

VIRGINIA DEPARTMENT OF TRANSPORTATION

LOCATION AND DESIGN DIVISION

DRAINAGE DESIGN MEMORANDUM

GENERAL SUBJECT: DRAINAGE INSTRUCTIONS	NUMBER: DDM 1.2 [*]
SPECIFIC SUBJECT: CULVERTS, STORM SEWERS AND MISC. DRAINAGE ITEMS	DATE: July 31, 2009
	SUPERSEDES: DDM1, IIM-LD-01 (D) 223, HDA-01-02, HDA-03-02, HDA-04-01, Road Design Manual Section 2E-2
ADMINISTRATOR APPROVAL: <i>Stephen D. Kindy, P.E.</i> State Hydraulics Engineer	

TYPE OF STRUCTURE SELECTION – Culverts

- Because of the numerous types of drainage structures that are available, a general rule would dictate that various types such as box culverts, pipe culverts, standard bridges, etc., be taken into consideration when determining the type of proposed structure.
- This design evaluation should consider cost comparisons, construction time, earth movement, maintenance, and service life expectancy.
- Design Considerations:
 - All metal culverts:
 - are comparatively flexible
 - rely on uniform soil pressure around the entire circumference of the structure to maintain proper and equal load distributions
 - are more sensitive to improper bedding and backfill than rigid structures
 - Structural plate pipe arch culverts:

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- concentrate considerable pressure in the haunch area.
 - require near perfect backfill and compaction in haunch area during construction.
 - should be avoided wherever alternate structural shapes are feasible, such as:
 - 1.) aluminum or steel box culverts
 - 2.) bottomless arch culverts on footings
 - 3.) circular culverts buried below streambed
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CULVERT END TREATMENT

- End Treatments will be provided, regardless of the highway classification, on:
 - all culverts conveying a live stream
 - all circular culverts with a diameter of 48 inch or greater
 - all culverts of an arch or elliptical shape with a hydraulic opening of 12 sq. ft. or greater.
 - all multiple line structures with a combined hydraulic opening of 12 sq. ft. or greater.
- Types of End Treatments:
 - Standard endwall
 - Modified endwall or special design endwall
 - Special Design Concrete Slab End Treatment, Special Design Drawing No. isd-2045 and msd-2045
 - Other types of end treatment with a foundation of sufficient width and depth to protect the culvert bedding material from seepage.

PIPE IN HIGH FILLS

- Concrete pipe with a height of cover exceeding 30 feet requires Special Design Pipe, certified in accordance with Section 105 of VDOT's Road and Bridge Specifications and Method A Bedding in accordance with Standard PB-1.
- The drainage description for these pipes should specify:

*Special Design Concrete Pipe, Method A Bedding
Pipe design to be in accordance with Section 105 of VDOT's Road and Bridge Specifications.*

SKEWED BOX CULVERT DETAILS

- Where box culverts are to be constructed on a skew, the Drainage Designer is to request, from the Structure and Bridge Division, the required details for modification of the standard drawings. This information is to be requested on Form LD-423. Box Culvert skews should be shown to the nearest five (5) degree increment.
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EXISTING BOX CULVERT EXTENSIONS

- When the extension of an existing box culvert is required, the Drainage Designer shall specify Standard BCE-01 as a part of the box culvert description on the plans.
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SMALL BOX CULVERTS

- Box culverts with heights and widths less than 4 feet should be avoided due to concerns with inspection and maintenance. If a box culvert with a height or width less than 4 feet is needed (e.g., for extension of an existing structure), the District Drainage Engineer should be consulted to determine if other alternate hydraulic structures are available.
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PILE FOUNDATION DESIGN FOR BOX CULVERTS

- When the Materials Division recommends pile foundations for box culverts, details are to be requested, by the Road Designer, from the Structure and Bridge Division on Form LD-422.

