Chapter 15 – Drainage Design Memorandums

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DDM1
Drainage Instructions

VIRGINIA DEPARTMENT OF TRANSPORTATION

LOCATION AND DESIGN DIVISION

DRAINAGE DESIGN MEMORANDUM

GENERAL SUBJECT: DRAINAGE INSTRUCTIONS	NUMBER: DDM 1.1
SPECIFIC SUBJECT: CULVERTS, STORM SEWERS AND MISC. DRAINAGE ITEMS	DATE: September 1, 2005
	SUPERSEDES: DDM1, IIM-LD-01 (D) 223, HDA-01-02, HDA-03-02, HDA-04-01, Road Design Manual Section 2E-2
ADMINISTRATOR APPROVAL: *R. T. Mills* 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:

    o 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

    o Structural plate pipe arch culverts:

        - 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

STORM DRAINS

- On projects that involve some storm drains and some cross drains (especially in areas which allow optional pipe material) the pipe description shall specify concrete pipe if the pipe is, or could become, a component part of a storm drain system under a roadway classification that requires concrete pipe only for storm drain systems.

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.

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.

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.

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.

- 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.

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.

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 propsed. 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 2001 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 104.05 of the Road & Bridge Specifications) or may be included in the cost of Regular Excavation. (See IIM-LD-110 & General Note D-10)

- 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:

D R A I N A G E S U M M A R Y	
FLOWABLE BACKFILL	REMARKS
C.Y.	
25	48 inch concrete pipe to be abandoned

- General Note D-13 (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.

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.

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.

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.

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.

- 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.

  o Standard Summary Example:

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

  o Streamline Summary Example:

800 L.F. 15 inch Pipe
200 L.F. 15 inch Pipe (Corrugated)
200 L.F. 15 inch Pipe (Conc.)
100 L.F. 24 inch Pipe (Conc.)
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 <u>type</u> of pipe is to be specified on the estimate <u>only</u> when:

  o It is the <u>only</u> type of pipe required for that particular size.

  o It is the <u>only</u> type of pipe required for the project (e.g., concrete pipe on an urban storm sewer project).

- 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.

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.

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:

DI-5	DI-7 Grate A	DI-12	
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.

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.

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 fumes, 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.

DDM2
Drainage Descriptions

VIRGINIA DEPARTMENT OF TRANSPORTATION

LOCATION AND DESIGN DIVISION

DRAINAGE DESIGN MEMORANDUM

GENERAL SUBJECT: DRAINAGE DESCRIPTIONS	NUMBER: DDM 2
SPECIFIC SUBJECT: BASIC DRAINAGE DESCRIPTION FORMATS FOR HYDRAULIC PLAN ITEMS	DATE: September 1, 2005
	SUPERSEDES*: IIM-LD-01 (D) 223, Road Design Manual, HDA 02-02, HDA-02-03, DDM1
ADMINISTRATOR APPROVAL: *R. T. Mills* State Hydraulics Engineer	

* - The information noted in this DDM supplants only specified individual items contained in the listed memorandums.

INSTRUCTIONS

- Descriptions for hydraulic items shall be written in accordance with these instructional guidelines. General examples of basic drainage descriptions are shown for illustrative purposes. These examples are intended to assist the Drainage Designer in the consistent application of VDOT procedures and practices. The numerical values utilized in the descriptions are for illustration only. These examples are reflective of the 2001 VDOT Road and Bridge Standards.

PLAN MEASUREMENTS

- The length of culverts and storm sewer pipe shall be shown to the nearest one foot.
- Invert elevations for culverts and appurtenances shall be shown to the nearest 0.1 foot.
- Invert elevations for storm sewer pipe and appurtenances shall be shown to the nearest 0.01 foot.
- Linear footage of manholes and heights of junction boxes and drop inlets shall be shown to the nearest 0.1 foot.

- The design height of cover for culverts and storm sewer pipe shall be shown to the nearest one foot.

- The skew angle for culverts shall be shown to the nearest 5 degree increment.

PIPE LENGTHS

- The actual scaled/measured value should be shown.

- Pipe lengths are typically determined based on the horizontal plan view distance between the ends of the pipe segment. Where pipes are specified to be laid on steep slopes, such as the outlet pipe from a shoulder slot inlet, the length of the pipe should be determined based on the length measured along the incline.

