL DIVIDED HIGHWAYS

Turn lanes are to be provided for intersections on rural divided highways in accordance with the attached drawing and the requirements as listed below. All references to pages, tables and exhibits herein are contained in the ~~2011~~ 2018 AASHTO publication "A Policy on Geometric Design of Highways and Streets".

LEFT TURNS

Left-turn lanes are to be provided on all rural divided highways. Where the design hourly volume (DHV) for the turn from the through roadway is equal to or greater than thirty (30), a taper, a deceleration lane, and a storage bay (minimum 100 feet long) shall be provided.

RIGHT TURNS

Where the DHV is less than thirty (30), an appropriate turning radius will be provided.

Where the DHV from the through roadway is equal to or greater than thirty (30) and less than 100 a right-turn taper shall be provided. An appropriate turning radius will be provided at the end of the taper.

When the DHV turning right is 100 or greater and/or the DHV on through lanes in one direction is 500 or greater, a deceleration lane and taper will be provided.

In certain situations where right-turn traffic movement delays cause problems with through traffic, a storage length (min. 100 feet) must be considered.

MEDIAN CROSSOVERS

A four (4) lane rural facility should have adequate median width to provide for protected left turns.

Where a median crossover is provided along a superelevated multi-lane highway with a median less than eighteen (18) feet wide and without provisions for a storage lane, the profile grade shall be carried in the center of the median.

Where a median crossover is provided along a superelevated multi-lane highway with a median of eighteen (18) feet or more and/or where a storage lane is provided, separate profile grades shall be carried for each set of lanes. A differential in grade lines (bifurcation) shall be used where required to provide a smooth median crossover grade, with the desirable grade being 2 two percent (2%) toward the low side. Excessive bifurcation is not desirable due to the possibilities of future widening of the roadway and possible future intersections being constructed on the roadway.

See Figure 9-59 9-43 "Above Minimum Design of Median Openings (Typical Bullet-Nose Ends)", page 9-155 9-123 of the 2011 2018 AASHTO publication "A Policy on Geometric Design of Highways and Streets".

WVDOH uses a control radius of seventy-five (75) feet for the design of median openings.

INTERSECTION DETAILS

Special details are required for all intersections. The pavement and shoulders shall be contoured to assure that superelevation, drainage, aesthetics, safety features and other aspects of the design have been properly considered. Pavement elevations will be indicated at ten (10) feet foot intervals around the returns and on the centerline of the side roads.

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INTERSECTIONS ON DIVIDED HIGHWAYS

Note 1:
R Is To Be Determined From ~~Table 9-15 Pages 9-57 to 9-59, And Table 9-16 Pages 9-60 to 9-63, Use As Applicable.~~ Chapter 9, Subsection 6, Of The 2018 AASHTO "A Policy on Geometric Design Of Highways and Streets." Use As Applicable.

Note 2:
Minimum Taper Length 300′ Min. For Curved Roadways With Design Speeds ≥ 50 MPH.

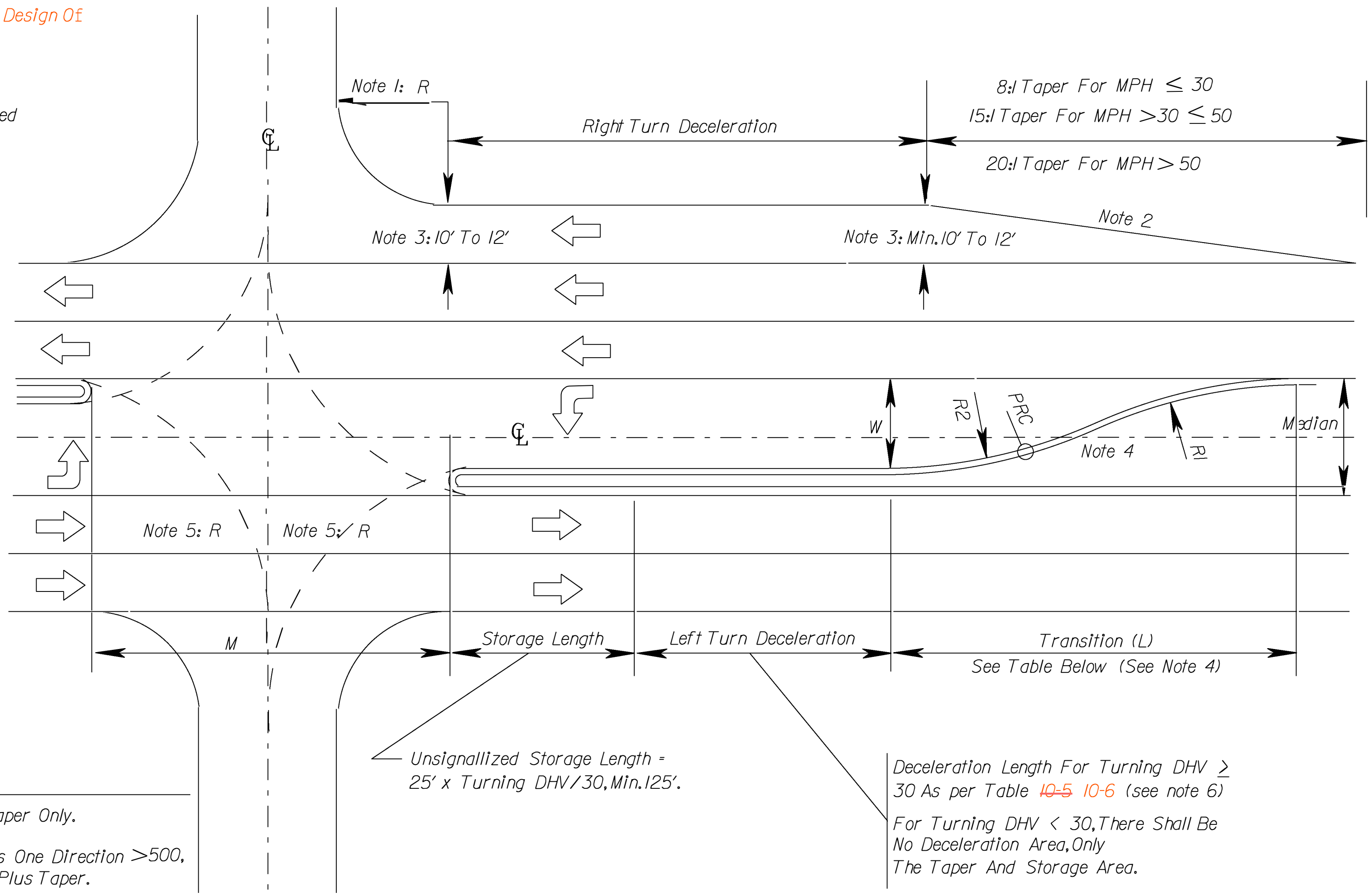
See Figures ~~9-49~~ 9-34a and 9-34b For L And R Values.

Note 3:
Auxiliary Lanes Should Have Same Width As Through Lanes.

Note 4:
When a Non Curved Typical Is Used A Straight Taper May Be Utilized.

Note 5:
R Is To Be Determined From Figure ~~9-59,~~ 9-43, WVDOT Uses Min. Radius Of 75 Feet.

Note 6:
For Turning DHV > 30 to 100, One Half (1/2) Of The Transision Length May Be Considered Part Of The Deceleration Length.



RIGHT-TURN LANE

For Turning DHV ≥ 30, But < 100, Use Taper Only.

For Turning DHV ≥ 100 And/Or Thru Lanes One Direction >500, Deceleration Length (As Per Table ~~10-5~~ 10-6) Plus Taper.

Note - Median opening (M) ~~Is Dependent On R.~~

~~See Table 9-27 Min. Design Of Median Openings. (75′ Control Radius)~~

Transition (L)									
Turn Lane Width (W)	30 MPH or Less			> 30 MPH to 50 MPH			> 50 MPH		
	8:1 Taper			15:1 Taper			20:1 Taper		
	L	R1	R2	L	R1	R2	L	R1	R2
12	96	262	131	180	906	453	240	1,606	803
11	88	240	120	165	828	414	220	1,470	735
10	80	218	109	150	752	376	200	1,338	669

DD-622

DRAFT

WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
~~DESIGN DIRECTIVE~~

DESIGN DIRECTIVE 625
INTERCHANGE WARRANTS
INSERT NEW DATE
Supersedes June 18, 2014

This purpose of this Design Directive is to provide guidance for determining whether to construct at-grade intersections or interchanges on roadways classified as expressways for the West Virginia Division of Highways. Information is given to aid the designer in choosing between an at-grade intersection or an interchange based on design-year traffic combined with sound engineering judgment. A procedure and a table for the warrant determination are given.

~~Attachment~~

10. Introduction and Background

Traffic signals are not safety devices; rather they function by alternately assigning the right of way to conflicting traffic streams. Signals are thus the most restrictive form of traffic control device.

When one of these traffic streams is traveling at a high speed (55 mph or greater) there may be safety issues involved with interrupting it. The presence of the signal can cause intersection capacity problems by itself. The steps that must be taken to assure good traffic operations can further degrade the intersection's capacity.

~~The goal of the West Virginia Division of Highways (WVDOH) is to place as few signals as possible on expressway-type facilities. Agreement was reached with the Federal Highway Administration in 1982 to use what are called the "Bleyl Numbers" for the design year traffic at an intersection. The "Bleyl Numbers" were defined by Robert Bleyl, who was the State Traffic Engineer in Utah at the time of the definition of the numbers. He utilized the Minimum Vehicular Volume (Warrant 1) and the Interruption of Continuous Traffic (Warrant 2) in the 1961 Manual of Uniform Traffic Control Devices (MUTCD) to define the numbers. In the 2000 or later issues of the MUTCD these two warrants were combined into Warrant 1, Eight-Hour Vehicular Volume with Conditions A and B. The attached table is based on Table 4C-1 of the 2003 MUTCD.~~

~~It is this warrant that the WVDOH will utilize to predict the future need for a traffic signal at any intersection on an expressway facility. The "Bleyl Numbers" table is attached to and made a part of this Design Directive.~~

The goal of the West Virginia Division of Highways is to minimize the installation of traffic signals on expressway-type facilities. For purposes of evaluating the future need for signalization on expressway facilities, WVDOH utilizes the Eight-Hour Vehicular Volume warrant (MUTCD Warrant 1), modified through application of the "Bleyl Numbers". The attached Bleyl Numbers table, derived from the applicable MUTCD vehicular volume warrant, shall be used to predict the design year need for signalization at expressway intersections.

If the warrant analysis shows that there is greater than a 95% probability that a signal will be required in the design year, then an interchange rather than an at-grade intersection, should be considered for construction at the time the facility is built. Other factors conforming to sound engineering judgment must be considered also. See Section 30 of this DD.

A traffic signal is NOT an interim measure for the future construction of an interchange. The signal which is warranted in the design year may or may not be warranted at the time of construction and opening to traffic of the facility, or for many years to come. Unwarranted signals have the potential to cause significant safety and delay problems at any intersection on any roadway, but especially at intersections on expressways.

20. Procedure

The designer is to follow the following steps to determine whether an interchange may be warranted instead of an at-grade intersection.

A. Acquire the design Average Annual Daily Traffic (AADT) volumes (20 or 25 years into the future from the predicted year of the facility opening to traffic) for each intersection on the new or reconstructed expressway facility. This information is obtained from the Traffic Modeling and Analysis Unit of the Planning Division, and is the same future year ADT data that is shown in the Design Designation block on the project's Title Sheet. See DD-802.

B. Compare these projected AADT's to the volumes shown in the attached table, by utilizing the number of lanes on the approach roadways, Major and Minor, as determined by the Designer. The expressway is normally the major road, but the designer may determine otherwise as long as the decision is documented to the project file. Satisfaction of the appropriate volumes indicates there is a 95% probability that a traffic signal will be warranted in the design year, in which case an interchange should be considered instead of an at-grade intersection.

C. Verify the conclusion reached in Step "B" above by dividing the AADT values used in that step by two (2), and comparing the result to eight times the required hourly warrant values.

D. Furnish the results of the analysis to the Traffic Engineering Division for verification, and for possible consideration of other factors that may affect the analysis, such as trucks, speed, pedestrians and/or bicyclists, which may affect the installation or operation of a signal.

E. Upon verification of the analysis by the Traffic Engineering Division, copies of all analyses and documentation are to be placed in the project file, as well as the Master File.

30. Other Considerations

There are other items that the Designer must consider after the determination is made that an interchange is or is not to be considered at any particular intersection. These include costs of right-of-way, utility relocation, future cost of construction versus the cost to construct the interchange at the present time, etc.; maintenance of traffic; environmental impacts; adjacent development; the impact the interchange will have upon the existing roadway and traffic network; etc. More conditions that the designer must examine are contained ~~on Pages 10-3 through 10-5~~ in Chapter 10 of the ~~2011~~ 2018 issue of the AASHTO publication "A Policy on Geometric Design of Highways and Streets".

After careful consideration of these and all other possible factors by the Designer, the conclusion that an interchange may not be possible to construct where one is warranted by this DD may be reached, or an intersection may be constructed where an interchange is warranted.

All factors, to include the warrant, are to be considered when the decision is made to build an at-grade intersection or an interchange at any intersection along expressway-type facilities. There is a possibility that a grade-separated mainline roadway with a two-way connector road (crossover to one side required on the mainline) could be constructed instead of a full interchange or full crossover to both sides. It is crucial that documentation of the reasons for the decision be placed in the project file and the Master File.

DRAFT

TABLE OF BLEYL NUMBER VALUES

NUMBER OF LANES FOR MOVING TRAFFIC ON EACH APPROACH		DESIGN YEAR AADT PROJECTIONS				EIGHT TIMES HOURLY MUTCD WARRANT VOLUME			
Warrant 1, Condition A - Minimum Vehicular Volumes									
MAJOR	MINOR	MAJOR		MINOR		MAJOR		MINOR	
1	1	9,600	*6,700*	5,750	*4,000*	4,000	*2,800*	1,200	*840*
2 OR MORE	1	11,550	*8,100*	5,750	*4,000*	4,800	*3,360*	1,200	*840*
2 OR MORE	2 OR MORE	11,550	*8,100*	7,700	*5,400*	4,800	*3,360*	1,600	*1,120*
1	2 OR MORE	9,600	*6,700*	7,700	*5,400*	4,000	*2,800*	1,600	*1,120*
Warrant 1, Condition B - Minimum Vehicular Volumes									
MAJOR	MINOR	MAJOR		MINOR		MAJOR		MINOR	
1	1	14,400	*10,100*	2,900	*2,050*	6,000	*4,200*	600	*424*
2 OR MORE	1	17,300	*12,100*	2,900	*2,050*	7,200	*5,040*	600	*424*
2 OR MORE	2 OR MORE	17,300	*12,100*	3,850	*2,700*	7,200	*5,040*	800	*560*
1	2 OR MORE	14,400	*10,100*	3,850	*2,700*	6,000	*4,000*	800	*560*

NOTES:

1. See Section 4C of the ~~2003~~ MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES (MUTCD), 11th Edition.

2. The higher of the two (2) minor approach volumes is to be used in the analyses.

3. The italicized values represent a reduction to 70% of the volumes corresponding to the MUTCD warrant. This reduction is taken where the major street speed is greater than 40 mph or the intersection lies in an isolated community with a population of less than 10,000.

WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
~~**DESIGN DIRECTIVE**~~

DESIGN DIRECTIVE 662
GUARDRAIL
INSERT NEW DATE
Supersedes June 1, 2017

Attached is the West Virginia Department of Transportation, Division of Highways' policy for the type, location, and termination of guardrail on highway projects. Designers shall incorporate these requirements in all contract plans.

~~Attachment~~

GUARDRAIL DESIGN POLICY

TYPE AND CLASS OF GUARDRAIL:

Type 1 Guardrail (Galvanized Steel Deep Beam) shall be specified on all new projects except Type 5 (Double-Faced Type 1) will be specified when double-faced guardrail is required.

The "Classes" of guardrail are as follows:

- Class I: 6'-3" post spacing with blocks
- Class II: 12'-6" post spacing with blocks
- Class III: 12'-6" post spacing without blocks
- Class IV: 3'-1½" post spacing without blocks
- Class V: 3'-1½" post spacing with blocks

On National Highway System (NHS) projects, all guardrail specified shall be Class I.

For projects not on the NHS, the class shall be in accordance with the following table, unless otherwise directed.

DESIGN YEAR ADT	**Low Volume Road 399 or less**	**400 or Greater or Multi-Lane**	
DESIGN/OPERATING SPEED*	25 MPH	Less than 40 MPH	40 MPH or Greater
CLASS	III, IV**	II, V**	I, V**

*Design speed shall be used when specifying guardrail for a new highway. The higher of Operating speed or Speed Limit shall be used when specifying guardrail for an existing highway. The operating speed shall be obtained from the Traffic Engineering Division.

** 3'-1½" post spacing provides lower guardrail deflection for locations with obstacles 4' or less behind the guardrail. A minimum 25' length of Class V should be used for obstacles. Other means of reducing deflection should also be considered.

APPROACH END TERMINALS:

Under ideal circumstances, all guardrail should be terminated outside the clear zone. In most cases, this cannot be accomplished requiring the installation of an approach end terminal.

The design of approach end terminals must be done on a case-by-case basis. When specifying an approach end terminal, the designer must ~~insure~~ ensure that the location at which the approach end terminal is specified provides the proper width, run out area, and cross slopes to allow proper installation of the approach end terminal.

The designer shall also include borrow excavation quantities, as necessary, to construct the grading required for approach end terminal installations (e.g., CST, FET, and TET) in accordance with the applicable Standard Detail Sheets. The grading limits and slopes shown on the Standard Details shall be used to determine the required earthwork quantities.

When Class I Guardrail must be terminated within the clear zone, a Manual for Assessing Safety Hardware, latest edition, (MASH) approved approach end terminal as discussed below shall be specified. All end terminals on NHS projects ~~to be let to construction after June 30, 2018,~~ shall conform to the latest edition of MASH. When Class II or Class III Guardrail must be terminated in the clear zone, an approved approach end terminal need not be specified; however, the guardrail shall be flared away from traffic. The minimum width of flare should be 4'-0". This information will be shown on the plan sheet.

The clear zone can be defined as the area available for use by errant vehicles starting at the edge of the traveled way and terminating at the closest obstruction. The width of the clear zone must be established for each project based on the type of highway, operating speed, traffic volume and roadside geometry. Refer to DD-606, Non-NHS 3R Policy and Chapter 3 of the AASHTO "Roadside Design Guide", current approved edition, (RDG), for more information on determination of the clear zone.

NHS PROJECTS:

The standard approach end terminal is the Cut Slope Terminal (CST) as detailed on Standard Sheets GR4 through GR4B. If the use of a CST is not possible then the designer should use, in order of preference, a Flared End Terminal (FET) or Tangent End Terminal (TET) as detailed on Standard Sheets GR5 or GR6 respectively.

Both the CST and the FET require flared installation, as well as modifications to the normal shoulder slope in the area of the flare. The FET also requires grading behind the guardrail. In order to accommodate these installations, consideration must be given to drainage. When the treatments, especially the CST, are placed on the downstream end of a cut, an inlet and carrier pipe may be necessary to drain the cut ditch.

The TET, which does not require a flare, is currently available. Its use should be limited to cases where high traffic volumes and high speeds exist, and the above treatments are impractical or not feasible.

The TET shall have a 4'-0" minimum offset from the inside edge of the extruder terminal to the outside edge of the traveled way. For narrow existing shoulders that have an offset of 5'-0" or less from the face of rail to the edge of the traveled way, the rail and terminal may be flared from the normal face of rail. The flared offset distance shall be 1'-0" at a taper rate of 25:1 or 50:1, which yields flare lengths of 25'-0" or 50'-0" respectively.