JACKING PIPE

- There are certain cases where it is not feasible to install pipe through the existing embankment by the usual open trench method. The alternative is to jack the pipe through the embankment. The Drainage Designer is to specify the pipe as “Jacked Pipe” on the plans. The contractor then has the option of tunneling or boring the pipe in accordance with Section 302.03 of VDOT’s Road and Bridge Specifications. Foundation information shall be requested for any size pipe that is to be jacked or bored in order to determine the feasibility of this installation method.
- Concrete pipe is normally employed in a jacking operation. In some cases, it is preferred to jack a Smooth Wall Steel Pipe (See Sec. 232 of VDOT’S Road and Bridge Specifications) through the embankment as the encasement structure. A concrete (or occasionally metal) pipe is then threaded inside of the steel pipe to act as the carrier for the stormwater. The void between the two pipes is to be pressure grouted in accordance with Section 302.03 of the VDOT Road and Bridge Specifications.
- On some specific occasions, it has been deemed appropriate to install only the Smooth Wall Steel Pipe and to let it serve as the drainage pipe. THIS IS NOT TO BE CONSIDERED A UNIVERSALLY ACCEPTABLE PRACTICE.
- The use of Smooth Wall Steel Pipe as the drainage pipe must conform to Notes 1, 2 and 4 for Table A of “Allowable Types of Pipe” as shown in St’d. PC-1. Any deviation from this policy must be approved by the State Location and Design Engineer and the District Materials Engineer.

FISH PASSAGE

- In areas of known fish habit, highway culverts are to be designed to accommodate the passage of fish. The design criteria for such culverts can be found in the following publications.
 - An Analysis of the Impediments to Spawning Migrations of Anadromous Fish in Virginia Culverts (Pages 61 through 66)
August 1985 by Mudre, Ney & Neves
 - Nonanadromous Fish Passage in Highway Culverts
Report No. VTRC 96-R6 October 1995 by Fitch
- Summary of General Design Criteria:
 - Criteria apply to normal water (ordinary high water) conditions.

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- Set invert elevations of the low flow culvert 6 inches minimum below the streambed.
 - Maintain a depth, width and velocity of flow in the culvert that matches the depth, width and velocity of flow in the natural channel adjacent to the culvert.
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NON-STANDARD ROADSIDE DITCHES

- Safety, appearance, and economy necessitate that non-standard roadside ditches not be used or their use be minimized to the greatest extent reasonable for all highway projects.
 - Where the volume, flow, or other considerations dictate enlarging or deepening the roadside ditch or otherwise deviating from the standard designs, careful consideration must be given to the following:
 - Using an enclosed drainage system, where economically feasible, in order to eliminate the need for the non-standard roadside ditch or channel.
 - Minimizing the size and depth of the proposed non-standard roadside ditch or channel.
 - Flattening the front slope (the slope adjacent to the highway shoulder) of the non-standard roadside ditch or channel. Where right of way is available, or can reasonably be obtained, the front slope of the non-standard roadside ditch or channel should be no steeper than the front slope of the standard roadside ditch for the specific roadway classification involved.
 - Locating necessary non-standard roadside ditches or channels as far from the proposed highway shoulder as the existing or proposed right of way will reasonably allow.
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BERM/TOE DITCH LOCATIONS

- Except where severe right-of-way limitations exist, a minimum of 5 feet is to be provided between the end of the cut slope round-off and the front slope of a berm ditch. Additional right-of-way is to be obtained for construction and maintenance of the berm ditch.
- Except where severe right of way limitations exist, a minimum of 5 feet is to be provided between the toe of the fill slope and the front slope of the ditch. Additional right of way is to be obtained for construction and maintenance of the ditch.

CONCRETE PIPE ON RADIUS

- Concrete Pipe may be laid on a radius when necessary to conform to design features, alignment, or topography and to eliminate or minimize the need for manholes or other structures.
- Installation of concrete pipe on a radius may be done by one of the following methods:
 - Open Joint Method - relatively long radius - using standard pipe and open joints a maximum of 25% of the spigot length.
 - Bevel Method - mid range radius - using modified pipe with one side shorter than the other.
 - Bevel and Open Joint Method - for shortest radius - a combination of the two methods above.
- Bevel pipe is expensive to manufacture and somewhat difficult to install. It is generally more economical to use bend joints in cases where three or more joints of bevel pipe would be required.
- The minimum radius obtainable is dependent upon two factors that differ between manufacturers:
 - Spigot or tongue length
 - Pipe joint length

The following table is a guideline for the minimum radius that should be obtainable using pipe from any manufacturer. A longer radius may be used as needed with the plan description denoting the method of obtaining the required radius. Certain manufactures may produce standard pipe joint lengths shorter than 8 feet. If so, a radius shorter than that shown in the table may be obtainable.