- The location of the ends of a segment of drainage pipe will vary depending on the type of terminal structure specified. The ends of the pipe should be established based on the following:

    - For terminal structures such as drop inlets, manholes, junction boxes, etc., the end of the pipe should be established based on the point at which the exterior walls of the pipe intersect the interior wall of the terminal structure. An exception to this would be where a terminal structure would have a base unit with an internal dimension less than the external dimension of the pipe. In this case the end of the pipe should be established based on that point at which the interior walls of the pipe intersect the interior wall of the terminal structure.

    - Where endwalls are specified as terminal structures, the end of the pipe and the location of the face of the endwall should be established based on that point at which the embankment slope intersects the interior wall at the crown (top) of the pipe.

    - Where end-sections are specified as terminal structures, the point at which the embankment slope intersects the exterior wall at the top of the end-section (at its full height) should be determined. Dimension “C” noted in the appropriate table on the Standard Drawings for ES-1, ES-1A or ES-2 (as applicable) should be subtracted from this point to establish the location (and pay line) for the end of pipe.

    - Where the pipe projects beyond the embankment with no type of terminal treatment specified, the end of the pipe should be established based on that point at which the embankment slope intersects the flow line (invert) of the pipe.

SKEW ANGLE OF CULVERTS

- The angle of skew shown on the plans for a drainage culvert is the acute angle formed by the centerline of the structure and a line drawn perpendicular to the roadway baseline that the culvert crosses. Where the culvert crosses more than one roadway baseline and where the baselines at the opposite ends of the structure are not parallel, an angle of skew for each end of the structure shall be shown in the description and in the summaries.

STRUCTURE NUMBERS

- A numbering system is to be used to identify all proposed drainage items on the plans and those existing items to be modified or adjusted with the proposed construction (Exception – Projects with minimal drainage items that will use a Streamline Summary). A two number designation is to be used. The first number will identify the number of the plan sheet that contains the item and the second number will designate the assigned item number (e.g., Structure 4-20 is item number 20 on plan sheet 4; Structure 11B-2 is item number 2 on sheet 11B).

- Culverts shall be identified by a single designation (e.g., 15-9).

- For storm drain systems, the structures (inlets, manholes, junction boxes, etc.) shall be individually numbered. The pipe connecting two such structures shall be identified as from point to point (e.g., 4-6 to 4-7 is the pipe between structures 4-6 and 4-7).

- The structure designation numbers are to be shown within ellipses. The descriptions are to be shown, space permitting, on the corresponding plan sheet. If all of the descriptions cannot be shown on the plan sheet, a separate drainage description sheet should be provided.

PROTECTIVE COATINGS

- Where a protective coating is required for culverts, storm sewers and concrete structures exposed to the normal ebb and flow of tidal water or a corrosive environment, the Drainage Designer should include the following notation in the drainage description for the specified structures:

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

PIPE DESCRIPTIONS

- Each description should list the categories of information, as may be appropriate in the following order:

    - All data pertaining to the pipe or culvert barrel (length, size, skew, cover, inverts)

    - The type of end treatment (including erosion control protection)

    - The recommended foundation data and minor structure excavation quantities

- The "Design Height of Cover" must be shown for each pipe description on the plans (including pipes under entrances) and on the Drainage Summary. This allows the Contractor to determine the proper strength, sheet thickness, or class of pipe from the Road and Bridge Standard PC-1 drawings applicable to a particular location. When specifying less than the standard minimum cover on concrete pipe, a reference to Drainage General Note D-15 should be included in the description for the structure.

- In those cases where the Materials Division's Subsurface Investigation Report indicates a soft, yielding or otherwise unsuitable foundation material, the description would include the recommended excavation and backfill information and be noted as follows:

    Excavate 20" below bottom of culvert and backfill with Bedding Material Aggregate #25 or 26
    200 Cu. Yds. Minor Structure Excavation
    100 Tons Bedding Material Aggregate #25 or 26

    - The specified bedding material quantity should be that required for backfilling the unsuitable material excavation below the normal 4 inches of bedding material and within the vertical limits shown in the Road and Bridge Standard PC-1 drawings.

    - The specified minor structure excavation quantity should be measured from the top of the existing ground surface or bottom of the normal roadway excavation limit, whichever is lower, to the bottom of the foundation trench and within the vertical limits shown in the Road and Bridge Standard PC-1 drawings.