NON-NHS PROJECTS:

The NHS criteria will be used when Class I Guardrail is specified. As previously stated when Class II or Class III Guardrail is used, an approved approach end terminal need not be specified; however, the guardrail shall be flared away from traffic. The minimum width of flare should be 4'-0". This information will be shown on the plan sheet.

3R PROJECTS:

Guardrail design for resurfacing, restoration and rehabilitation projects shall conform to the criteria previously established for NHS projects or Non-NHS projects, whichever is applicable. The following information is intended to supplement these criteria.

Guardrail design for 3R projects presents unique challenges to the designer such as limited shoulder width and limited run out area at approach end terminals. The designer should not accept the location of the existing guardrail and end terminals as being correct and simply replace them with new material. The designer’s goal should be improved safety.

The approach end terminals, as described above, shall be specified on 3R projects, if applicable, based on the class of guardrail being installed. On all NHS 3R projects, the approach end terminals in the project area shall be upgraded to a CST, FET, or TET as previously described. On all Non-NHS 3R projects requiring Class I Guardrail, NHS criteria will be used. This may require that additional work be specified such as site grading, which may require a quantity of borrow excavation, or raising the elevation of the adjacent ditch line. It may be necessary to extend the guardrail beyond the point of theoretical need in order to place the approach end terminal in a location where it can be installed in accordance with the appropriate Standard or Special Detail. The designer is encouraged to eliminate short gaps between runs of guardrail especially when the approach end terminal cannot be installed in accordance with the appropriate Standard or Special Detail. This decision would be influenced by the cost of the end terminals versus the cost of the guardrail.

On Non-NHS 3R projects where the FET or the TET is the desired end terminal, but cannot be installed in accordance with Standard Detail Sheet due to lack of run out area behind the end terminal, the following guidance shall apply:

The area immediately behind and beyond the approach end terminal should be reasonably traversable and free from fixed-object hazards to the extent practicable. If a clear run out path is not attainable, this area should at least be similar in character to upstream unshielded roadside areas.

Ownership and storage location of any guardrail removed and stored (Item 607010) will be indicated in the plans by a General Note.

SPECIAL TRAILING END TERMINALS:

The Special Trailing End Terminal (STET) shall be specified when Class I Guardrail is specified; and, the guardrail is outside the clear zone of the opposing traffic. Generally, this will be on divided highways.

When the guardrail is not located outside the clear zone of the opposing traffic, it shall be designed as an approach end. The guidelines as mentioned in the Approach End Terminals Section are to be followed.

BRIDGE TRANSITIONS:

When the bridge shoulder width is less than the roadway shoulder width, a transition in the guardrail on the approach end and trailing end of the bridge is required. These transitions should occur on 15:1 straight tapers. There shall be a minimum of 12'-6" of standard guardrail between the bridge transition guardrail and the tapered guardrail.

BRIDGE TRANSITIONS – CONNECTIONS:

The Thrie-Beam Guardrail Bridge Transition-Connection Detail, as shown on Standard Sheet GR11, is to be used on all new projects when transitioning approach end guardrail to a concrete shape. New bridges will have a vertical concrete face as detailed in the plans.

Existing bridges that do not have the proper vertical concrete end post, as shown on Standard Detail Sheet GR11, will require the installation of the Modified Concrete End Post. Special Detail Sheets for the Modified Concrete End Post can be obtained from the Engineering Division.

Guardrail that must tie to new or existing bridges that have steel guardrail parapets rather than concrete parapets shall tie directly to the steel guardrail parapet.

The post spacing of the approach guardrail shall be equal to or less than the post spacing of the guardrail on the bridge. If the post spacing of the approach guardrail is greater than the post spacing of the bridge guardrail, the post spacing of the approach guardrail shall be decreased by one-half every twenty-five feet until the post spacing of the approach guardrail and the bridge guardrail are equal.

THEORETICAL POINT OF NEED, WARRANTS, AND LENGTH OF NEED:

The best available guide for guardrail theoretical point of need determination and warrants is the RDG. It shall be used on all projects.

An assumed encroachment angle for a vehicle leaving the highway will be used for length of need determination in lieu of the run-out lengths as shown in the RDG. When a vehicle is approaching the obstacle, this angle will be 8 degrees for NHS projects and 15 degrees for Non-NHS projects. When the trailing end is being considered, this angle will be 15 degrees for all projects. The use of these angles should be limited to tangent or near tangent sections of roadway. Scaling as demonstrated in Section 5.6.4 and Figure 5-48 of the RDG should be used in other cases. Results shall be documented in the project files.

The designer is cautioned to fully investigate each guardrail/end treatment installation to assure that the runout area is free of obstacles, including cut or fill slopes, and is traversable. The guardrail/end treatment installation may have to be lengthened to protect secondary obstacles behind the installation. See Section 8.3.3.3 of the RDG for more information.

GUARDRAIL LOCATION IN RELATION TO THE SHOULDER SLOPE (P.I.):

On new designs where Class I or Class II Guardrail is specified, the P.I. shall be offset 1'-0" from the back of the guardrail post. The post will be between the P.I. and the edge of pavement.

On new designs where the typical has not been set and Class III Guardrail is specified, the P.I. shall be offset 2'-0" from the face of the guardrail. The guardrail will be between the P.I. and the edge of pavement.

GUARDRAIL LOCATION - 3R PROJECTS:

On Interstate and APD 3R projects, the guardrail offset from edge of pavement shall be as originally constructed.

On all other 3R projects, the back of the guardrail post shall preferably be set at 1'-0" from the P.I. If this results in restricting the usable shoulder width, 8'-0" long posts shall be specified and the guardrail shall be placed at its prior location.

WVDOH Manuals Committee Meeting
Tuesday, April 7, 2026
Meeting Location: 190 Dry Branch Drive, Charleston, WV

Also meeting virtually via Google Meet. Email distribution includes instruction.

Old Business:

NONE

New Business:

ITEM	Champion
1st time to Committee. • ***Drainage Manual – Chapter 6:*** This is an update to Chapter 6 Culverts. The revision incorporates the changes implemented by the "Technical Engineering Memo – Driveway Conduit Placement" issued January 2023	D. Holmes

Chapter 6 Ditches

West Virginia
Department of Transportation
Division of Highways
Drainage Manual

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CHAPTER 6 DITCHES

6.1 INTRODUCTION

Roadway ditches are V or trapezoidal shaped channels lined with grass, concrete, rock, or manufactured protective linings. They are generally designed to convey the design discharge and resist erosion of the in-situ soil. Higher discharge amounts than the design criteria may be necessary when a ditch intercepts offsite drainage. Ditches may also drain subsurface water from the base of the roadway which is conveyed through underdrains.

Ditch design is accomplished by the selection of a cross-section geometry, horizontal alignment, grade, and protective linings to convey the design discharge via the allowable depth. The selection is then examined using a lower, more frequent discharge to avoid erosion before the lining is considered viable.

6.2 DESIGN POLICY

Roadway ditches shall be designed to collect rainfall runoff from the roadway right of way (pavement surface, median area, cut and embankment fill slopes), contributory drainage areas outside of the right of way, and possible natural water course flow sources. These ditches shall convey the flow in a manner which minimizes the potential for adverse effects on the roadway.

The designer shall use the following general policies as a guide to plan, select, and design ditches placed along roadways:

- Ditches shall be located by adhering to the cross-section geometry of the WVDOH Design Directive 601. Modifications shall consider the clear zone requirements and take advantage of the terrain.
- Ditches shall be hydraulically designed.
- Ditch linings shall be designed to be structurally stable.
- Permanent erosion control matting shall not be used in a ditch where the frequent removal of sediment is anticipated.
- Ditches and ditch outlets shall be designed to consider construction and maintenance costs, maintenance access, risk of lining failure, traffic safety, and environmental considerations.

6.3 DESIGN CRITERIA

Design criteria are controlled by geometric and safety standards applicable to the roadway project. The following criteria shall apply to the hydraulic design and stability of ditches:

6.3.1 FREQUENCY

Median, roadside, and secondary ditches shall be designed to carry onsite runoff from the roadway right of way for a frequency (probability of occurrence) of 10% or a return period of 10 years.

6.3.2 SIZE AND SHAPE

Roadside and median ditches shall be designed to be triangular or trapezoidal in shape with side-slopes specified by the typical roadway section (Design Directive 601). The bottom width of trapezoidal ditches shall vary depending on the capacity required. Consideration shall be given to achieving the project clear zone when sizing a ditch.

If significant flow from offsite is carried within a roadside ditch, then the ditch shall be sized to carry the design discharge for the offsite drainage area. For example, an offsite discharge may flow into a roadside ditch, then to a culvert crossing perpendicular to the roadway. The design discharge would be defined by the culvert crossing at the end of the ditch which may require a higher design discharge (such as 4% or a 25-year return period).

A Rockfall Catchment Area Ditch (RCAD) is constructed to retain falling rock. These ditches typically have long 24-foot fore-slopes with a 1-foot flat bottom and a steep backslope. The RCAD will have similar hydraulic conveyance as compared to the standard geometry of Design Directive 601. Coordinate with the roadway designer and the geotechnical engineer when a RCAD ditch is part of the design and include the modified ditch geometry in the hydraulic calculations.

6.3.3 FLOW DEPTH

The maximum flow depth in a median ditch shall be 0.6 feet or 7.2 inches.

The maximum flow depth in a roadside ditch shall be 1 foot and shall not exceed a depth which is 1.5 feet below the edge of the shoulder. Roadside ditches along low volume roads may be exempted from this standard to enable a cost-effective design. The flow depth shall not be higher than the lowest elevation of the roadway subgrade. If “flooding the subgrade” cannot be avoided, then pavement underdrain should be used (see Section 5.3.2.11).

6.3.4 LONGITUDINAL SLOPE

The longitudinal slope of a median or roadside ditch shall not be less than 0.5 percent. Flatter slopes may be permitted with the use of concrete pavement within the ditch. In general, the longitudinal slope of the ditch shall be sufficient to satisfy the minimum velocity criteria.

6.3.5 MINIMUM FLOW VELOCITY

The flow velocity in a median or roadside ditch shall not be less than 0.5 foot per second when ditch is flowing at one-third of the design flow depth.

6.3.6 DITCH INLETS AND MAXIMUM SPACING

Inlets with the WVDOH standard Type G grates ranging in size from 32” X 38” to 60” X 66” are primarily used in median and roadside ditches. The Type 1 Grate has 1” bars, 2” on center. The type 2 grate has 1” bars, 4” on center.

The maximum pipe length between inlets shall not be greater than 400 feet to allow for maintenance access. Upon WVDOH approval, this distance may be extended up to 100 feet to enable practical drainage layouts. See design criteria for access structures in Chapter 5, Section 5.2.7.

6.3.7 SECONDARY DITCHES

Secondary ditches are drainage structures which may reside at the top or toe of cut slopes and at the bottom of embankments. These are usually used to separate offsite drainage from the median or roadside ditch system. The need for secondary ditches should be determined by factors such as:

- Protection of the median or roadside ditch system.
- Directed conveyance of runoff to a temporary sediment basin.
- Separation of runoff due to environmental requirements.
- Lessen the contributing drainage area or concentration of runoff.
- Maintenance of existing drainage patterns

Pipe flumes and cascades may also be considered as options to convey offsite drainage from steep slopes. See the culvert design criteria in Chapter 8 (Section 8.3).

6.3.8 ROUGHNESS COEFFICIENT SELECTION

The Manning’s roughness coefficient for ditch protection should be based on the condition that represents the minimum resistance to flow. This value shall be selected with consideration of a variation with flow depth and whether vegetative linings will be maintained (mowed or unmowed). Values for ditches with vegetative linings that cannot be mowed due to their location (such as ditches located at the bottom of steep embankments) shall be selected based on the condition that provides the maximum resistance to flow. This yields a higher flow depth and a higher shear stress.

Roughness coefficient for vegetative linings shall be selected from the ranges shown in Table 6-1. Vegetative ditch linings should consist of seed mixture Type B with the use of Type C-1 in areas viewable and traversable by traffic. More information on the standard seed mixtures can be obtained from Section 652 of the WVDOH standard specifications. For flat longitudinal ditch slopes a higher value within the range should be selected. Roughness coefficient for non-vegetative linings shall be based on the material type and flow depth as shown in Table 6-2.

Table 6-1

Manning's Roughness Coefficient for Vegetative Ditch Linings

WVDOH Grass Seed Mixture	Minimum roughness coefficient. n	Standard roughness coefficient n	Maximum roughness coefficient n
Type B (mowed)	0.036	0.042	0.050
Type C-1 (mowed)	0.030	0.036	0.040
Type C-2 (mowed)	0.022	0.027	0.033
Type B (unmowed)	0.050	0.090	0.140
Type C-1 (unmowed)	0.050	0.080	0.120
Type C-2 (unmowed)	0.025	0.030	0.040

Table 6-2

Manning's Roughness Coefficient for Non-Vegetative Ditch Linings

Material Type	Manning's Roughness Coefficient, n		
	Depth Range (ft) 0 – 0.5	Depth Range (ft) 0.5 – 2.0	Depth Range (ft) > 2.0
Rigid			
Concrete	0.015	0.013	0.013
Grouted Rock	0.040	0.030	0.028
Unlined			
Bare Soil	0.023	0.020	0.020
Rock Cut	0.045	0.035	0.025
Rock (D_{50})			
4-inch	0.090	0.058	0.035
6-inch	0.104	0.069	0.035
12-inch	-	0.078	0.040

Source: Design of Roadside Channels with Flexible Linings, HEC-15, FHWA, 1988

6.3.9 DITCH PROTECTION

The selection of vegetative lining with or without temporary or permanent erosion control matting shall be based on permissible shear stress criteria. Proper installation of matting is critical to its performance. The design drawings shall stress that matting must be installed in strict accordance with the manufacturer's specifications to facilitate a correct installation.

Rock linings shall be designed based on permissible shear stress criteria. This type of lining should not be placed within the highway clear zone; however, it may be permitted to protect existing ditches in the clear zone that have eroded into deep gullies. It also may be permitted where pavement resurfacings have created deep ditches provided that the top 6 inches of rock does not have sizes exceeding 4 inches in diameter. A filter layer shall be used between the underlying soil and the rock lining to prevent erosion at the rock soil interface (refer to specification 218). An acceptable standard aggregate filter layer is 6" of #467 stone placed underneath the entirety of the rock lining. The designer can refer to federal publication HEC-15, Section 6.4.3 for the design procedure for granular rock filters. Standard drawings for rock linings, filter layers, and concrete gutters are shown in the WVDOH Standard Details.

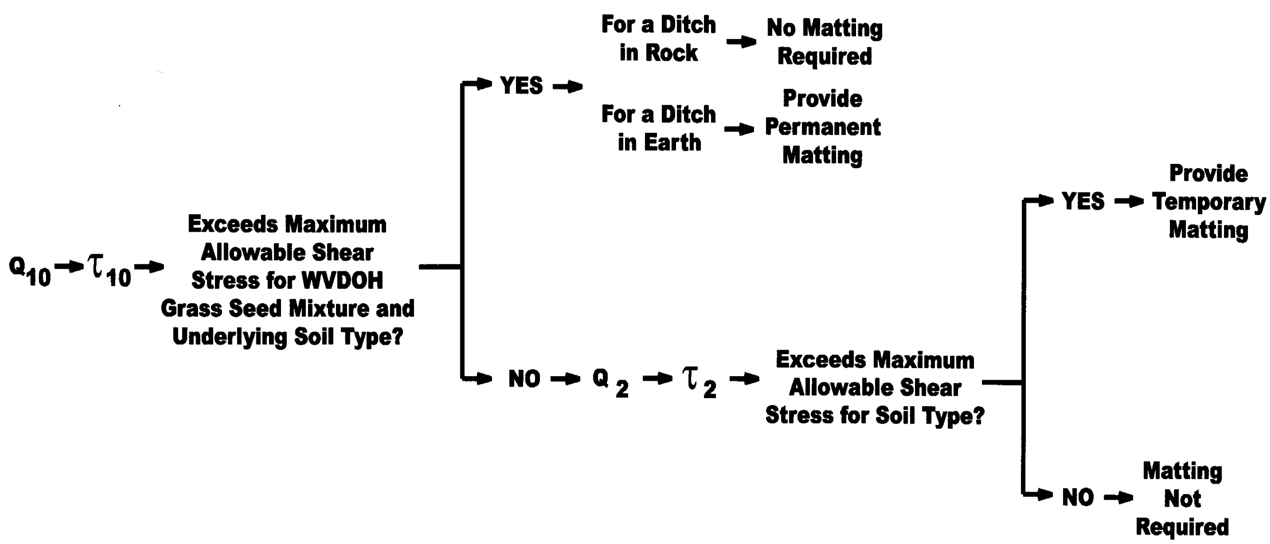
6.3.10 DESIGN METHODS

Ditches shall be analyzed for depth, shear stress, and minimum velocity at appropriate intervals by solving Manning's equation. Ditches should typically be analyzed at 50-foot intervals. Additional points of analysis may be required due to change in slope, inflow from other channels or pipes, a change in channel material, or a sudden increase in drainage area. Shear stress examination is shown in Figure 6-1. It should be noted that even if the ditch is in rock, one side of the ditch consisting of fill will not be able to withstand the shear stresses comparable to rock. Ditch design charts, programs, or nomographs may be used, provided the sources are documented and the data is presented in Form 6-1. The FHWA program Hydraulic Toolbox is recommended for ditch and ditch lining design.

Where design discharges exceed 50 cubic feet per second, the design of rock linings shall be based on FHWA's HEC-11. For additional design guidance see HEC-23 Chapter 5 and Design guidelines 4 and 16.

Figure 6-1

Ditch Analysis Flowchart



6.3.11 DRIVEWAY CONDUIT

The design goal for a driveway conduit placement is to convey the approaching and departing ditch flow with consistency (depth, velocity, and flow state) and without flooding the adjacent roadway subgrade. As a roadside ditch approaches a driveway, the conduit shall be sized and placed at a depth to meet the goal. The tables of Section 6.4.4 provide minimum guidelines for the roadside ditch (side slopes of 2:1) approaching and departing a driveway. These tables were created using typical site scenarios according to the type of property the driveway serves. The driveway conduit can be designed as a culvert for a more accurate hydraulic representation of its function for the rainfall runoff. This may reduce the required roadside ditch depth when compared to the tables.

The approaching and departing ditch width (away from the conduit) should be a minimum width equal to the diameter. The approaching and departing grade should be the same as the conduit grade for a minimum distance equal to the conduit length. The preferred distance of equal grade is one equivalent to the bordering length of the property adjacent to the DOH right-of-way. In some cases, a consistent ditch grade approaching, through, and departing the driveway conduit may not be possible. The use of a flatter grade may benefit by creating a reduction in flow velocity; however, flow state changes can cause ditch erosion or aggradation due to sedimentation. The same flow state (subcritical or supercritical flow) should be present on both sides of the conduit. See Chapter 5, Section 5.3.6.9 regarding a change in the state of flow.

Driveways which intersect a roadway at a downgrade shall not discharge rainfall runoff from the driveway surface onto the adjacent sidewalk, shoulder, or traveled way. The preferable driveway profile should include a vertical sag curve prior to intersecting the adjacent roadway. If this profile cannot be achieved, the driveway surface flow shall be intercepted by a cross drain (refer to the Overland Flow Inlet Capacity Section of Chapter 5). See Section 10.4 and Figures 9A and 9B of the published Manual on Rules and Regulations for Constructing Driveways on State Highway Rights-of-Way.

The placement of the driveway conduit shall not alter the natural water course.