GUIDELINES FOR MINIMUM RADII – CONCRETE PIPE			
Pipe Diameter	MINIMUM RADIUS BASED ON 8 foot PIPE JOINT LENGTH		
	Open Joint*	Full Bevel	Full Bevel Plus Open Joint *
Inch	Feet	Feet	Feet
12	240	95	70
15	280	125	90
18	295	125	90
21	340	125	90
24	350	120	90
27	390	120	90
30	395	120	90
33	400	120	90
36	405	120	90
42	410	120	90
48	530	120	95
54	505	120	100
60	500	120	100
66	515	120	100
72	560	120	100
78	570	120	100
84	650	120	100
90	655	120	100
96	730	120	100
108	615	120	100

* Maximum of 25% of spigot length

PIPE ON STEEP SLOPES

- Concrete Pipe
 - The gradient of concrete pipe should be limited to no more than 16%. If a grade of greater than 16% is required, the design should incorporate a “step down” manhole system (See in this DDM “Step Down Manhole” section) or anchor blocks. When anchor blocks are used, they should be installed at every other pipe joint, as a minimum.
 - See Special Design Drawing No. A-73 and MA-73 for Anchor Details for Concrete Pipe.

- Corrugated pipe
 - Corrugated pipe may be used on steep slopes in situations similar to those where shoulder slot inlets are proposed. Corrugated pipe should not be used in areas where the flow is expected to carry an abrasive bed load or that have PH and resistivity factors beyond the ranges specified in Standard PC-1 of the VDOT Road and Bridge Standards.
 - See VDOT's Road and Bridge Standard PI-1, Sheet 104.37 for Anchor Details for Corrugated Pipe.
- Step Down Manholes – In situations where the pipe grade needs to be more than 16%, structures at the upper end of the pipe system may be made deeper to help reduce the gradient. Additional “step down” manholes may also be added to the system to reduce the gradient. Where “step down” manholes are used, the Drainage Designer should provide any needed protection to prevent deterioration of the bottom of the manhole. This protection can be provided by the addition of a ½ inch steel plate in the bottom of the manhole. This protection should be considered for use if the vertical difference between the inverts of the inlet pipe and outlet pipe is 4 feet and **any** one of the following factors are present or anticipated:
 - The flow is expected to carry any abrasive material.
 - Continuous live flow or live flow lasting several days may be expected.
 - The size of the main pipes is 48” or greater in diameter (for circular pipe) or the hydraulic opening is 12 sq. ft. or greater (for shapes other than circular).
- Velocity dissipation is usually needed at the outlet of pipes on steep grades and the Drainage Designer should provide the type of dissipation appropriate for velocity, pipe size, discharge and site constraints.

EXISTING DRAINAGE STRUCTURES

- The Drainage Designer will determine if existing pipe and box culverts and storm sewer pipe will remain and be utilized in the proposed design or removed or abandoned.
- Pipes to be removed, abandoned or cleaned out are to be indicated on the plans for bidding purposes and labeled "To be Removed", "To Be Abandoned", or "To Be Cleaned Out".

- Any large amount of pipe and appurtenances to be removed, such as an existing storm sewer, should be set up as a separate bid item and summarized in a separate column in the Incidental Summary.
- When not set up as a separate pay item, small amounts of pipe and appurtenances to be removed are included in the cost of Clearing and Grubbing (See Section 105.15* of the Road & Bridge Specifications) or may be included in the cost of Regular Excavation. (See IIM-LD-110 & General Note G-4)
- Any drainage pipe that is abandoned and left in place shall be backfilled and plugged in accordance with VDOT’s Road and Bridge Standard PP-1. These pipes are to be labeled on the plans "To Be Abandoned". The pay item for abandoning existing structures is "Flowable Backfill, Cu. Yds." and includes, furnishing and placing backfill material and plugging both ends of the drainage pipe.
- The quantity for Flowable Backfill (includes flowable backfill or fine aggregate) is to be estimated in accordance with Standard PP-1. This estimated quantity is to be summarized in the Drainage Summary. The pipe location/structure number should be shown in the Drainage Summary and the pipe size should be noted in the remarks column.

EXAMPLE:

DRAINAGE SUMMARY	
FLOWABLE BACKFILL	REMARKS
C.Y.	
25	48 inch concrete pipe to be abandoned

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- General Note D-12 (See IIM LD-110) is to be included on the General Note Sheet in all applicable project assemblies.

PROTECTIVE COATING FOR CULVERTS, STORM SEWERS AND CONCRETE STRUCTURES EXPOSED TO TIDAL WATER OR CORROSIVE ENVIRONMENT

- Treatment of concrete exposed to the normal ebb and flow of tidal water is defined in Section 404 of the VDOT Road and Bridge Specifications.

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Corrosive environment may be indicated in certain geographic areas by the degradation of concrete culverts, concrete lined ditches or other concrete structures. Proposed concrete items in these areas should have a protective coating or alternative materials should be considered.

- The Drainage Designer is responsible for preliminary determination for need and location of protective coating and is to specify in the drainage structure description where protective coating is required.
- The final determination for need and location of protective coating should be made by the Materials Division. The request for the final determination should be made either by the use of Form LD-252 or direct contact between the Drainage Designer and the Materials Division.
- The Drainage Designer is responsible for ensuring that the following notation is noted in the final drainage structure description on the plans and in the drainage summary:

Pipe or structure is to have protective coating applied in accordance with Section 404 of the VDOT Road and Bridge Specifications.

REQUESTING CULVERT DATA AND MATERIALS DIVISION RECOMMENDATIONS

- The Drainage Designer will determine locations where foundation investigation and other culvert data/recommendations are required.
 - Foundation, pH, resistivity, abrasive bed load data and channel bed material classification and recommendations for bedding, pipe camber and protective coating will be requested by the Roadway Designer, from the Materials Division, on Form LD-252. This request will be made immediately after locations requiring such information have been determined by the Drainage Designer or as soon after Field Inspection as possible.
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FOUNDATION INVESTIGATION

- Foundation data will be requested for all culvert installations with a diameter or span of 36 inch or greater. For multiple pipe installations, the span is measured between the interiors of the outside walls of the outer most pipes and is measured along a line perpendicular to the barrel of the pipe. Foundation data may be requested for culvert installations with smaller spans if deemed necessary. Foundation data should be requested on all pipes of any size that are to be bored or jacked.

- Foundation data should be requested for all SWM basins in order to determine if:
 - The native material will support the dam and provide adequate protection for seepage under the dam.
 - Excavation from the basin may be used to construct the dam.
 - Rock may be encountered in the area of excavation.
 - A high water table is present which may alter the performance of the SWM basin.

Borings shall be taken and information provided in accordance with Section 305.01(a) of the Materials Division Manual of Instructions. For large basins, more than one (1) boring for the dam and one (1) boring for the area of the basin may be needed. The number and locations of the borings are to be determined/requested by the Drainage Designer.

- The existing foundation soils data is not to be shown on the plans, however, the recommended amount of additional excavation and type of backfill material is to be shown in the drainage description.
- Locations that require a pH and resistivity analysis as well as an evaluation of the abrasive bedload potential should be noted on the plans that are used to request culvert foundation information from the Materials Division. The pH and resistivity analysis of the soil and water and the potential for an abrasive bed load are to be requested for each culvert location allowing a metal culvert where **any** of the following conditions exist:
 - Diameter or span of 36 inches or greater (including multiple pipe installations)
 - Culvert is to be installed in a live stream environment
 - Culvert is to be installed in an area of known premature pipe failure
- At each location where a foundation investigation is requested for pipe or box culvert installations, the Materials Division is to evaluate and classify the bed material in the outlet channel in close proximity of the downstream end of the proposed culvert. The bed material is to be classified in accordance with the AASHTO Soil Classification System. This information is needed in order to evaluate the scour potential at the culvert outlet. This information is to be requested by the Drainage Designer along with the other soil and water data for each appropriate culvert installation
- In areas of known premature pipe failure, the pH and resistivity analysis is to be requested for any type of proposed pipe material.