6.4 DESIGN GUIDELINES

6.4.1 MANNING'S EQUATION

Uniform flow exists in a channel when there is no change in velocity, the channel is straight, and without variance in slope or cross section along its length. Under this condition the acceleration is zero and the streamlines are straight. Uniform flow exhibits a constant velocity head with an energy grade line and water surface slope parallel to the channel bottom. When flow is uniform, the depth in the channel is referred to as normal depth. Uniform flow conditions can be assumed within ditches because they generally exhibit the above conditions within the analysis intervals and have prismatic shapes (triangular or trapezoidal). Therefore, Manning's equation can be used to compute the velocity and normal depth for ditches.

$$Q = \frac{1.486}{n} AR^{2/3} S^{1/2}$$

n = roughness coefficient

R = Hydraulic Radius = A/P (ft)

A = Cross-sectional area of flow (ft^2)

P = Wetted Perimeter of the cross-section (ft)

S = Slope of the energy grade line (ft/ft)

For a given discharge, normal depth is calculated by expressing A in terms of depth (d) and then solving for depth by trial and error. The slope of the energy grade line (S) can be approximated as the channel slope.

6.4.2 PERMISSIBLE SHEAR STRESS

Permissible shear stress is the force required to initiate movement of the ditch boundary material. The permissible shear stress or tractive force approach became recognized in the 1950's, based on research conducted by the US Bureau of Public Roads and later developed by the USDA Soil Conservation Service. This method is physically based and focuses on stresses developed at the interface between flowing water and the materials forming the ditch boundary. Factors such as the vegetative stiffness, density, height, ditch geometry, flow depth, and flow velocity of are considered. The ditch slope is an important parameter in determining the shear stress and it is generally dictated by the roadway profile. Ditches with slopes steeper than 2% will generally flow in a supercritical state and have higher shear stresses. Shear stress in a ditch is not uniformly distributed along the wetted perimeter. It is proportional to the depth of flow. The failure criteria for the lining material are represented by a single shear stress value that is applicable over a wide range of ditch slopes and shapes.

The maximum shear stress shall be used for the design of ditch protection, and it shall not exceed the permissible shear stress of the selected lining material. The maximum shear stress in a straight ditch occurs on the bed and is given by:

$$\tau_\rho = \gamma \, d \, S$$

T_ρ = Permissible soil shear stress (lb/ft^2)

γ = Unit weight of water (62.4 lb/ft^3)

d = depth of flow (ft)

S = Energy slope assumed equal to the ditch average bed slope (ft/ft)

Flow in a bend creates secondary currents which impose higher shear stresses on the ditch side slopes. As shown in Figure 6-2, at the beginning of the bend the maximum shear stress is near the inside and then moves towards the outside as flow leaves the bend. The maximum shear stress in a bend is a function of the ratio of ditch curvature to the top water surface width (R_c/T). As the bend becomes sharper (as R_c/T decreases), the maximum shear stress in the bend increases as shown in Chart 6-1.

The maximum shear stress in a ditch bend is given by:

$$\tau_\rho = K_b\, \tau_d$$

T_ρ = Permissible soil shear stress (lb/ft^2)

T_d = Maximum shear stress in an equivalent straight section of ditch (lb/ft^2)

K_b = Ratio of channel bend to bottom shear stress

K_b can be determined from the following equation:

$$K_b = 2.38 - 0.206\left(\frac{R_c}{T}\right) + 0.0073\left(\frac{R_c}{T}\right)^2$$

Rc = radius of curvature of the bend to the ditch centerline (ft)

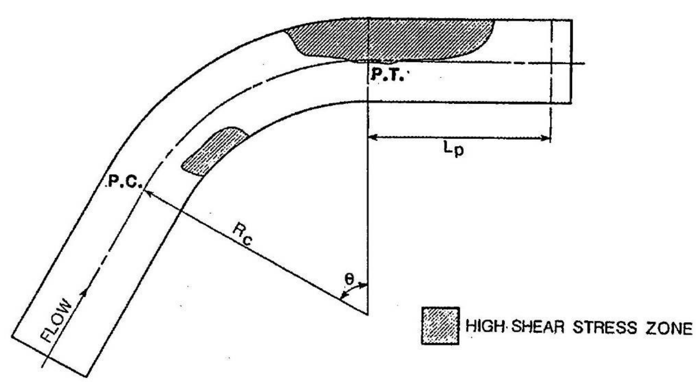
T = Top water surface width (ft)

Kb = 2 for $R_c/T \leq 2$

Kb = 10 for $10 \geq R_c/T$

Figure 6-2

Shear Stress Distribution in a Bend



Source: Design of Roadside Channels with Flexible Linings, HEC-15, FHWA, 2005

The increased shear stress caused by the bend persists a distance L_p, downstream of the bend. Chart 6-2 can also be used to determine the required protection length downstream of ditch bends.

The protection length downstream of the bend is given by the following equation:

$$L_p = 0.60\left(\frac{R^{\frac{7}{6}}}{n_b}\right)$$

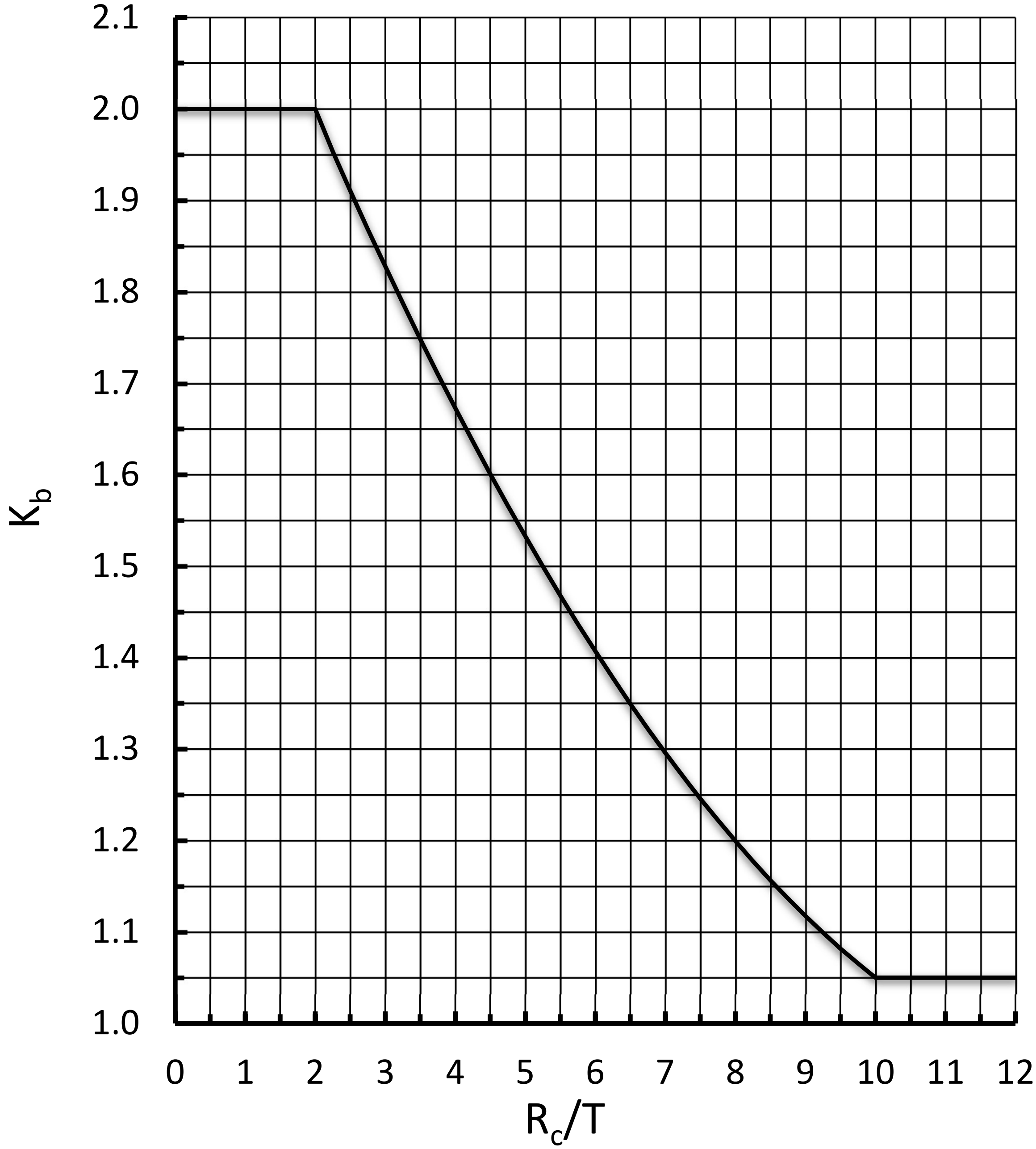
L_p = Protection length downstream of bend (ft)

R = Hydraulic radius of the ditch (ft)

n_b = Manning's roughness coefficient in the bend

Chart 6-1

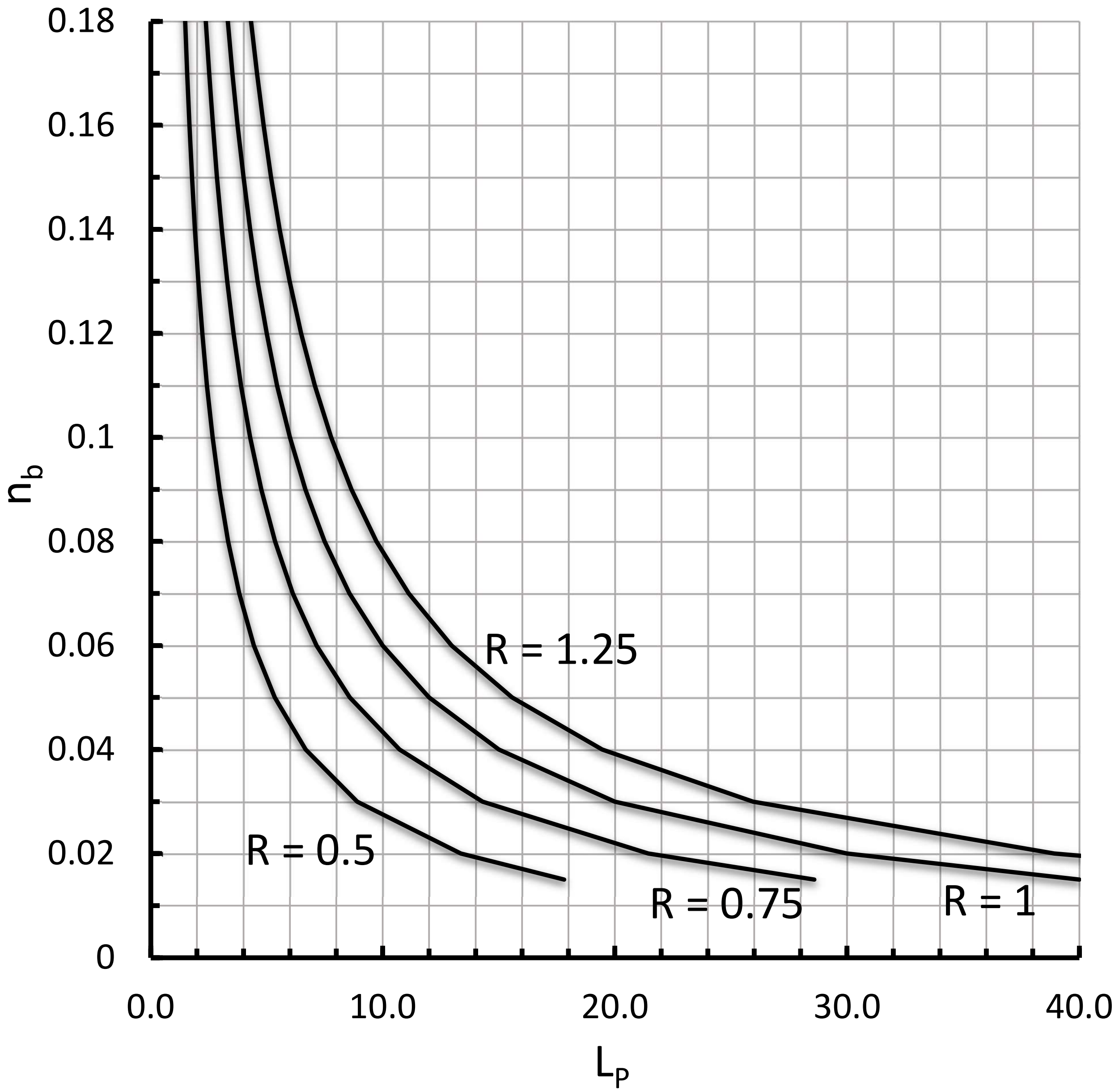
K_b Ratio of Channel Bend to Bottom Shear Stress



Source: Design of Roadside Channels with Flexible Linings, HEC-15, FHWA, 2005

Chart 6-2

Protection Length L_P Downstream of Ditch Bend



Source: Design of Roadside Channels with Flexible Linings, HEC-15, FHWA, 2005

6.4.2.1 Permissible Shear Stress for Soil

Erosion of the soil boundary occurs when the effective shear stress exceeds the permissible soil shear stress. Permissible soil shear stress is a function of particle size, cohesive strength, and soil density. The permissible soil shear stress is needed to determine whether temporary matting will be used before vegetation is established. In most cases, the use of temporary matting is good practice; however, in certain cases the existing soil will stand up to the lower return period storm for the temporary situation. This soil stress value is intended to support the judgment of not using temporary matting.

A clay soil can behave like a solid, semi-solid, plastic solid, or liquid depending on the amount of water in the soil. The water contents corresponding to the transitions between these states are known as the Atterberg Limits. Each of the Atterberg limits varies with the clay content, type of clay mineral, and ions (cations) contained in the clay. The Atterberg plastic limit (PL) and liquid limit (LL) are used to classify a soil. The plastic limit is the amount of water in the soil that transitions it from the semi-solid state to the plastic state. The liquid limit is the amount of water in the soil that transitions it from the plastic state to the liquid state. The difference between the liquid and plastic limits is known as the plasticity index (PI = LL-PL). This index indicates the range in moisture content over which the soil is in a plastic state. In this state the soil can be deformed and still hold together without crumbling. A PI greater than 20 is considered high and indicates that a considerable amount of water can be added before the soil reaches the liquid state. The plasticity index correlates with strength, deformation properties, and insensitivity.

Non-Cohesive Soils

The erodibility of coarse non-cohesive soils (defined as soils with a plasticity index of less than 10) is due mainly to particle size. The permissible shear stress for fine grained, non-cohesive soils is estimated at 0.02 lb/ft^2. For coarse grained, non-cohesive soils the value ranges between 0.02 lb/ft^2 and 0.8 lb/ft^2. If a gradation is available, the coarse-grained value is determined by:

$$\tau_\rho = 0.4\ D_{75}$$

τ_ρ = Permissible soil shear stress (lb/ft^2)

D_{75} = Soil size where 75% of the material is finer (in)

Cohesive Soils

Cohesive soils are largely fine grained, and their permissible shear stress depends on cohesive strength and soil density. Cohesive strength is associated with the plasticity index (PI), which is the difference between the liquid limit and plastic limit of the soil. Soil density is a function of the void ratio. A simplified approach for estimating permissible soil shear stress is illustrated in Figure 6-3.

Figure 6-3

Permissible Shear Stress for Cohesive Soil

			Stress Range (lb/ft^2)
Cohesive Soil	Fine Grained	10 < PI < 20	0.03 to 0.09
		20 < PI	0.08 to 0.09
	Clay	20 < PI	0.12
	Coarse Grained	10 < PI <20	0.10 to 0.15
		20 < PI	0.15

6.4.2.2 PERMISSIBLE SHEAR STRESS FOR SOIL WITH VEGETATION

Grass linings are generally suitable for protecting ditches with gradients up to 10 percent and with side-slopes flatter than 3H:1V. The combined effects of the soil permissible shear stress and the effective shear stress transferred through the vegetative lining results in a permissible shear stress for the vegetative lining.

Table 6-3 provides the permissible shear stress values for the WVDOH Standard Specification seed mixtures. Vegetative ditch linings should consist of seed mixture Type B with the use of Type C-1 in areas viewable and traversable by traffic. Type C-2 may be used in areas next to the roadway in an urban setting.

The computed maximum shear stress value is compared to the permissible shear stress for the selected category of grass lining/seed mixture and underlying soil type. This is accomplished by determining the maximum depth in the ditch and computing the shear stress at the bed. If the permissible shear stress of the selected grass lining and underlying soil type is greater than the computed maximum shear stress at the bed, the grass lining is considered adequate. If the grass lining is determined unacceptable, another seed mixture with a higher permissible shear stress should be selected. The use of permanent erosion control matting should also be considered to supplement the grass lining if shear stress values are at the maximum permissible limit.

If the design situation requires more detail, see HEC-15 2005 Edition, Section 4.3.3. A soil sample will be required and tested to provide the soil grain roughness, plasticity index, void ratio, gradation, and ASTM soil classification.

Table 6-3

Permissible Shear Stresses for Grass Linings

WVDOH Grass Seed Mixture	Permissible Shear Stress (lbs/ft^2)	Underlying Soil Type
Type B (mowed)	1.0	non cohesive and cohesive
Type C-1 (mowed)	1.0	non cohesive and cohesive
Type C-2 (mowed)	0.35	non cohesive and cohesive
Type B (unmowed)	3.2	non cohesive
	4.2	cohesive
Type C-1 (unmowed)	3.2	non cohesive
	4.2	cohesive
Type C-2 (unmowed)	0.53	non cohesive
	0.70	cohesive

6.4.2.3 PERMISSIBLE SHEAR STRESS FOR MATTING WITH VEGETATION

The Erosion Control Technology Council refers to Erosion Control Mats as Rolled Erosion Control Products (RECP). RECPs are defined as temporary, or degradable, and long-term or non-degradable materials designed and manufactured to reduce soil erosion and assist in the growth, establishment, and protection of vegetation. Matting is classified as either temporary or permanent based on performance and durability.

Temporary Matting – Temporary, degradable matting is composed of materials that are designed to break down leaving a vegetative lining behind. They are typically constructed of straw, jute, and coconut fibers in one or two layers. Pure straw matting is not recommended for use in ditch design.

There are two types of temporary matting that are acceptable for use in ditches. Each is classified by their effective lifespan and permissible shear stress (Table 6-4). The first type usually consists of a 70% straw to 30% coconut fiber matrix that is stitched together with a biodegradable thread between two layers of biodegradable jute netting. This type typically has an effective life span of about 18 months. The second type usually consists of a 100% coconut fiber inner layer between two layers of biodegradable jute netting. This type typically has a slightly longer effective life span of about 24 months.

The permissible shear stress value for the permanent condition shall be the same as that for the vegetation and underlying soil after matting has biodegraded. The design shear stress for the temporary condition shall be one caused by a discharge for a two-year recurrence interval storm (see Figure 6-1). The matting shall resist the shear stress for the temporary condition.

Table 6-4

Permissible Shear Stresses for Temporary Matting

Matting Type	Permissible Shear Stress for Temporary Matting (lbs/ft^2)
Straw and Coconut matrix	2.0
Coconut only layer	2.2

Permanent Matting - Long term, non-degradable or permanent matting is composed of materials that are designed to enhance vegetative growth and extend the erosion control performance of grass linings. WVDOH permanent matting types are covered in the standard specifications in section 715.24. Each type is specified by ASTM test methods describing minimum mat thickness, tensile strength, elongation, porosity, resiliency, and ultraviolet stability. Acceptance of other permanent matting for use on a project shall be based upon meeting the state specification and provided certified test data justifying adherence to those specifications.

Permissible shear stress values for each permanent matting type in vegetated and non-vegetated states are given in Table 6-5. Permissible shear stress for the non-vegetated state is considerably less than the values for the vegetated state and will usually control the design. When the maximum shear stress exceeds the maximum permissible shear stress of the grass lining with permanent matting, stronger materials such as rock or concrete lining should be considered.