PIPE CAMBER

- Construction of longitudinal camber in a pipeline shall be considered when **all** of the following conditions are present:
 - Grade of the pipe is less than 0.5%
 - Fills (not height of cover) greater than 20 feet
 - Diameter or span 36 inch or greater
 - Foundation is subject to settlement
 - The Drainage Designer will request that the Materials Division determine the amount of anticipated settlement along the pipeline. This request will accompany the request for culvert foundation data. The plan description for the structure will then note a camber equal to the amount of anticipated settlement.
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GENERAL NOTES

- The Drainage Designer should refer to IIM LD-110 for the general notes pertaining to drainage, stormwater management and erosion and siltation control and shall select the appropriate notes to be used on each project.
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DRAINAGE SUMMARIES

- A Standard (Detailed) Summary is to be used on normal construction (C) projects.
- A Streamlined Summary may be used on Minimum Plan (M), No Plan (N) and Safety projects.
- When a specific type of pipe is required, such as concrete for the extension of an existing pipe or corrugated for a shoulder slot inlet, etc., the type of pipe required is to be specified in both the Streamlined and Detailed Summary.
- When the Drainage Summary sheets are compiled, the drainage items in the Drainage Summary are to be referenced by their assigned structure numbers with no further reference to sheet number, station, or location needed.

- Pipe that is considered storm sewer pipe is to be so designated as storm sewer pipe.*
- The following methods of listing pipe in the Standard Summary and the Streamlined Summary are to be used to eliminate a possible contractor’s error when ordering the pipe.

- Standard Summary Example:

DRAINAGE SUMMARY					
	PIPE	CORRUGATED PIPE	CONCRETE PIPE	STORM SEWER PIPE	REMARKS
	15 in	15 in	15 in	24 in	
	L.F.	L.F.	L.F.	L.F.	
	800				
				100	
			200		EXTEND EXIST. PIPE
		20			EXTEND EXIST. PIPE
		20			FOR SHOULDER SLOT INLET
TOTALS	800	40	200	100	

- Streamline Summary Example:

800 L.F. 15 inch Pipe
 40 L.F. 15 inch Pipe (Corrugated)
 200 L.F. 15 inch Pipe (Conc.)
 100 L.F. 24 inch Pipe (Storm Sewer Pipe)
 200 L.F. 72 inch Pipe (Special Design Conc.)

- The total linear feet of all like size pipe (regardless of type) are generally combined for the purposes of the estimate.
- The type of pipe is to be specified on the estimate only when:
 - It is the only type of pipe required for that particular size.
 - It is the only type of pipe required for the project (e.g., concrete pipe on an urban storm sewer project).

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- Projects on which the allowable pipe type tabulation allows optional materials for new pipe installations and end sections are required, the Drainage Summary shall have a column indicating the optional standard, “St'd. ES-1 or St'd. ES-2 “, for the end sections. A separate column on the Drainage Summary is required when specifying only a St'd. ES-1 or St'd. ES-2 end section for pipes of a particular material.
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STRUCTURES

DI-12 MULTIGRATE DROP INLETS

- The DI-12 Multigrate Drop Inlet is intended to provide one (1) standard grate configuration to handle the various traversable and non-traversable ditch slopes. The DI-12 Drop Inlet is to be located only in areas not normally subject to traffic. The narrow width of the DI-12 grate makes it more adaptable to narrow medians where difficulty retaining a traversable slope has been experienced with the DI-7 Drop Inlet's width. The DI-7 is still to be used in situations where a traversable slope can be maintained.
- To provide the most economical design, all locations should first be checked to see if the smaller chambered DI-12B or DI-12C drop inlet can be used. The size of the pipes entering and exiting the chamber will generally dictate whether or not a Standard DI-12B or DI-12C drop inlet can be used.
- The Standard DI-12 and DI-12A drop inlets are to be specified at locations where the DI-12B and DI-12C drop inlets cannot be used.
- Toe of fill and top of cut ditches with 2:1 slopes may use the St'd. DI-12 series drop inlet as well as those in the St'd. DI-5 and St'd. DI-7 series.