Table 6-5

Permissible Shear Stresses for Permanent Matting

Matting Type	Permissible Shear Stress for Permanent Matting (lbs/ft^2)	
	Vegetated (Evaluate for Q_{10})	Non-vegetated (Evaluate for Q_2)
Type A	4	1
Type B	6	1.5
Type C	8	2

While matting has been shown to be effective in protecting vegetated ground surfaces, it is not appropriate in all locations Matting should not be used in:

- Ditches where maintenance is likely due to sediment build up. Pulling ditches with matting can result in loss of contact with the soil or loss of the matting completely.
- Uneven surfaces where ground contact of the matting will not be continuous.
- Rocky soils where anchorage is difficult.
- Non-vegetated applications
- Severe slopes
- Ditches with continuous flow
- Unfertile soils
- Shoreline applications with high wave action

It is important that the installation of temporary or permanent matting follow the manufacturers' guidelines. The permissible shear stress values depend upon proper installation.

6.4.2.4 PERMISSIBLE SHEAR STRESS FOR ROCK LINING

Ditches within rock cut sections shall not require a determination of a permissible shear stress.

Mannings roughness value (n) is based on the design depth.

The procedure for determining the proper characteristic size of rock lining shall follow that of Hydraulic Engineering Circular-15, Chapter 6, September 2005. The latest version of the FHWA Hydraulic Toolbox uses the methods of HEC-15 and may be utilized for design calculations. Equation 6.8 of that document shall be used to size the lining for the bottom of the ditch when the grade of the ditch is less than 5 percent. Equation 6.11 of that document shall be used when the grade of the ditch is greater than 10 percent. This equation provides the characteristic size of rock lining for the channel bottom and the channel sides. For slopes between 5 and 10 percent, both equations will be applied, and the larger characteristic size of rock lining shall be used for design.

For ditch gradients less than 5 percent, the rock lining design process can be simplified when limiting the D_{50} to 4, 6, or 8 inches by examining the shear stress. The permissible shear stress values in Table 6-6 shall be used to obtain the required characteristic size of the lining for rock linings in ditches with gradients less than 5 percent. These permissible values are compared to the maximum shear stress along the bottom of the ditch (see Section 6.4.2).

Table 6-6

Permissible Shear Stresses for Rock Lining with Less than 5% Grade

Rock (D_{50}) inches	Permissible Shear Stress (lbs/ft^2)
4	1.6
6	2.4
12	4.8

The shear stress on the sides of the ditch is less than the maximum shear stress occurring on the ditch bottom. The stability of a side slope lining is a function of the side slope and the angle of repose of the lining material. This essentially results in a lower permissible shear stress on the side slope than on the bottom. These two counterbalancing effects lead to the following equation to obtain the required characteristic size of the lining (D_{50}) for rock linings in ditches with side-slopes steeper than 3H:1V.

$$(D_{50})_{SIDES} = \frac{K_1}{K_2}(D_{50})_{BOTTOM}$$

K_1 = side to bottom shear stress ratio

K_2 = tractive force ratio

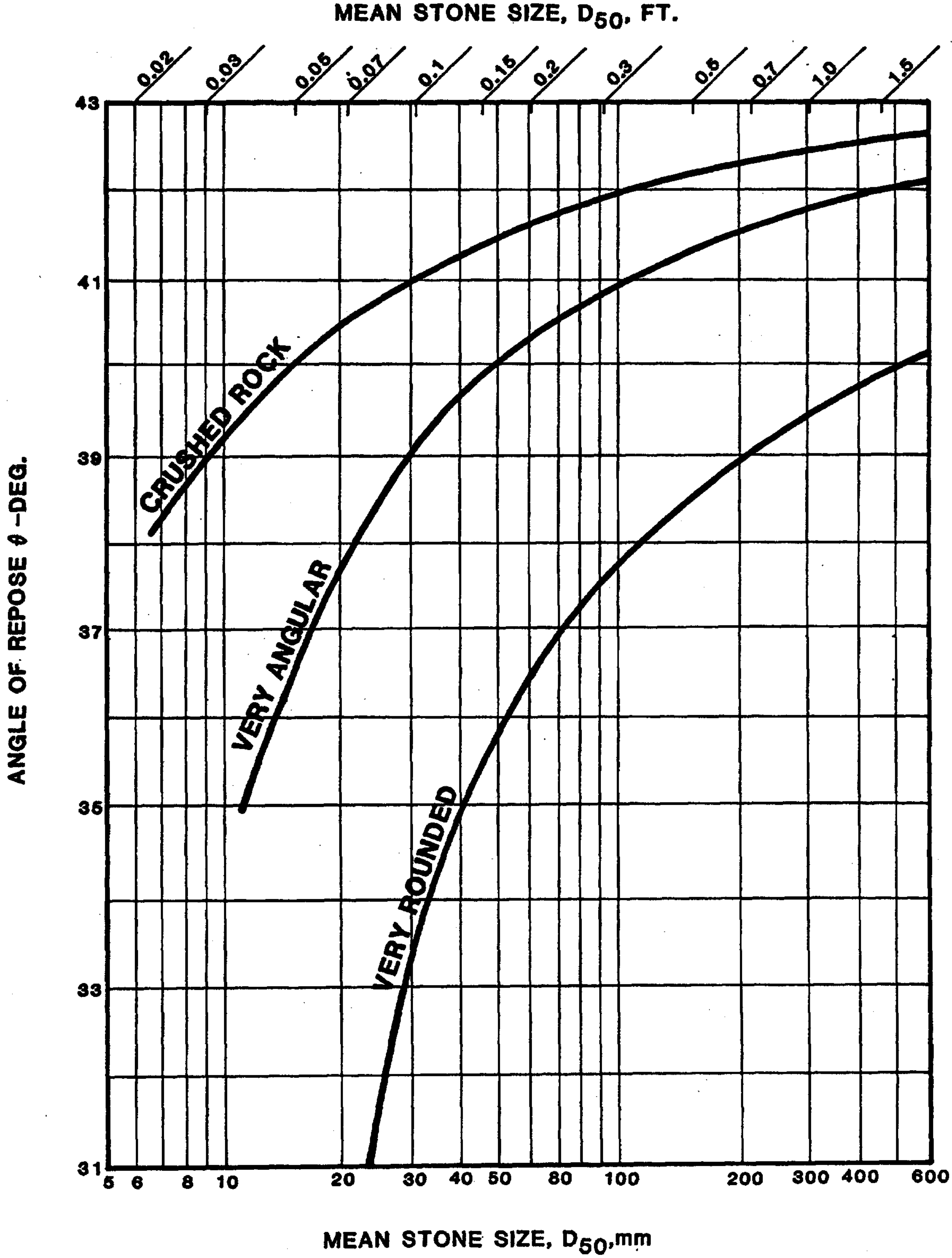
The angle of repose for different rock shapes (Θ) and sizes is presented in Chart 6-3. Chart 6-4 is used to obtain the ratio of the shear stress on the side-slopes to the shear stress on the bottom of the ditch (K_1). Values needed to obtain this shear stress ratio are the ratio of the bottom width of ditch (B) to flow depth (d) and the ditch side-slope (Z). Chart 6-5 is used to obtain the tractive force ratio (K_2) based on the angle of the side-slope and the angle of repose of the rock lining. Rock should be graded so that it follows a smooth size distribution curve and the spaces between the larger stones are filled in an interlocking fashion by the smaller stones. Most gradations that fall in the range of D_{100}/D_{50} = 3.0 and D_{50}/D_{20} = 1.5 are considered acceptable.

The rock should be angular rather than rounded, flat, or slab-like. An approximate guide to a stone shape is that neither the breadth nor the thickness should be less than one-third of its length. The thickness of the rock lining should equal the diameter of the largest rock size in the gradation. For most gradations, this will mean a rock lining thickness equal to 1.5 to 3.0 times the mean rock diameter (D_{50}).

If the rock lining design is not performed using the shear stress comparison with Table 6-7 or the ditch gradient is greater than 5 percent, using Varying n value with respect to the flow depth.

Chart 6-3

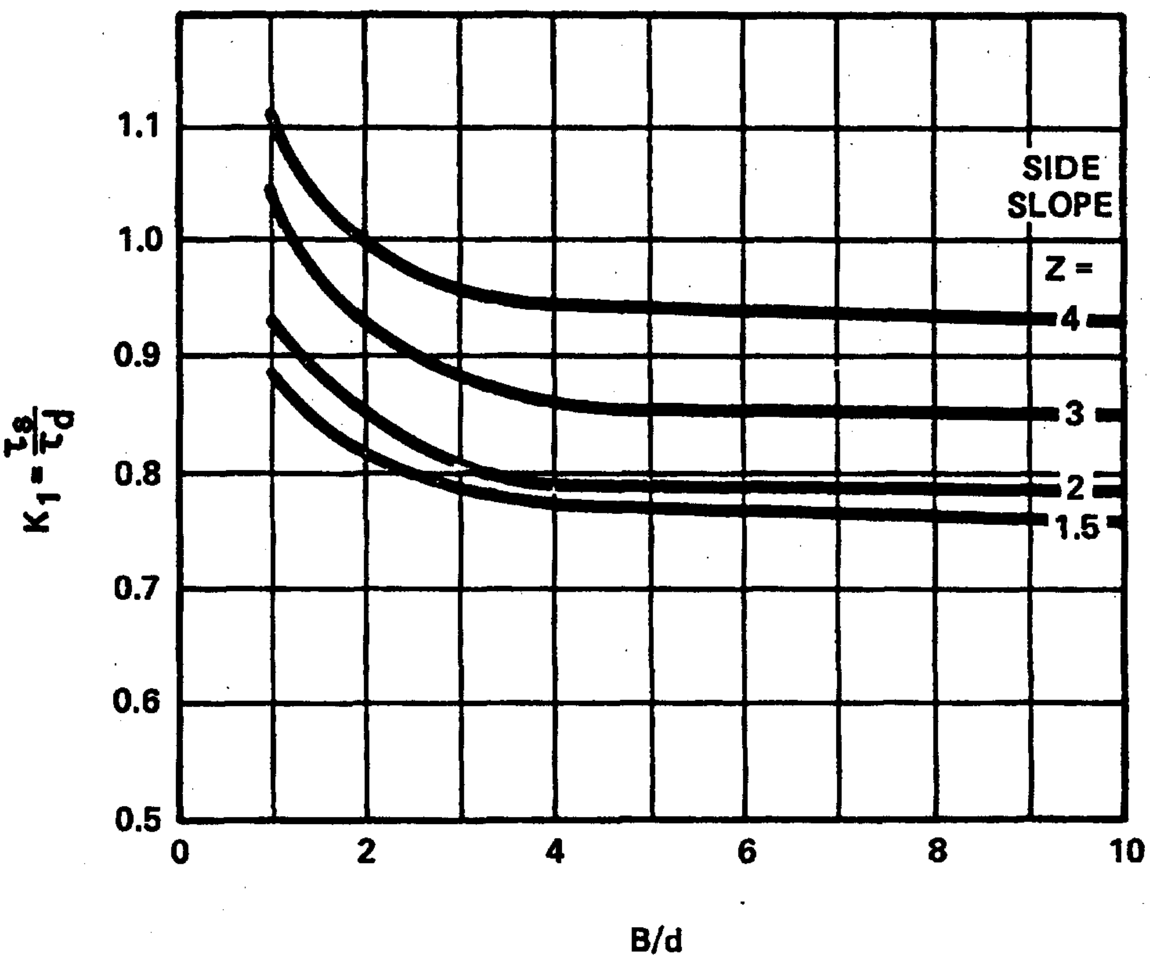
Rock Lining: Angle of Repose



Source: Design of Roadside Channels with Flexible Linings, HEC-15, FHWA, 1988

Chart 6-4

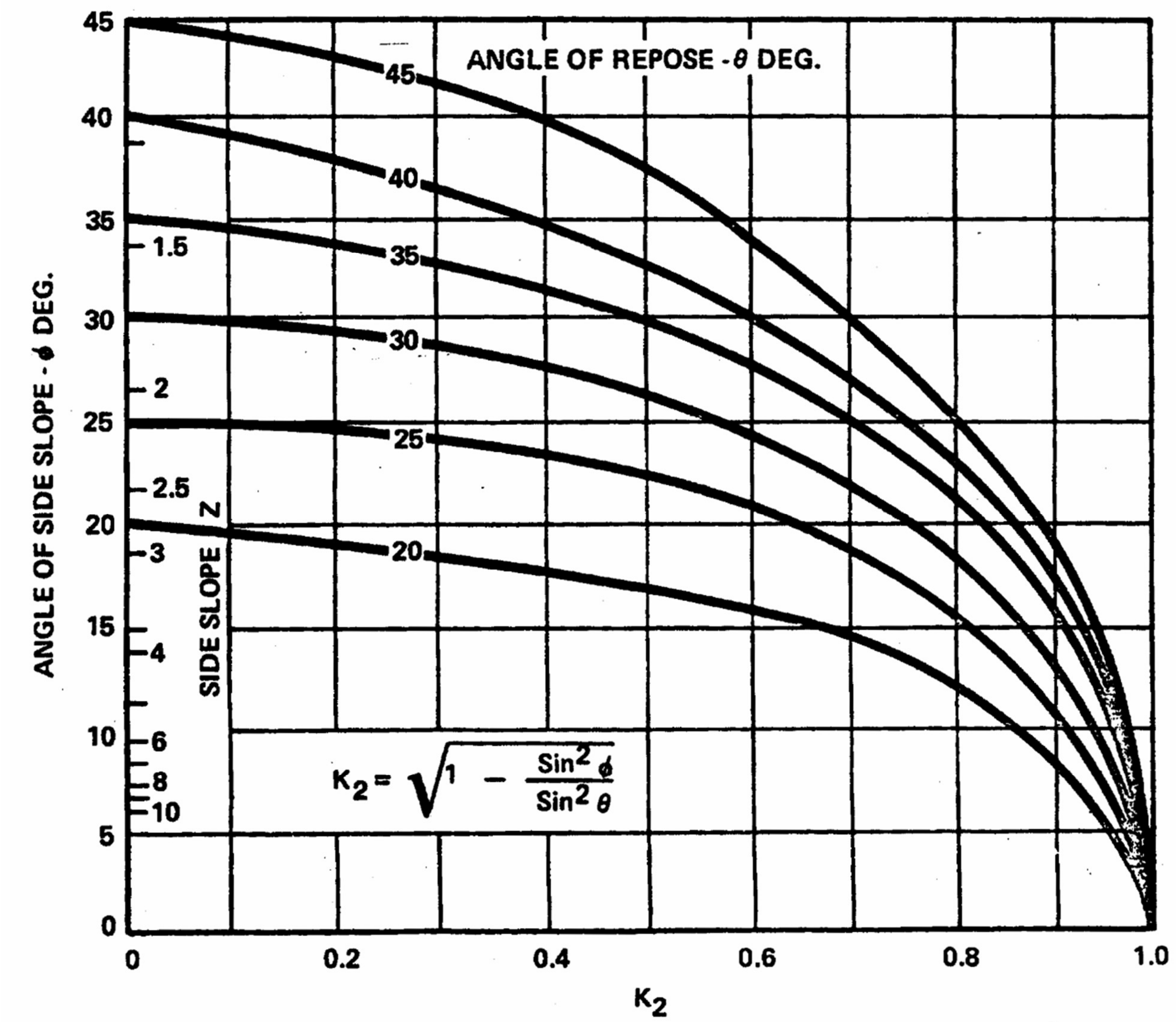
Rock Lining: Side to Bottom Shear Stress Ratio K_1



Source: Design of Roadside Channels with Flexible Linings, HEC-15, FHWA, 1988

Chart 6-5

Rock Lining: Tractive Force Ratio K_2



Source: Design of Roadside Channels with Flexible Linings, HEC-15, FHWA, 1988

6.4.3 DITCH INLET CAPACITY

It is important to note that ditches are designed for a return period of 10 years; therefore, the grate inlet capacity should be based on the 10-year storm. As stated in Section 6.3.6, ditch inlets use Type G grates. These inlets are installed with a 1-foot-high mound down grade of the grate at eight to ten feet (see WVDOH standard details and Table 6-7). This installation results in the determination of capacity as if it were in a sag vertical curve (see Section 5.3.4.8).

Chart 6-7 through Chart 6-20 were developed from equations in HEC-22. These charts provide the interception capacity for standard Type G grates ranging in size from 32” X 38” to 60” X 66” according to the average depth of flow over the grate. The average depth is used in case the choice is made to install the grate on the incline of the mound. This type of installation may be useful for a roadside ditch in an area where a large amount of natural litter is present.

The amount of available ponding depth should be checked for each inlet as this will depend on the grade of the ditch line it resides (see Figure 6-4). In most cases, the maximum allowable depth within the ditch (see Section 6.3.3) or the maximum allowable inlet spacing will control the ponding at the inlet. However, the ponding depth should be checked to ensure that it does not adversely affect the roadway pavement subgrade. Table 6-7 shows the amount of available ponding depth for ditch slopes of 0.5% to 7.5%. A depressed inlet may be installed to provide additional ponding depth. For slopes greater than 7.5% a special detail for the inlet mound will be needed as the standard detail provides little to no ponding depth at such steep slopes.

Figure 6-4

Profile View of Ponding Depth at a Type G Inlet

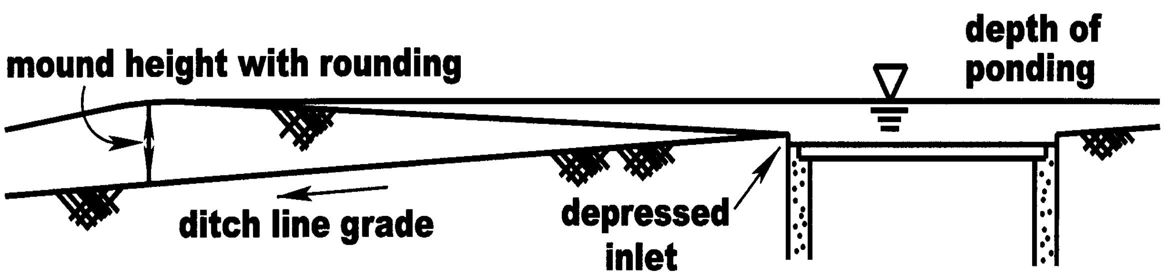


Table 6-7

Type G Inlet Available Ponding Depth

Ditch Grade (%)	Horizontal Distance to Top of Mound (ft)	Available Ponding Depth (0.5” loss due to mound rounding) (in)
0.5	10	10.9
1	10	10.3
2	10	9.1
3	10	7.9
4	9	7.2
5	9	6.1
6	8	5.7
7	8	4.8
7.5	8	4.3

Overtopping of the inlet mound shall not be allowed, but it may be calculated for a check storm. This overtopping discharge would be calculated using equations for flow over a broad crested weir according to the depth of flow over the mound. The inlet capacity charts can be used to determine the ponding depth that causes the mound overflow.

In a case where a Type G inlet is used in a rural roadside ditch or an urban ditch without a mound down grade it is treated as an inlet on grade (meaning bypass flow can occur). The ditch flow is primarily all frontal flow if the width of the grate is equal to the bottom width of the ditch. If the width of the ditch bottom is wider than the width of the grate there will be some side flow (see Figure 6-5).