DI-5 DROP INLETS

- DI-5 Drop Inlets shall specify the type of cover (St'd. PG-2A Type) which most closely matches the ditch configuration at the inlet location. This data shall be shown both in the structure description on the plans and in the Drainage Summary.
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CONCRETE GUTTERS

- Where DI-7 or 12 series inlets are utilized to intercept concentrated flow (e.g., roadside, median, berm or toe ditches) the type of inlet that requires the concrete gutter should be specified (e.g., DI-7A, DI-7B, DI-12A or DI-12C).

GRATES

- When grate drop inlets, such as DI-5's, DI-7's and DI-12's are specified, it is necessary to note on the plans and in the Drainage Summary the type of grate that is required. A general guideline for selecting grate type is:

<u>DI-5</u>	<u>DI-7</u> Grate A	<u>DI-12</u>	
Type I	Type I	Type I	Limited Access and Rural Unlimited Access- Pedestrian Access Unlikely
Type III	Type III	Type II	Urban Areas-Pedestrian Accessible Areas

- The grate is to be installed so that the bars are parallel to the flow line of the ditch or swale.
- When it is necessary to locate a DI-7 in an area subject to occasional traffic (e.g., shoulders, parking areas, etc.) the load carrying Grate B shall be specified.

END SECTIONS FOR PIPE CULVERTS

- The Standard ES-2 drawing in the Road and Bridge Standards includes a pay line designation that should not be interpreted as a required length of pipe to be attached to the end section. The connector section length may be whatever length the supplier wishes to attach, but the portion of the culvert included within the limits of the "C" dimension will be considered, for payment purposes, to be included in the price bid for the end section.
- The supplier may furnish metal end sections with no connector section or with whatever length of connector section they determine convenient. The supplier and contractor will be responsible for determining what culvert pipe length will be required based on the length of connector sections if any, that is furnished. Regardless of the length connector furnished as an attachment to the end section, that portion of the culvert designated "C" in the standard drawing will be measured and paid for as end section.
- It is especially important that inspectors and other field personnel be aware of these instructions in order that an end section will not be rejected simply because the length of the connector is not the same as that shown on the Standard drawing. This variance is entirely acceptable provided the contractor has appropriately adjusted the length of the pipe.

PIPE ENDWALLS WITH LOAD CARRYING GRATE

- Pipe endwalls with load carrying grates (St'ds. EW-11 and EW-11A) are designed as a safety feature to prevent an errant vehicle from encountering the hazards of a collision with conventional endwalls or end sections. They are intended for use on low height embankments which would be traversable by an out of control vehicle and where guardrail would otherwise not be required or desired.
- Standard EW-11 is to be used for cross drain culverts. The grate configuration must be installed perpendicular to the edge of the shoulder line.
- Standard EW-11A is designed for use at crossover locations where there is no other alternative to placing a pipe culvert under the crossover.
- The Drainage Designer is to carefully study each situation before specifying Standard EW-11 or EW-11A Endwalls on the plans. Guidelines for the use of these structures are as follows:
 - Pipe endwalls with load carrying grates are to be used with traversable slopes (3:1 or flatter) on all classes of highways.
 - Pipe endwalls with load carrying grates are not to be installed where guardrail is required.
 - Pipe endwalls with load carrying grates will not be required on culverts with ends located outside of the normal clear zone width. For clear zone width guidelines, see Section A-2 of the VDOT Road Design Manual.
 - Crossover locations should be thoroughly studied to eliminate, if possible, the need for a pipe culvert under the crossover. In the event there is no other alternative, the Standard EW-11A is to be specified.
 - When pipe endwalls with load carrying grates are specified, the plans must be reviewed to ensure that all other hazards in the area are treated in an equally safe manner.

EXTENSION OF EXISTING PIPES

- Existing pipes are to be extended with the same size and type of pipe that is in place. If end sections are required, then only the appropriate end section for the type of pipe (Standard ES-1, ES-2, or ES-3) is to be specified. Pipes for extension are to be so noted in the "Remarks" column of the Drainage Summary.