As stated in Chapter 5 (see Section 5.3.4.4), the total intercepted flow capacity of an inlet grate is:

$$Q_i = E\,Q$$

E = total efficiency of a grate

Q = total gutter flow (ft^3/s)

With total efficiency as:

$$E = R_f\ E_o + R_S\left(1 - E_o\right)$$

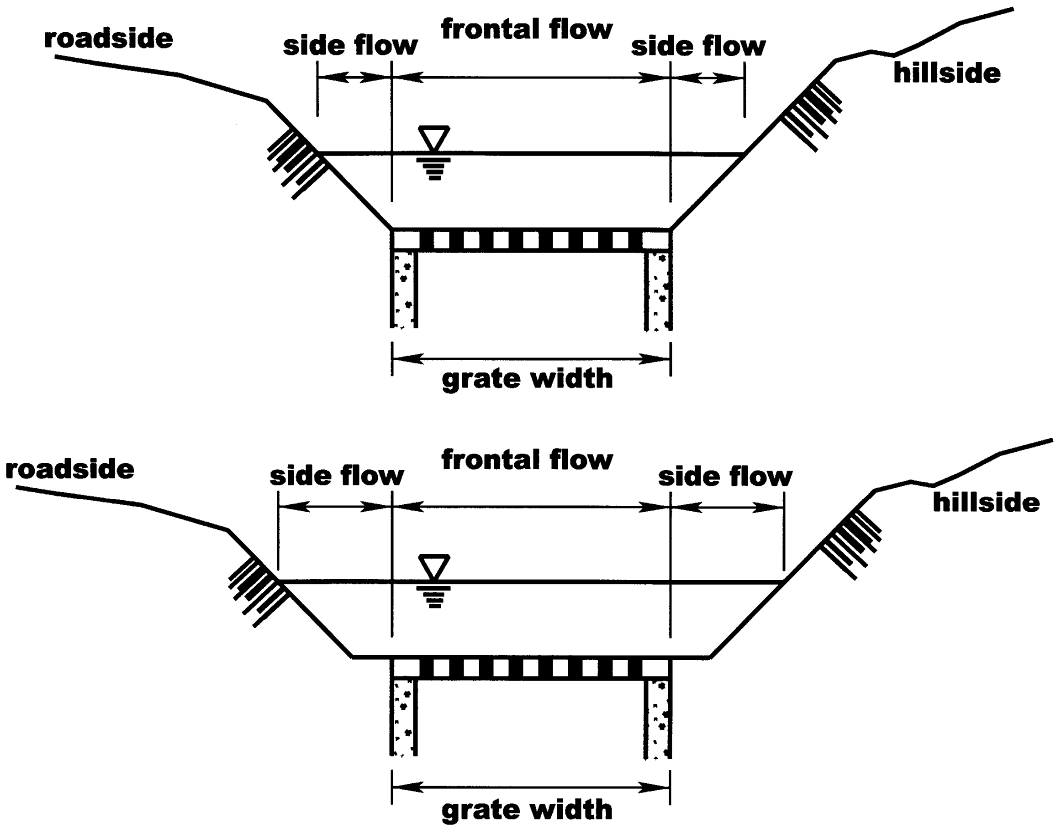
R_f = ratio of frontal flow intercepted to total frontal flow

R_s = ratio of side flow intercepted to total side flow

E_o = ratio of frontal flow to total gutter flow

Figure 6-5

Frontal and Side Flow for Type G Inlets without the Mound



The interception efficiencies for frontal and side flow for Type G grates are obtained from Chapter 5, Chart 5-7, and Chart 5-8, respectively. The ratio of frontal flow to total gutter flow (E_o) for a trapezoidal channel is shown in Chart 6-6 and obtained from the following equation:

$$E_o = W / (B + d\ z)$$

W = width of the grate (ft)

B = bottom width of the channel (ft)

d = depth of flow (ft)

z = horizontal distance of side slope to a rise of 1 ft vertical (ft)

For a trapezoidal channel, Manning's equation becomes:

$$Q = \frac{1.486}{n}\left(Bd + z\,d^2\right)\left(\frac{Bd + z\,d^2}{B + 2\,d\,\sqrt{z^2+1}}\right)^{0.67} S_L^{0.5}$$

n = roughness coefficient

S_L = bed slope (ft/ft)

This equation can be used to solve for depth of flow knowing the flow amount at any point in the ditch (usually obtained by the Rational Method). See Section 5.3.4.4 in Chapter 5 for more specific information on calculating inlet capacity on grade using frontal (R_f) and side (R_s) flow efficiencies.

The flow area is needed to determine the average velocity within the ditch. It is calculated as the area of a trapezoid (four-sided shape consisting of two parallel sides). The average velocity is required to determine the frontal flow and side flow efficiencies R_f and R_S, respectively.

$$A = \frac{1}{2}\,d\,\left(B + T\right)$$

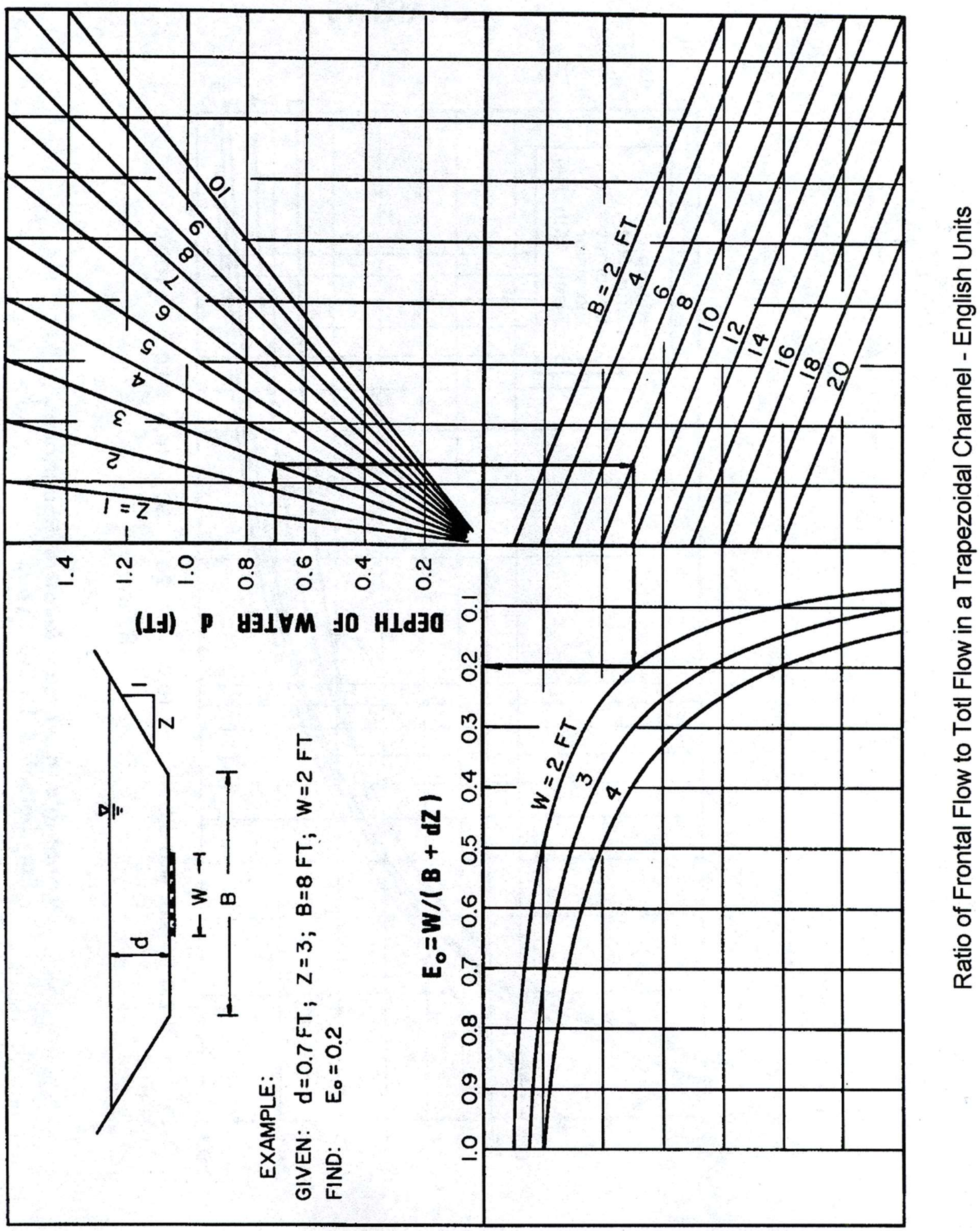
T = top width of the flow, ft

Flanking inlets may be necessary if the roadside ditch alignment has a sag vertical curve, and the mounding detail is not used. The designer shall examine the possibility of flooding the roadway subgrade if the grate should become completely blocked at the sag. The flanker inlets will most likely be the same as that of the sag inlet for grate installations without the mounding detail. See Section 5.3.4.10 in Chapter 5 for more information.

As stated in Section 5.3.4.7 a grate inlet in a sag location operates as a weir to depths that are dependent on the size of the grate and as an orifice at greater depths. Charts 6-12 through 6-24 give the value for interception capacity (Q_i) for an average depth over the grate (d_{AV}) in weir flow based on the effective perimeter (P) in feet and in orifice flow based on the effective clear open area of the grate (A) in square feet.

Chart 6-6

Frontal Flow / Total Flow for a Trapezoidal Channel



Source: Urban Drainage Design Manual, HEC-22, FHWA, August 2001

Chart 6-7

32” X 38” Type G grate inlet with mounding detail (Type 1 grate)

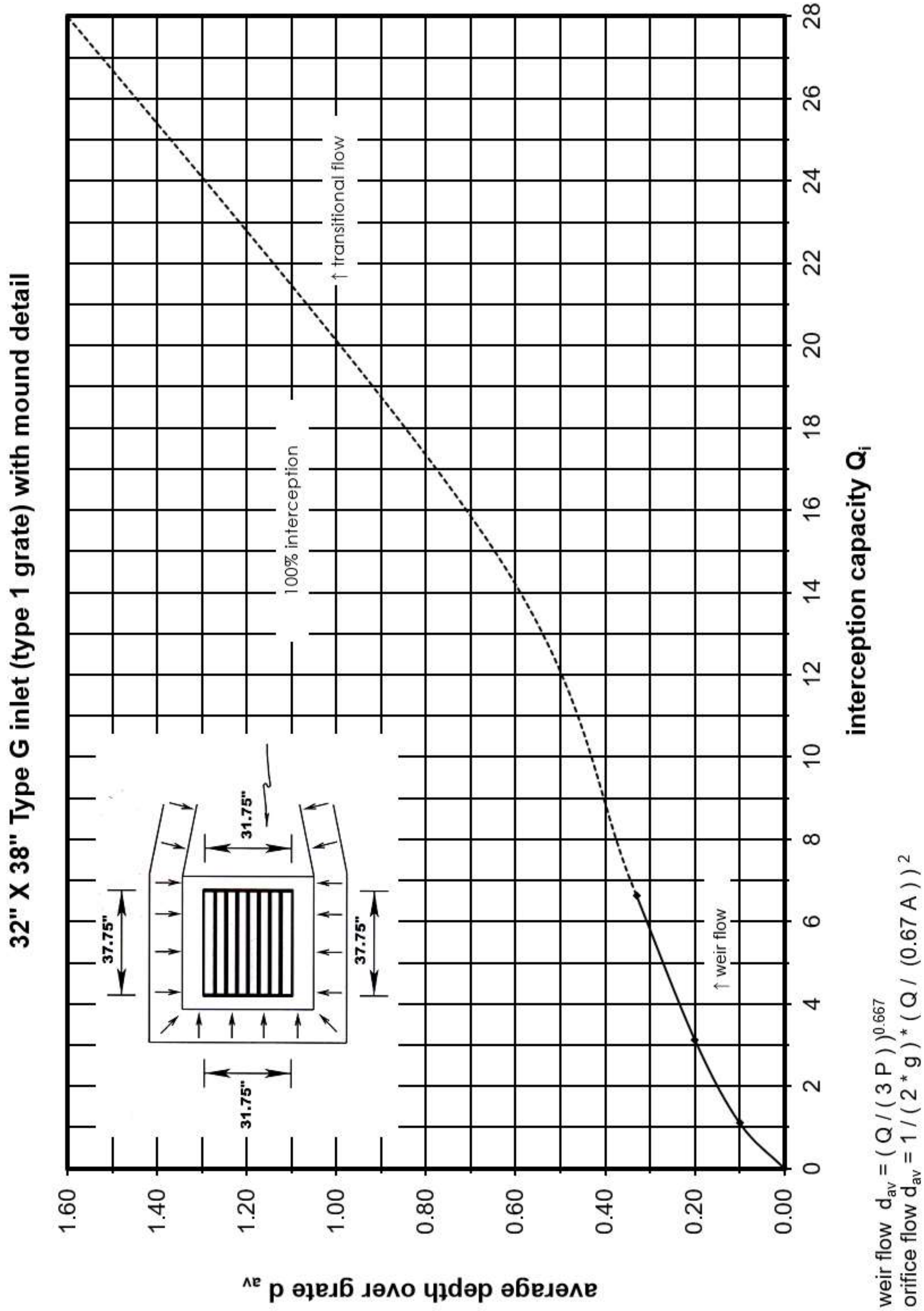


Chart 6-8

36" X 42" Type G grate inlet with mounding detail (Type 1 grate)

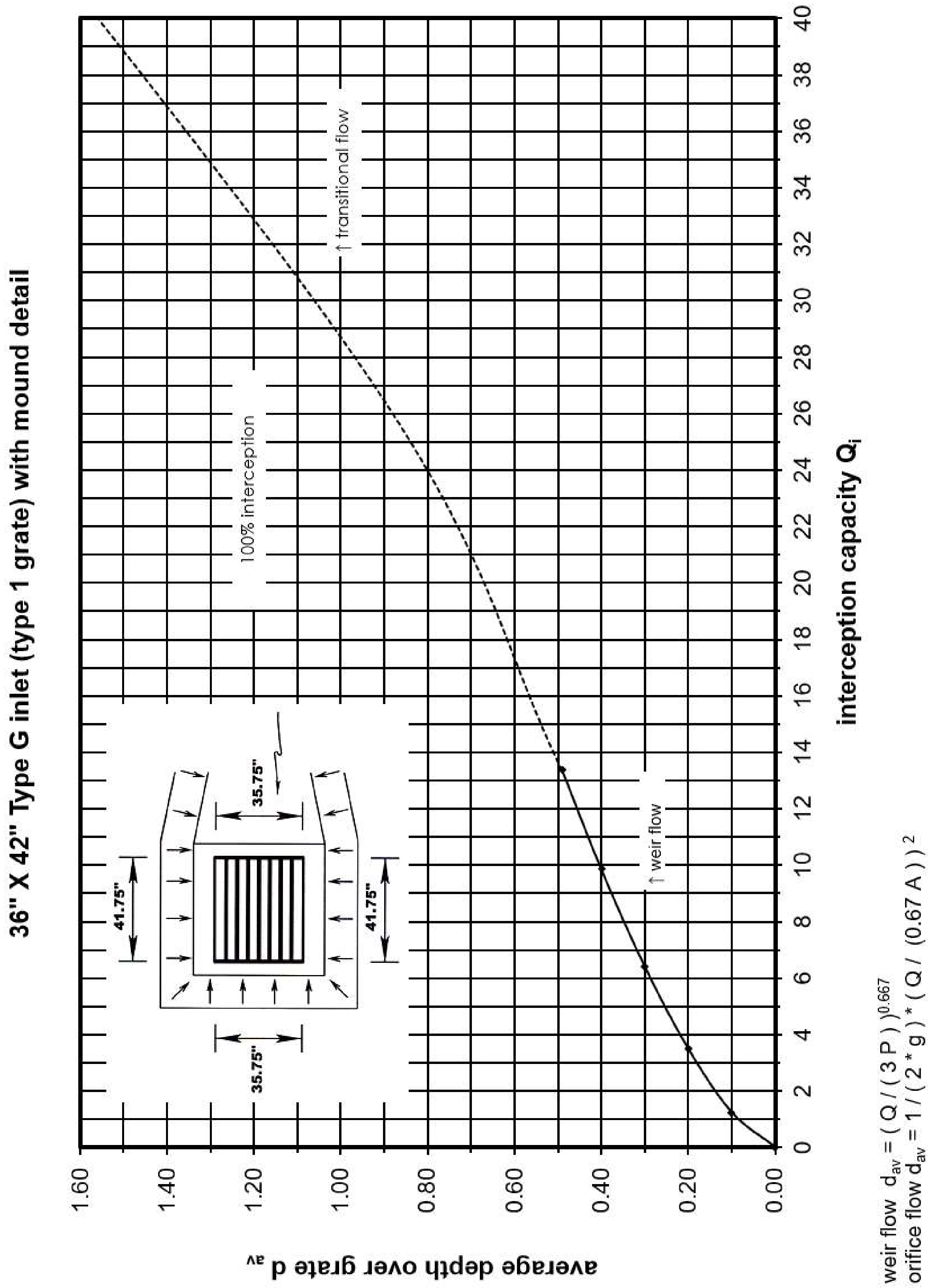


Chart 6-9

42” X 48” Type G grate inlet with mounding detail (Type 1 grate)

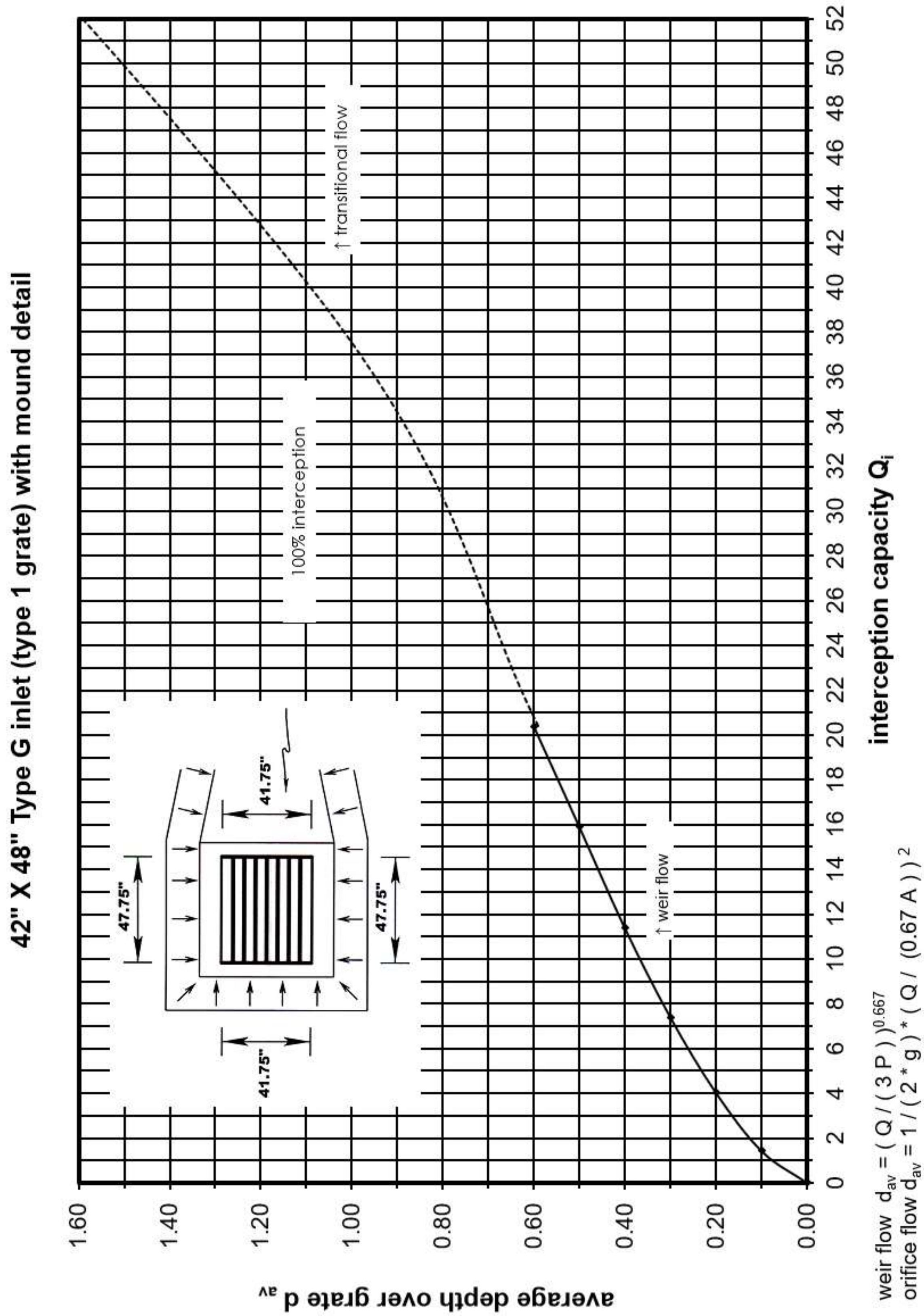


Chart 6-10

45” X 51” Type G grate inlet with mounding detail (Type 1 grate)

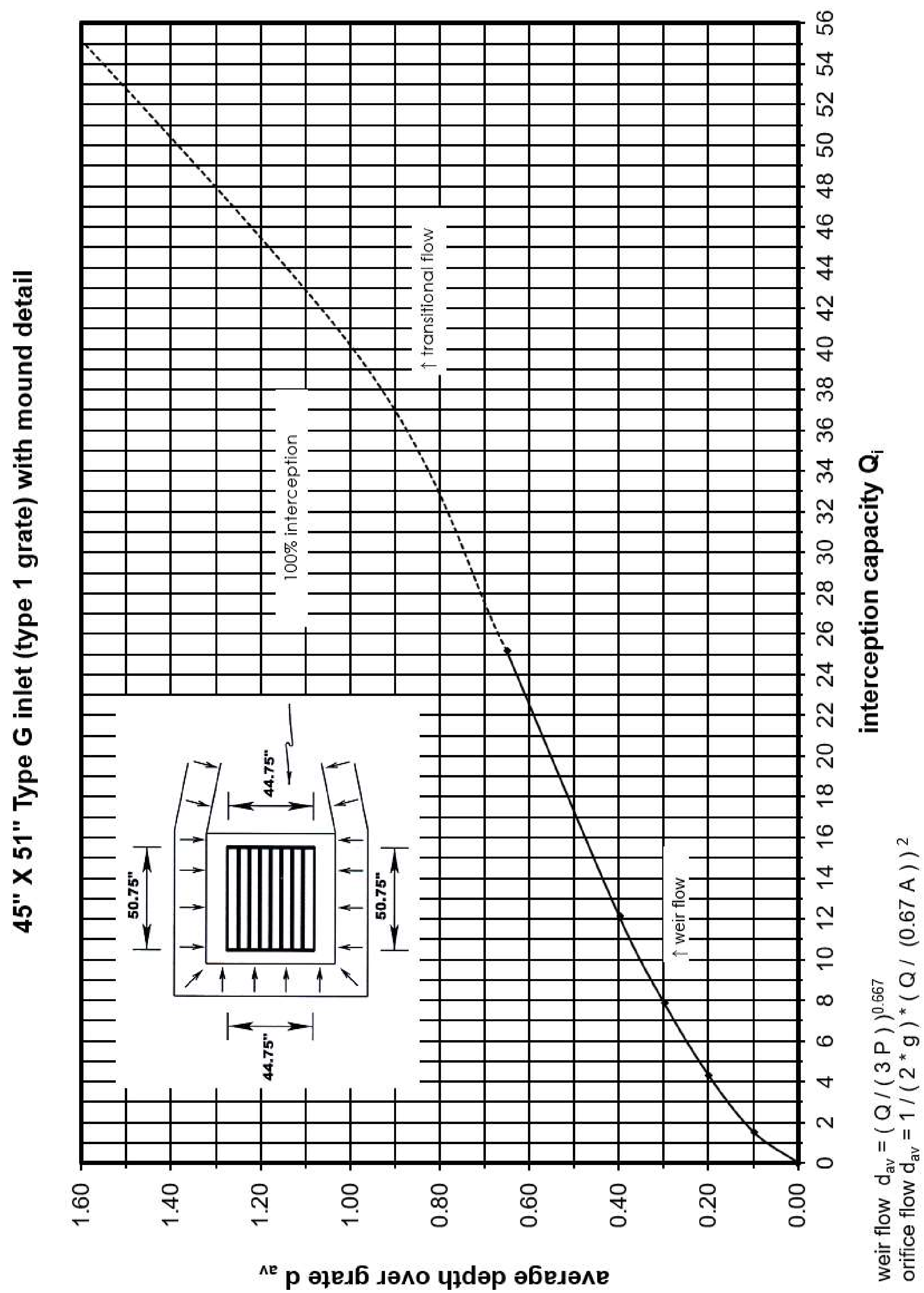


Chart 6-11

48” X 54” Type G grate inlet with mounding detail (Type 1 grate)

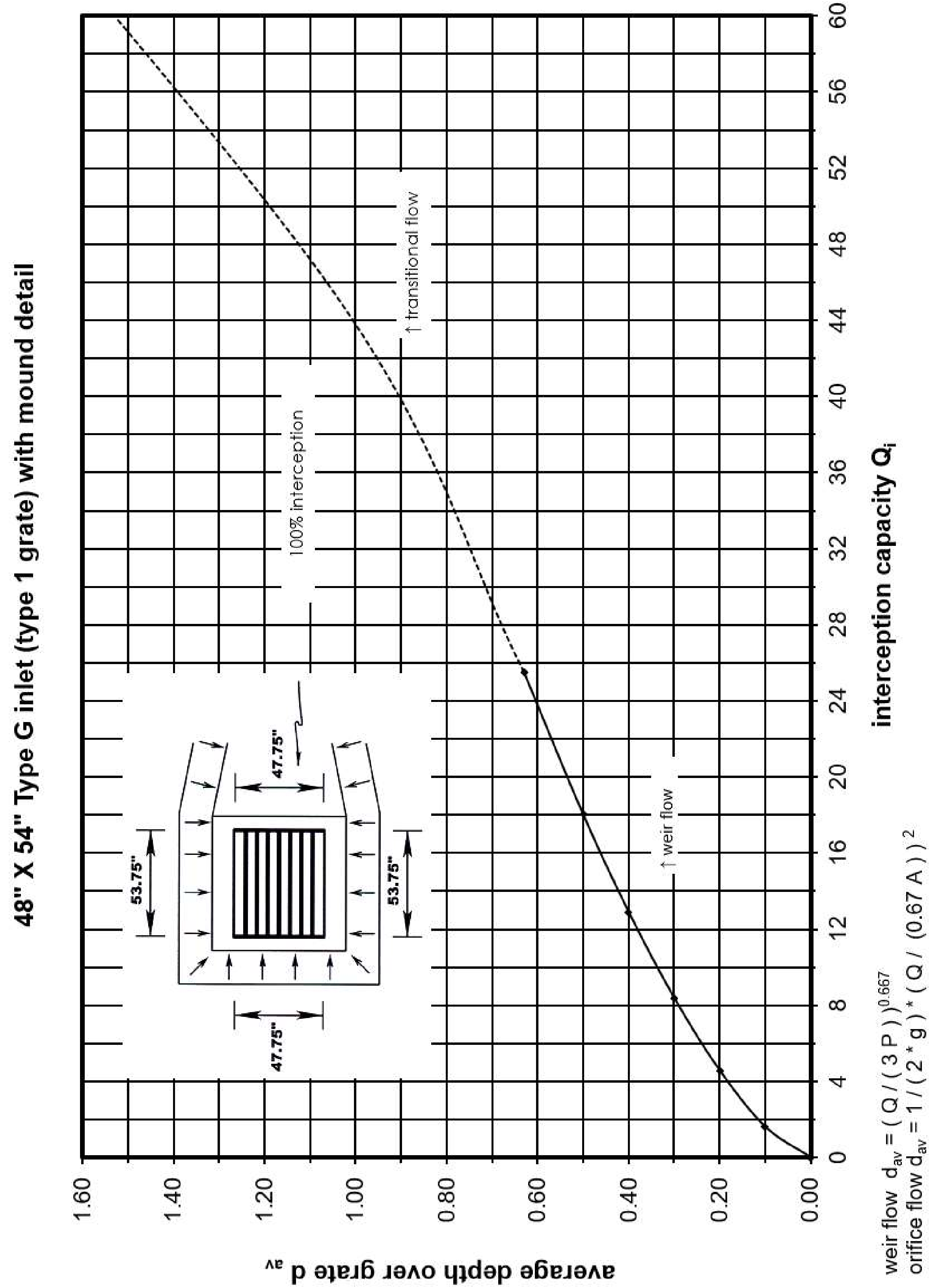


Chart 6-12

54" X 60" Type G grate inlet with mounding detail (Type 1 grate)

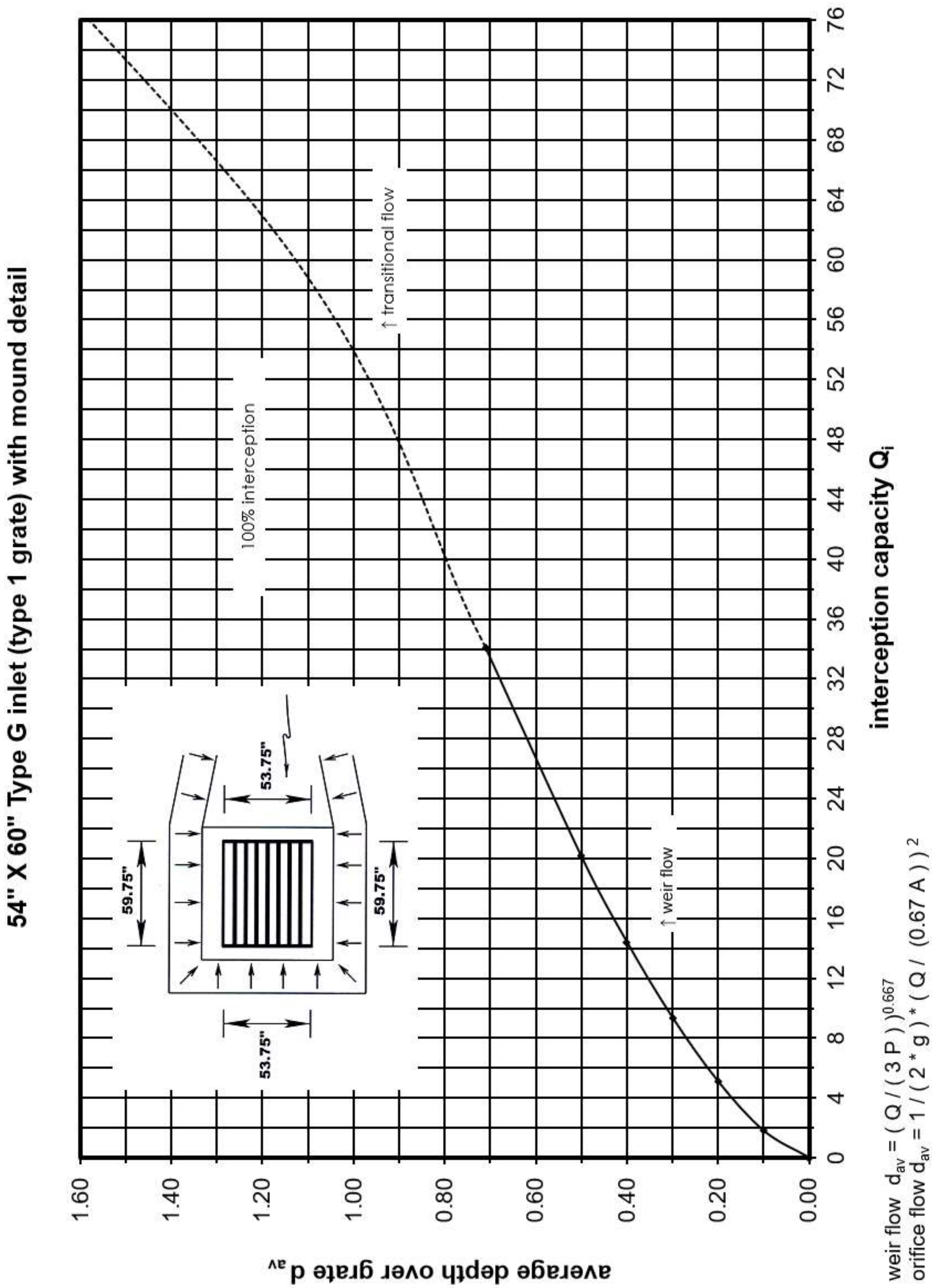


Chart 6-13

60" X 66" Type G grate inlet with mounding detail (Type 1 grate)

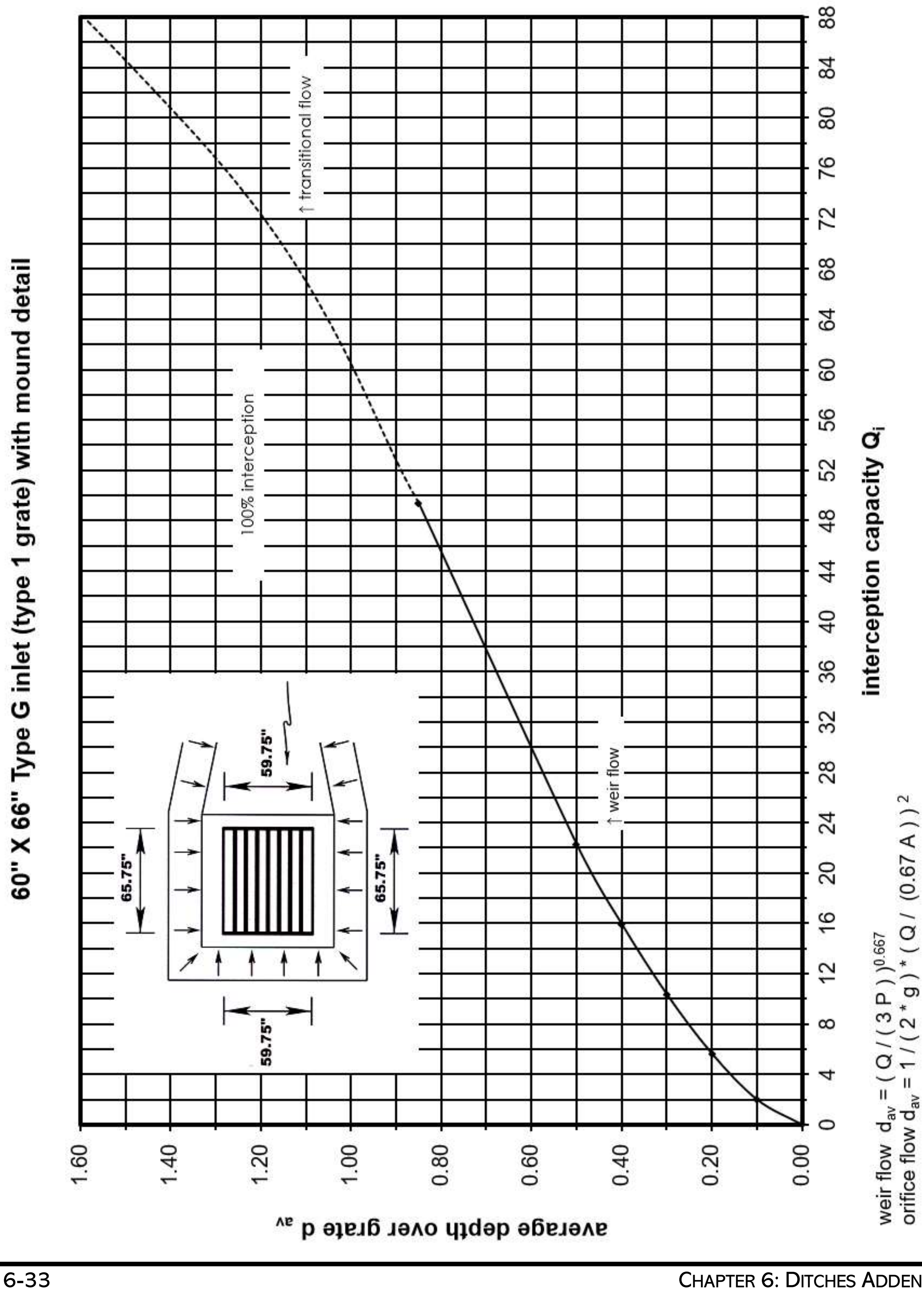


Chart 6-14

32” X 38” Type G grate inlet with mounding detail (Type 2 grate)

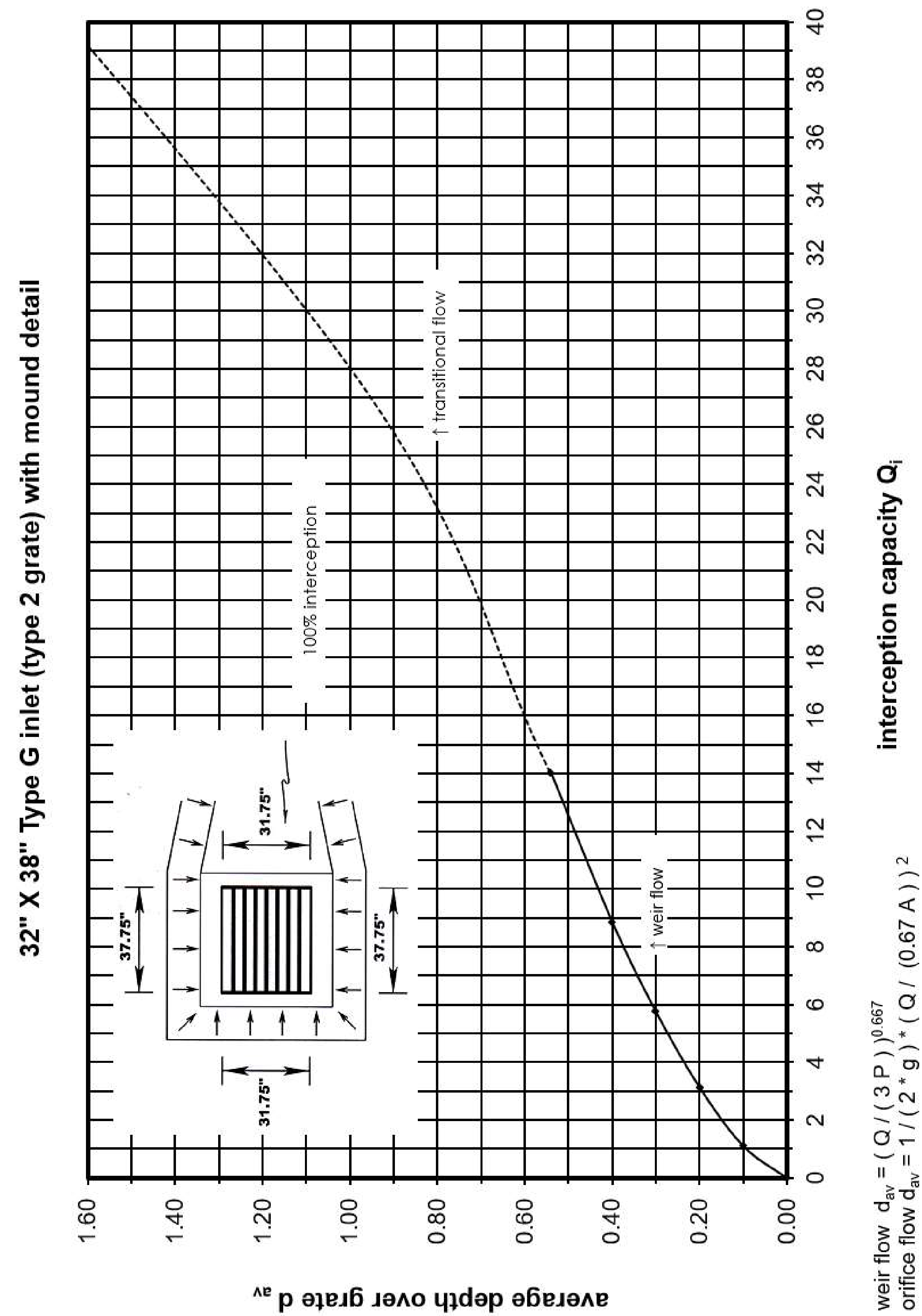


Chart 6-15

36" X 42" Type G grate inlet with mounding detail (Type 2 grate)