DI-13 Shoulder Slot Inlets

- The DI-13 was specifically designed to:
 - Collect water running along the bituminous curbing used under a guardrail system in high embankment areas.
 - Discharge collected water through a 15” corrugated pipe exiting the back of the structure and traversing down the slope to the toe of the embankment.
 - Be an economical structure to pre-cast because of its standardized dimensions.
- Any modification to the standard details for this structure, or use in areas not consistent with the above guidelines, voids the original intent of the structure’s design. The details for the DI-13 are not to be altered in any manner from those noted on the standard drawings.
- If a structure is needed to both intercept the water collected along the bituminous curbing under a guardrail system and to accommodate pipe sizes or locations other than those shown in the Standard DI-13 details, a Standard DI-2 structure may be considered for use. The structure should utilize a Type A Nose Detail (in order to match the Standard MC-3B curb configuration) and the concrete gutter and grate should employ one inch of additional (local) depression below the normal shoulder elevation.
- In order to satisfy the guardrail alignment and block out requirements in the areas where the DI-2’s are utilized, a cast-in-place only structure must be specified. No DI-2’s should be placed within 25 feet of a bridge terminal wall in order to avoid conflict with the Guardrail Fixed Object Attachment.
- The following notes should be included with the structure description for DI-2’s utilized along bituminous curbing under guardrail:
 - Type A Nose Required.
 - Concrete gutter and grate elevation at curb line to be one inch below normal shoulder elevation.
 - Structure to be cast-in-place only.

STRUCTURE HEIGHTS

- All drop inlets (both curb and median), catch basins, junction boxes and other structures that require a frame and cover or grate at finished grade elevation, shall show the height dimension (H) on the plans and on the Drainage Summary. This dimension is to be measured from the invert elevation to the top of structure and is to be shown in the drainage description. Manholes will be shown as the number of linear feet required, as measured from the invert to the top of the concrete or masonry structure, not including the frame and cover.
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SAFETY SLABS

- Structures requiring safety slabs are to be determined by the Drainage Designer. Safety Slabs (Standard SL-1) shall be considered for use in deep drainage structures in order to reduce the hazard potential for persons accidentally falling into or within the structure.
- Standard SL-1 Safety Slabs shall be required as part of the drainage design for manholes, junction boxes and drop inlets with heights greater than 12 feet. The spacing of the slabs should be 8 feet to 12 feet with no slab located within 6' of the top or bottom of the structure. The slabs should be located so as to not interfere with the flow into or through the structure. On tall structures, where pipes inflow at various locations vertically, the safety slabs should not be placed below any 30 inch diameter or larger pipe opening.
- Safety Slabs should not be considered for use where **both** the interior length and width of the structure's chamber are less than 4' or the interior diameter is less than 4'. This condition generally occurs with some of the smaller cast-in-place inlet structures (e.g., DI-1A, DI-3AA, DI-3BB, DI-3CC, DI-7, DI-7A, DI-7B, etc.) However, if the contractor installs the precast option for these structures (which he often does), the precast option would have a chamber dimension 4' or greater and, therefore, safety slabs could be utilized. The Drainage Designer should assume that precast units in lieu of cast-in-place will be used and specify safety slabs accordingly. The following General Note should be included on the General Note Sheet:

D-18 St'd. SL-1 Safety Slab locations are based on the assumed use of precast structures. If cast-in-place structures are utilized, and the interior chamber dimensions (length and width, or diameter) are less than 4 feet, the safety slabs shall not be installed.
- On structures whose vertical height is 12' or greater and Safety Slabs are not specified, the use of bolt down or lock down covers or grates should be considered.

- The cost of the SL-1 is included in the bid price for the structure. The drainage descriptions should specify how many safety slabs are needed for each structure and the quantity should be noted in the remarks column on the Drainage Summary.
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STORMWATER CONVEYENCE DOWN STEEP SLOPES

- Due to the substantial number of failures and continual maintenance problems associated with PG-4 flumes on fill slopes, it is recommended that flumes not be used on fill slopes.
- In lieu of paved flumes, it is recommended that the appropriate type of drop inlet and pipe be used in all possible situations. For design considerations of pipe on steep slopes see “Pipe on Steep Slopes” section in this DDM.
- To a lesser degree, similar problems and concerns have been noted with paved flumes in cut sections. The alternatives for paved flumes in cut sections are usually very limited unless the cut is of a shallow depth.
- When design situations involve the apparent need for paved flumes, the Drainage Designer should explore all feasible alternatives to develop a design that will address both constructibility and future maintenance concerns.