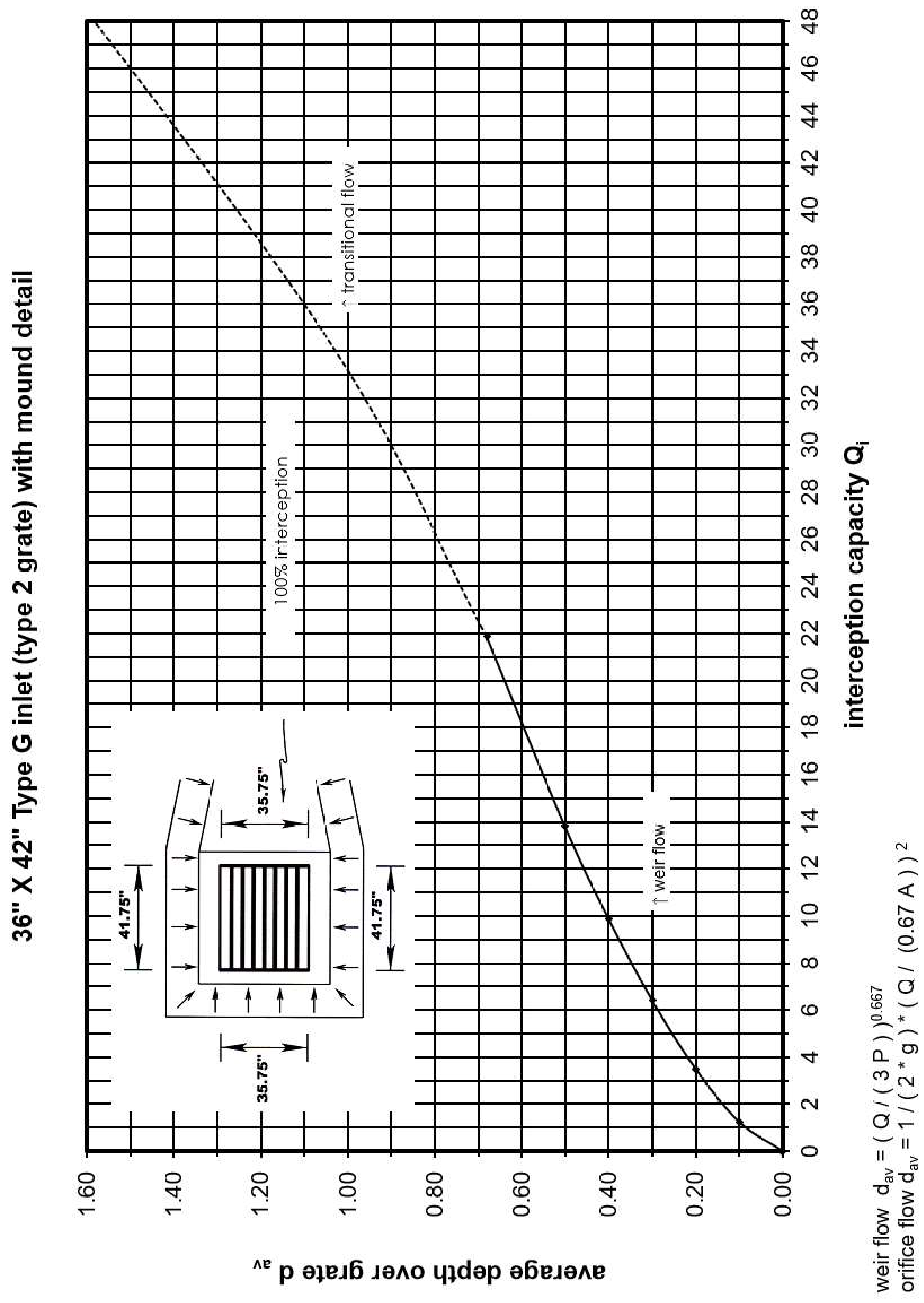


Chart 6-16

42” X 48” Type G grate inlet with mounding detail (Type 2 grate)

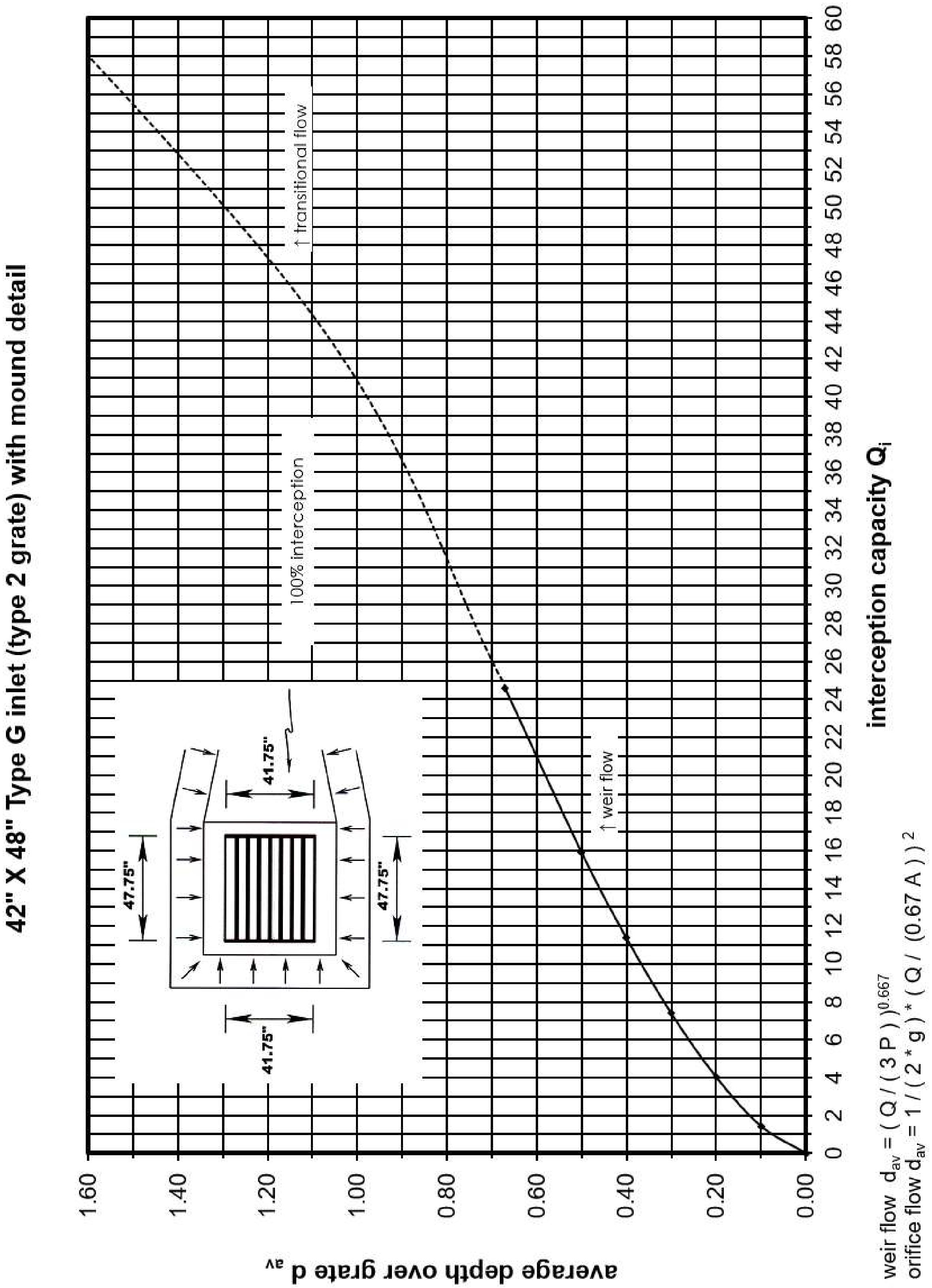


Chart 6-17

45” X 51” Type G grate inlet with mounding detail (Type 2 grate)

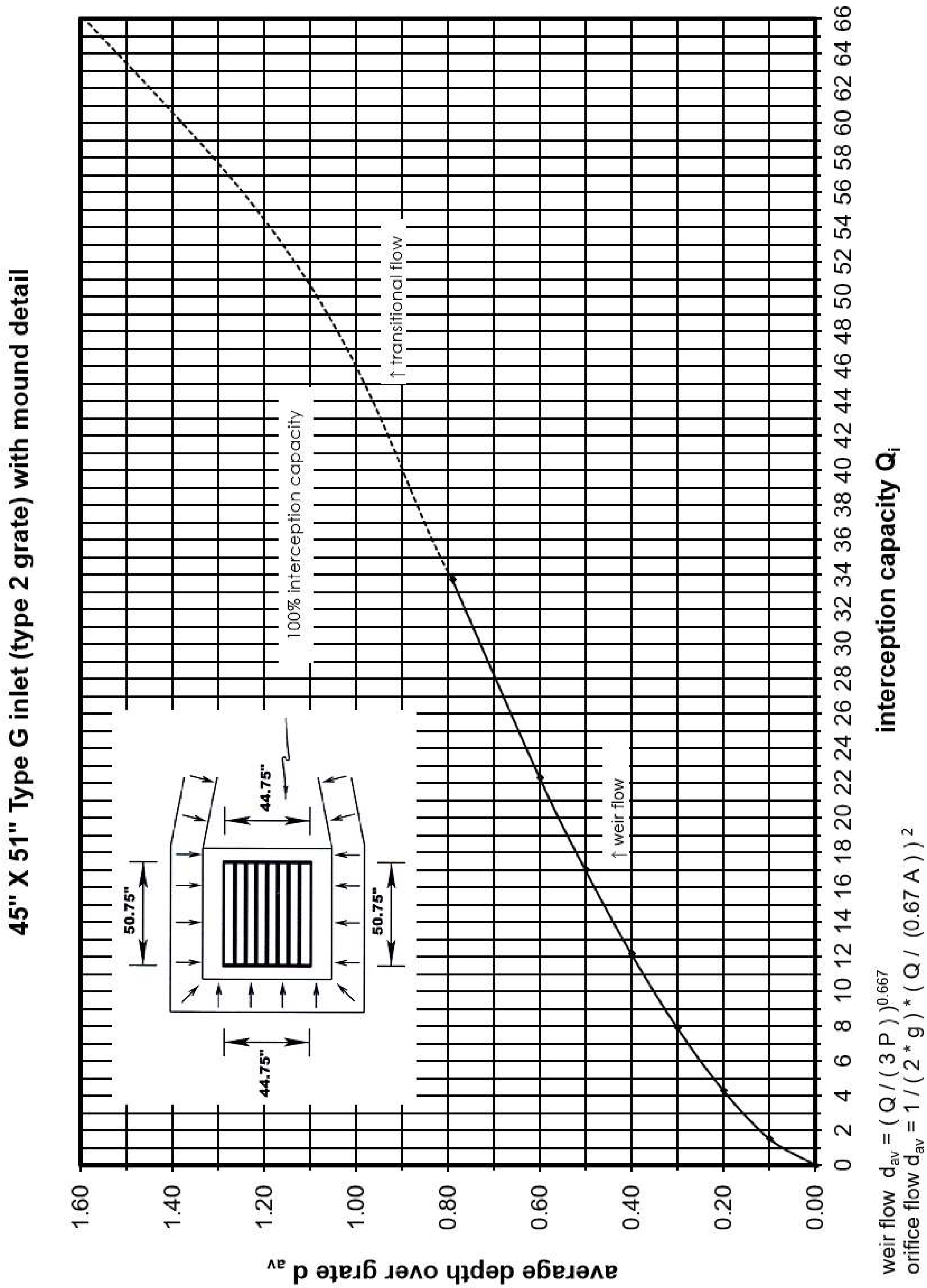


Chart 6-18

48” X 54” Type G grate inlet with mounding detail (Type 2 grate)

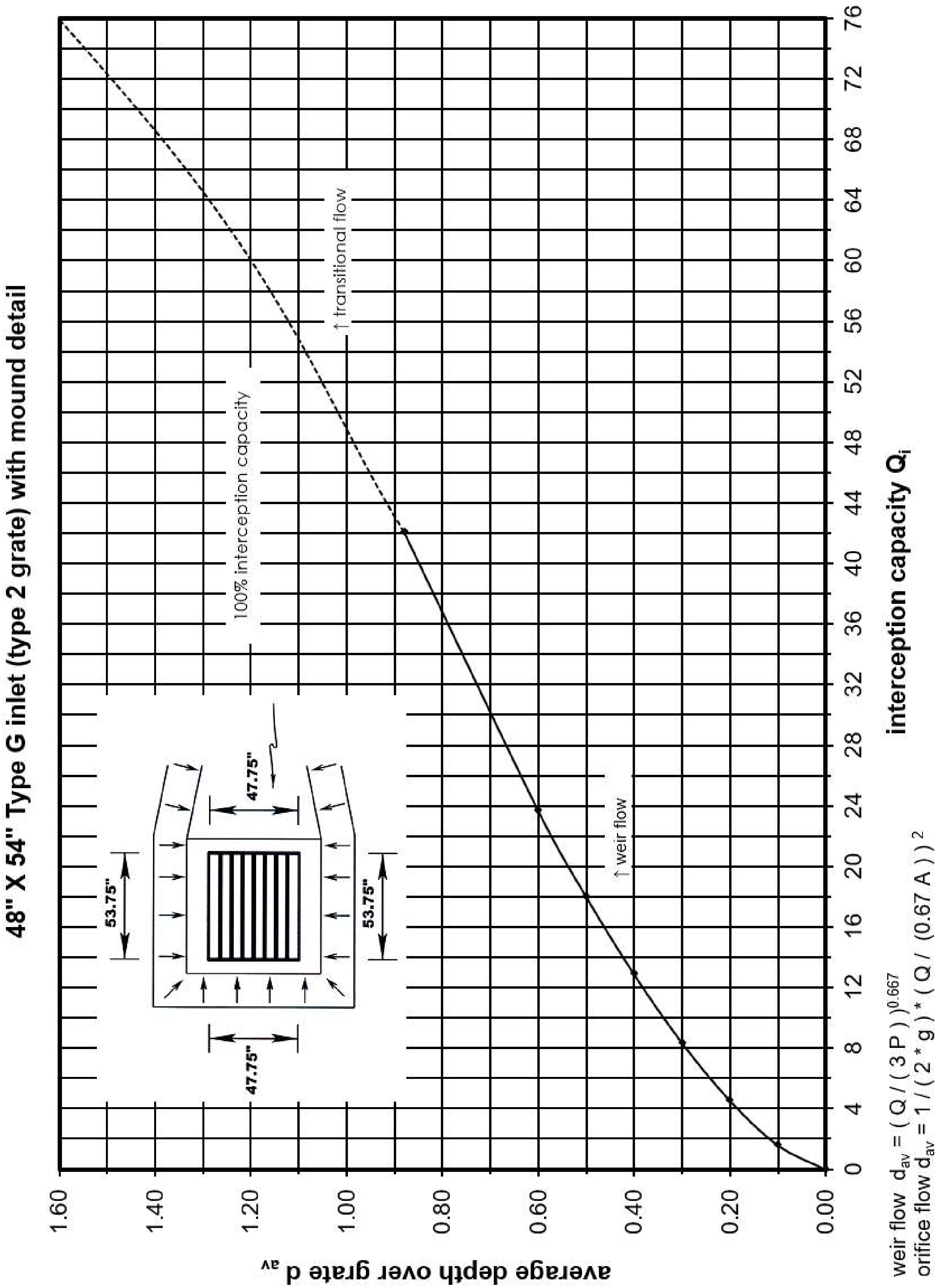


Chart 6-19

54” X 60” Type G grate inlet with mounding detail (Type 2 grate)

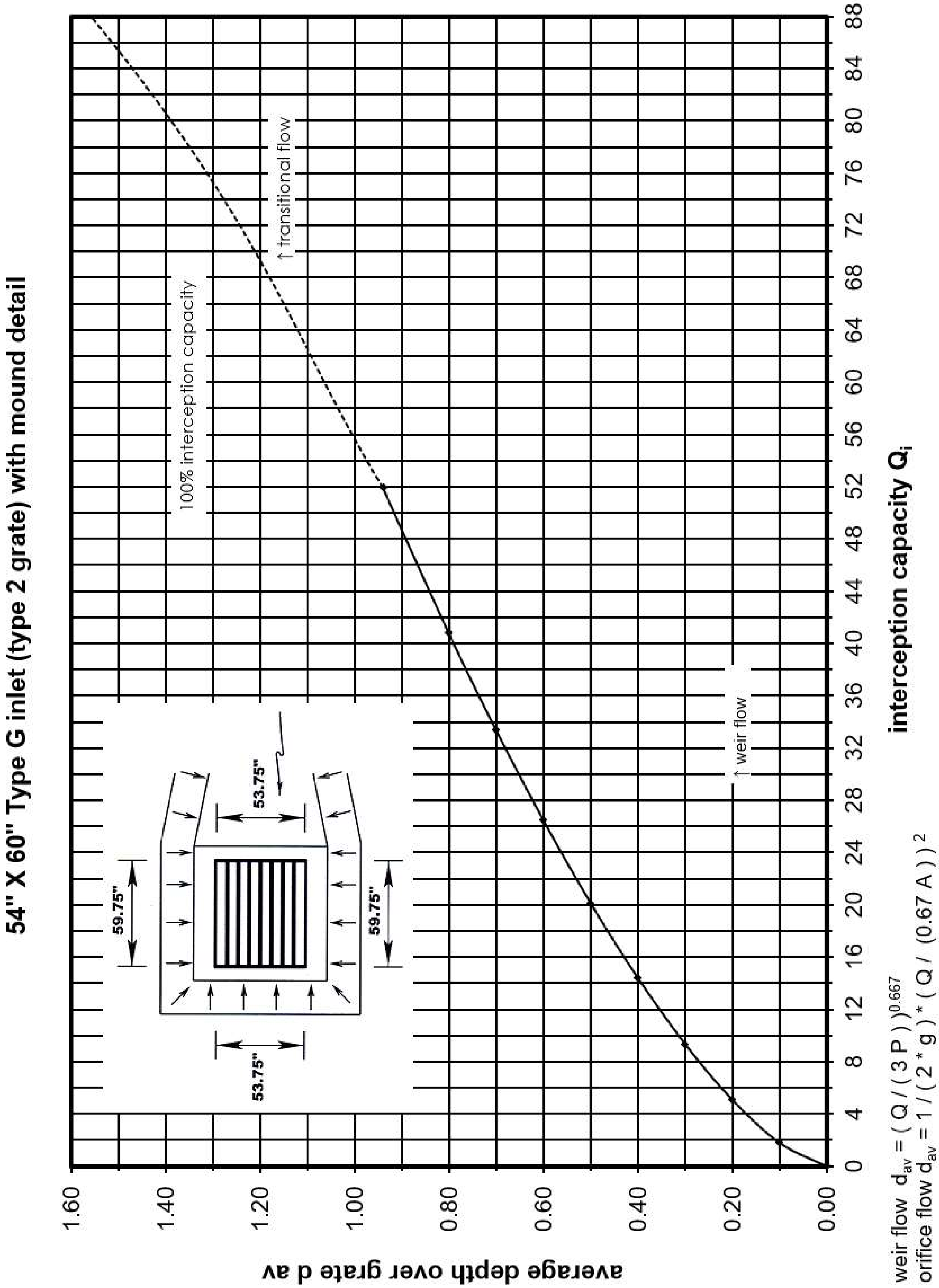
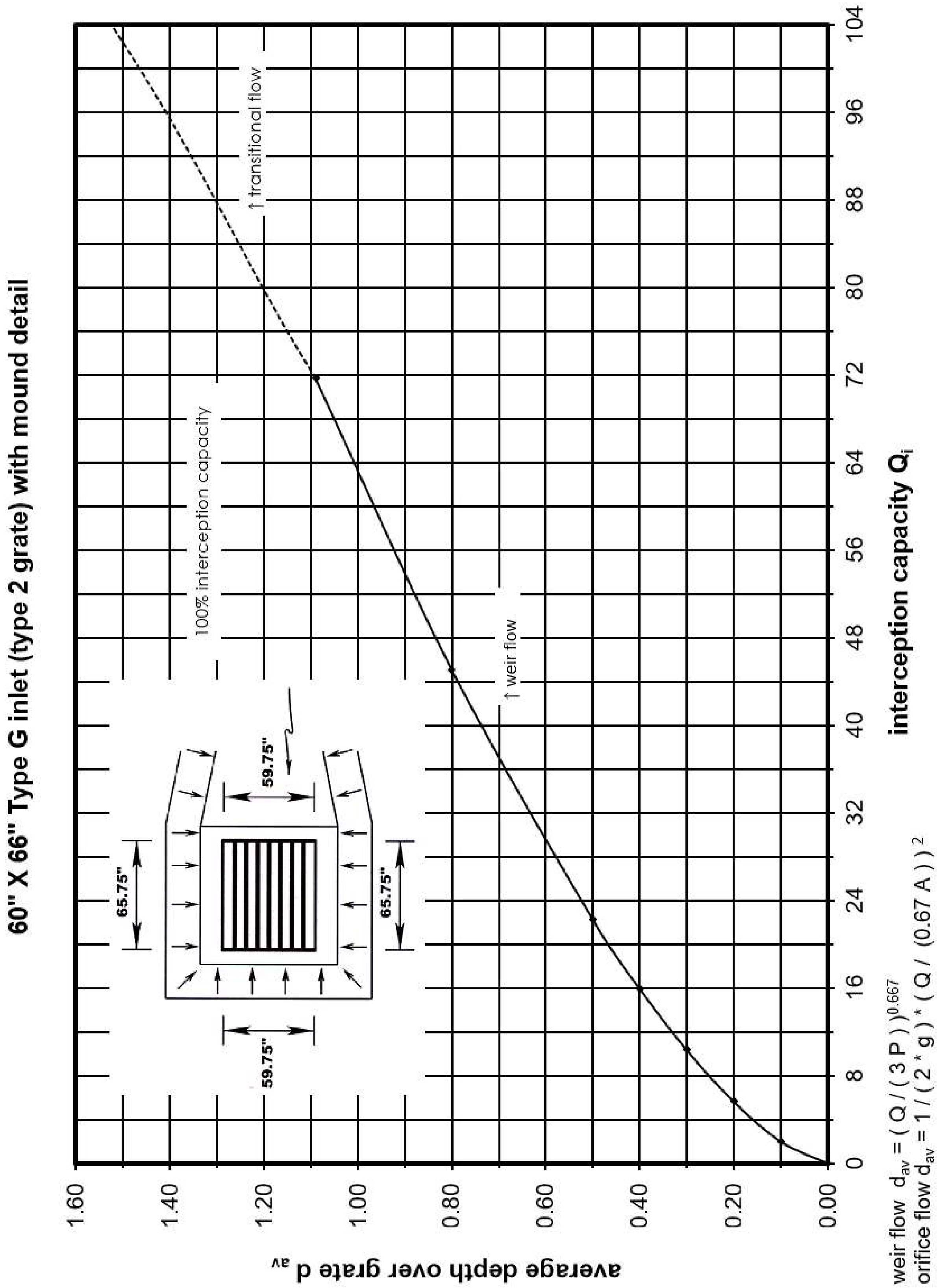


Chart 6-20

60” X 66” Type G grate inlet with mounding detail (Type 2 grate)



6.4.3.1 DITCH INLETS AND STORM SEWER CONSIDERATIONS

Storm sewers connecting ditch inlets shall be subject to the same rules and guidance as stated in Section 5.3.6. Section 5.3.6.1 states that under ordinary conditions storm drains should flow at a depth of 0.8 times the pipe diameter or equivalent at the design discharge. It may not be economically feasible to provide this much capacity when ditch inlets are involved. Pipe size between the inlets may be limited due to available cover or earthwork requirements for installation (such as pipes in ditches along high cut slopes). Limitations such as these may require special circumstances that allow the pipes connecting the inlets to flow above 0.8D at the design storm.

It is important to be mindful when several ditch inlets are connected by conduit (thus creating a storm sewer), and a large offsite drainage area flows to one of the inlets in the system. For example: an offsite flow enters a ditch inlet from an area oriented perpendicular to the roadway. The inlet that accepts the offsite flow is connected to the ditch storm sewer paralleling the roadway and the proceeding inlets continue to accept only roadway and adjacent cut slope area runoff. The storm drain conduit leaving the offsite flow inlet is designed as a culvert. The remaining storm drainpipe to the outlet shall also be designed for a culvert flow as conduit size shall not decrease in the downstream direction. See Section 5.2.6 for additional information.

6.4.4 DRIVEWAY CONDUIT

The cover above the conduit shall be a least at least 6 inches. The cover height is defined from the crown of the conduit to the bottom of the subgrade of the adjacent roadway pavement. The tables in this Section use historical pavement designs. If a culvert analysis is used for the driveway conduit, a reasonable assumption of roadway pavement thickness and with a 6-inch subgrade thickness shall be noted. When plastic conduit is used for a commercial/industrial driveway, a Type F trench shall be required according to the published DOH Standard Details.

Driveways which approach a roadway at a downgrade and cannot provide a sag vertical curve to divert surface rainfall runoff shall use an inlet to intercept the runoff. A slot drain type of inlet along the top of the conduit may be used to intercept rainfall runoff under the following conditions:

- The driveway grade toward the adjacent roadway is less than 9%.
- The driveway is in a suburban area with small yards and only the driveway surface contributes flow to the slot drain.
- The driveway is within a commercial/industrial area, is 16 feet wide or greater, and has an impervious contributing drainage area of 0.04 acre (such as an area of 40 feet by 40 feet or 20 feet by 80 feet) or less.
- The potential for a quantity of natural debris on the driveway surface is low.

Where a slot drain cannot be utilized, a box and grate drain shall be used to intercept rainfall runoff. An 8- 10- or 12-inch-wide Type A grate can be used (the width is the dimension parallel to the flow direction). In areas where bicycle traffic is present, a Type C grate shall be used. A gravel driveway which slopes toward the adjacent roadway shall require a box and grate drain.

A driveway access which meets any of the following conditions is re-classified as a culvert and it shall be hydraulically designed according to the standards of Chapter 8.

- Crosses continuously moving flow (perennial in nature) with a defined bed and bank full depth and an ordinary high-water mark (a vegetation break just above the bottom of the channel).
- A driveway location with a contributing drainage area of 20 acres or greater.
- The size of the driveway conduit exceeds 36 inches in diameter. A maximum size of 42 inches is allowed in the case of a 14 to 20-acre suburban area with a high amount of impervious surface.

Values for the following tables were determined by representative drainage areas for a typical ground cover and slope likely serving a driveway in WV. The range of area runoff flows were determined based on three categories of acreage. The middle value within this range was applied for a 35-foot-long metal pipe at a 2-2.5% slope projecting from the driveway side slope to be conservative. The headwater was then placed against representative pavement thicknesses (infusing the influence of the ADT) from previously designed projects in residential and urban/commercial areas. The resultant ditch depths were rounded to the nearest 0.25 feet.

6.4.4.1 Residential Driveway Conduit

The minimum size of a residential driveway conduit shall be:

- 15 inches for access to a single property with 1 acre or less of contributory drainage area.
- 18 inches for access to a single or multiple properties with more than 1 acre of contributory drainage area.

Apartment complexes consisting of three buildings or less are considered to represent a residential classification.

The approaching and departing ditch depth and top width dimensions should be according to the tables below for the bordering length of the property that is adjacent to the DOH right-of-way (or equal to the conduit length). Table 6-8 provides dimensions according to the predominant land cover of a single property (maximum 1 acre) which contributes rainfall runoff. For a single property that may contribute more than one acre of runoff refer to Table 6-9.

The minimum ditch depth accounts for the headwater created at the inlet end of the driveway conduit for a representative flow from a watershed area with the primary ground cover noted. If the inlet headwater is less than the diameter plus 6 inches, the minimum cover of 6 inches will determine the ditch depth.

Table 6-8

Residential Driveway Ditch Approaching and Departing/Single Property

Area in acres	Primary Ground Cover	Conduit Diameter	Minimum Ditch Depth	2:1 Side Slope Ditch Top Width	1.5:1 Side Slope Ditch Top Width
		inches	feet	feet ft-inch	feet ft-inch
0-1	Forested or Grasses	15	3	13.25' 13'-3"	10.25' 10'-3"
0-1	Impervious Surface	18	3.25	14.5' 14'-6"	11.25' 11'-3"

Table 6-9 provides dimensions according to the predominant land cover of multiple properties (for a maximum of 20 acres) that contribute rainfall runoff to the driveway location. The blank spaces in the table denote values where large depths would be necessary due to high headwater values on smaller pipes. In these instances, larger pipes must be used due to the higher rainfall runoff flow amounts. Notice the ditch top width based on the depth required to guard the adjacent pavement from the 10-year storm reaching the subgrade. Longitudinal width for the placement of the ditch leading to and from the driveway should account for the required ditch top width. Ditch side slopes of 1.5:1 may be necessary but are not provided on the table.

Table 6-9

Residential Driveway Ditch Approaching and Departing/Multiple Properties

Acres	Primary Ground Cover	18" Conduit		24" Conduit		30" Conduit		36" Conduit		42" Conduit	
		Min Ditch Depth	Top Width 2:1 Side Slopes	Min Ditch Depth	Top Width 2:1 Side Slopes	Min Ditch Depth	Top Width 2:1 Side Slopes	Min Ditch Depth	Top Width 2:1 Side Slopes	Min Ditch Depth	Top Width 2:1 Side Slopes
		ft ft-inch	ft	ft ft-inch	ft	ft ft-inch	ft	ft ft-inch	ft	ft ft-inch	ft
1-5	Forested or Grasses	3.5' * 3'-6"	15.5'	4.0' * 4'-0"	18'	4.5' * 4'-6"	20.5'	------	------	------	------
1-5	Suburban with Yards	4.0' ** 4'-0"	17.5'	4.0' * 4'-0"	18'	4.5' * 4'-6"	20.5'	------	------	------	------
1-5	Impervious Surface	------	------	4.75' ** 4'-9"	21'	4.5' * 4'-6"	20.5'	------	------	------	------
5-14	Forested or Grasses	------	------	5.25' ** 5'-3"	23'	4.5' * 4'-6"	20.5'	------	------	------	------
5-14 14-20	Suburban with Yards Forested or Grasses	------	------	------	------	5.25' ** 5'-3"	23.5'	5.0' * 5'-0"	23'	------	------
14-20	Suburban with Yards	------	------	------	------	------	------	6.5' ** 6'-6"	29'	5.5' ** 5'-6"	25.5'

* Depth is based on the conduit diameter plus the minimum cover of 6 inches.

** Depth is based on the headwater at the conduit inlet.

6.4.4.2 COMMERCIAL OR INDUSTRIAL DRIVEWAY CONDUIT

The minimum size of a commercial or industrial driveway conduit shall be 18 inches. The side slopes of the ditch approaching and departing the conduit shall be 2:1 or flatter. The approaching and departing ditch depth and top width dimensions shall be according to Table 6-10 for the bordering length of the property adjacent to the DOH right-of-way.

Apartment complexes consisting of more than three buildings are considered to represent a commercial or industrial classification.

If an increase in rainfall runoff occurs due to the development of the property requesting/using access, the flow increase shall be the responsibility of the developer. Post development flow which approaches DOH right-of-way shall be equal to or less than the predevelopment flow. This criterion includes flow that is initially directed away from the right of way but will affect DOH right-of-way within a short distance downstream. The increase in runoff should be detained by in-line, above ground, or below ground detention via a stormwater management system outside of DOH right-of-way.

Flow from the property requesting/using access shall not be discharged into a DOH drainage system via a closed connection. A closed connection shall be classified as a subsurface or piped connection to a DOH conduit, culvert, storm sewer pipe or system, manhole, or drop inlet. Municipal Separate Storm Sewer Systems (MS4) policy implies that the discharger is defined by the ownership of an outlet location. The DOH could be viewed as the discharger of a flow source originating outside of right-of-way, thus responsible for any pollutants within the flow from an adjacent property.

Table 6-10 provides dimensions according to the predominant land cover (for a maximum of 20 acres) that contribute rainfall runoff to the driveway location.

Table 6-10

Commercial or Industrial Driveway Ditch Approaching and Departing

Acres	Primary Ground Cover	18" Conduit		24" Conduit		30" Conduit		36" Conduit		42" Conduit	
		Min Ditch Depth	Top Width 2:1 Side Slopes	Min Ditch Depth	Top Width 2:1 Side Slopes	Min Ditch Depth	Top Width 2:1 Side Slopes	Min Ditch Depth	Top Width 2:1 Side Slopes	Min Ditch Depth	Top Width 2:1 Side Slopes
		ft ft-inch	ft	ft ft-inch	ft	ft ft-inch	ft	ft ft-inch	ft	ft ft-inch	ft
1-5	Forested or Grasses	4.0' * 4'-0"	17.5'	4.25' * 4'-3"	19'	4.75' * 4'-9"	21.5'	------	------	------	------
1-5	Suburban with Yards	3.75' * 3'-9"	16.5'	4.25' * 4'-3"	19'	4.75' * 4'-9"	21.5'	------	------	------	------
1-5	Impervious Surface	4.5' ** 4'-6"	19.5'	4.25' * 4'-3"	19'	4.75' * 4'-9"	21.5'	------	------	------	------
5-14	Forested or Grasses	------	------	5.0' * 5'-0"	22'	4.75' ** 4'-9"	21.5'	------	------	------	------
5-14	Suburban with Yards	------	------	------	------	4.75' ** 4'-9"	21.5'	5.25' * 5'-3"	24'	------	------
14-20	Forested or Grasses	------	------	------	------	5.5' ** 5'-6"	24.5'	5.25' * 5'-3"	24'	------	------
14-20	Suburban with Yards	------	------	------	------	------	------	6.25' ** 6'-3"	28'	5.75' * 5'-9"	26.5'

* Depth is based on the conduit diameter plus the minimum cover of 6 inches.

** Depth is based on the headwater at the conduit inlet.

6.5 DESIGN APPROACH

Each project is unique, but the following six basic design steps are normally applicable:

Step 1: Establish the roadside plan.

- Collect available site data including possible offsite flows and underlying soil and rock materials.
- Obtain or prepare existing and proposed plan-profile layout.
- Determine the roadside and median ditch outlets.
- Draw the drainage divides for each outlet location.
- Layout the proposed ditches and analysis intervals.

Step 2: Select initial ditch cross-section.

- Select initial ditch depth, side slopes, and bottom width.
- Identify constraints that may restrict cross-section design such as clear zone requirements, right-of-way limits, utilities, existing drainage facilities, and environmentally sensitive areas.

Step 3: Select initial longitudinal gradient.

- Plot initial grade on plan-profile layout.
- Consider influence of type of lining on grade.

Step 4: Check flow capacity and adjust ditch size, as necessary.

- Compute 10-year design discharge at the downstream end of the ditch analysis interval.
- Select roughness coefficient and the maximum allowable depth criteria.
- Compute flow depth using Manning's equation to check ditch capacity.
- If ditch capacity is inadequate, possible adjustments include increasing bottom width, using flatter side slopes, increasing longitudinal gradient, providing smoother lining, installing drop inlets and parallel storm drain pipe to supplement ditch capacity.
- Provide smooth transitions at changes in ditch cross-sections.

Step 5: Determine channel protection lining needed.

- Select a lining and determine the permissible shear stress.
- Calculate the maximum shear stress in the ditch and check if the lining is adequate. If the maximum shear stress in the ditch is more than the permissible shear stress of the lining, consider the following options: use more resistant lining, such as concrete or rock,

decrease longitudinal slope, use drop structures, increase channel width, or decrease channel side slopes.

Step 6: Analyze outlet points and downstream effects.

- Identify adverse impacts such as increased erosion or flooding to downstream properties that may result from discharge at the ditch outlet. Possible adverse impacts could include increase in discharge, increase in velocity, concentration of sheet flow, change in outlet water quality, and diversion of flow from the watershed.
- Mitigate adverse impacts as required. Mitigation activities could include the following possibilities: enlarging the receiving channel to accommodate increased flows, installing storm water detention structures, installing energy dissipaters to control high velocities, providing erosion protection for the downstream receiving channel, and installing sedimentation or infiltration basins.

The use of Form 6-1 is recommended for recording the design calculations. This form does not cover ditch protection calculations for bends and steep longitudinal gradients.

Form 6-1

Ditch Hydraulic Design Form

DRAINAGE COMPUTATION FORM 6-1
DITCH HYDRAULIC DESIGN

PROJECT NAME ______________________
PROJECT NUMBER ______________________

DESIGNER_______ DATE______
REVIEWER_______ DATE______

SHEET_____ OF _____

LOCATION		DITCH FLOW (AT THE END STATION)									DITCH PROPERTIES							DITCH FLOW PROPERTIES					MIN. FLOW VEL. (0.5 ft/s)	
				CA		TIME OF CONCENTRATION																		
BEGIN STATION	END STATION	DRAINAGE AREA	RUNNOFF COEFICIENT	INCREMENT	ACCUMULATED	INCREMENT	ACCUMULATED	RECURRENCE INTERVAL*	RAINFALL INTENSITY	RUNOFF = C I A	LONGITUDINAL DITCH SLOPE	BOTTOM WIDTH	FORESLOPE	BACKSLOPE	SOIL TYPE	DITCH LINING	ROUGHNESS COEFFICIENT MANNING'S n	DEPTH	MAXIMUM ALLOWABLE DEPTH	VELOCITY	SHEAR STRESS	MAXIMUM PERMISSIBLE SHEAR STRESS	1/3 DESIGN FLOW DEPTH	DITCH FLOW VELOCITY
		A	C	ΔCA	ΣCA	Δt_c	Σt_c	2-yr. or	i	Q	S						n	d		V	τ		1/3 d	$V_{1/3}$
		acres		acres	acres	min	min	10-yr.	in / hr	cfs	ft / ft	feet						feet	feet	ft / s	psf	psf	feet	ft / s
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25

*Ditches shall be designed for a 10-year (10%) storm. If permanent matting is used, then the 2-year (50%) storm shall also be analyzed for the non-vegetated state.

6.6 REFERENCES

(1) Design of Roadside Channels with Flexible Linings, Hydraulic Engineering Circular-15 (HEC-15), Federal Highway Administration, September 2005

(2) Design of Riprap Revetment, Hydraulic Engineering Circular-11 (HEC-11), Federal Highway Administration, March 1989

(3) Erosion Control Technology Council, Internet Website: https://www.ectc.org/recps

(4) Hydraulic Design of Flood Control Channels, EM 1110-2-1601, Engineer Manual, U.S. Army Corps of Engineers, July 1, 1991

(5) AASHTO Drainage Manual, American Association of State Highway Transportation Officials (AASHTO), 2014