- The quantities specified for minor structure excavation and bedding material should include that required for endwalls, wingwalls, or other appurtenances. This quantity is based on the ratio of the plan area of the endwalls, wingwalls, or other appurtenances to the plan area of the culvert or pipe barrel. (See DDM3)

- The strength, thickness, gage, class of pipe or method of bedding will not be noted on the plans except in those cases where, for specific reasons, the Road and Bridge Standards PC-1 and PB-1 Tables will not govern.

- Pipe fittings such as tees, wyes, reducers, etc. are paid for as linear feet of pipe based on the largest dimension. Therefore, such items should be included in the description of the larger size pipe and their length included in the total length of that pipe segment.

TYPICAL CULVERT DESCRIPTIONS

- These descriptions allow the Contractor the option of utilizing any of the pipe materials specified in the Allowable Pipe Type Table for a particular location. If there is only one type of allowable culvert material, the type of pipe material should be specified in the description (e.g., 100'-48" Conc. Pipe Req'd.).

(2-3) 100'-48" Pipe Req'd. (6' Cover)(20°Skew)
Inv.(In) 435.0 Inv.(Out) 434.0
2 St'd. EW-2 Req'd.
11 Tons Erosion Control Stone Class I, St'd. EC-1 Req'd. Lt.
378 Cu. Yds. Minor Structure Excavation

(2-5) 100'-24" Pipe Req'd. (3'Cover)
Inv.(In) 435.0 Inv.(Out) 434.0
1 St'd. ES-1 or 2 Req'd. Lt.
1 St'd. EW-11 Req'd. Rt. 4:1 Slope

CONCRETE PIPE ON RADIUS

- Concrete pipe may be installed on a radius using the open joint method or using the bevel pipe method with or without open joints. Concrete pipe that is installed on a radius using the open joint method is standard pipe and should <u>not</u> be specified as concrete radial pipe. See DDM1 for the minimum radius for each method for various pipe sizes.

o OPEN JOINT METHOD

(2-3) 100'-48" Pipe Req'd. (6' Cover)
(530' Radius with open joints – using 8' pipe joint lengths)
Joints are to be opened a maximum of 25% of the spigot or tongue length.
Inv.(In) 435.0 Inv.(Out) 434.0
2 St'd. EW-2 Req'd.
1 Tons Erosion Control Stone Class I, St'd. EC-1 Req'd. Lt.
378 Cu. Yds. Minor Structure Excavation

o BEVEL PIPE METHOD

(3-1) 100'-48" Conc. Radial Pipe Req'd. (6' Cover)
(120' Radius – using 8' pipe joint lengths with full bevel)
Inv.(In) 435.0 Inv.(Out) 434.0
2 St'd. EW-2 Req'd. Lt.
11 Tons Erosion Control Stone Class I, St'd. EC-1 Req'd.
378 Cu. Yds. Minor Structure Excavation

o BEVEL PIPE WITH OPEN JOINT METHOD

(6-7) 100'-48" Conc. Radial Pipe Req'd. (6' Cover)
(95' Radius with open joints – using 8' pipe joint lengths with full bevel)
Joints are to be opened a maximum of 25% of the spigot or tongue length.
Inv.(In) 435.0 Inv.(Out) 434.0
2 St'd. EW-2 Req'd.
11 Tons Erosion Control Stone Class I, St'd. EC-1 Req'd. Lt.
378 Cu. Yds. Minor Structure Excavation

JACKED PIPE

(5-6) 80'-48" Jacked Conc. Pipe Req'd. (25' Cover)
Inv.(In) 197.6 Inv.(Out) 197.0
2 St'd. EW-2 Req'd.
11 Tons Erosion Control Stone Class I, St'd. EC-1 Req'd. Rt.

MULTIPLE PIPE INSTALLATION

(8-9) 300’-48” Pipe Req’d. (7’ Cover)
(Triple Line – 100’ each line)
Inv.(In) 164.8 Inv.(Out) 164.1
2 St’d. EW-7 Req’d.
34 Tons Erosion Control Stone Class I, St’d. EC-1 Req’d. Rt.
1,134 Cu. Yds. Minor Structure Excavation

EXISTING PIPE EXTENSION

- The vertical and horizontal alignment of the pipe extension should duplicate that of the existing pipe. The type of pipe specified for the extension should be the same as the existing pipe. The cover specified should be the maximum that occurs along the entire run of pipe, including the existing section.

(2-3) Existing Pipe To Be Extended with 50’-36” Corrugated Steel Pipe Req’d. (7’ Cover)
Inv.(In) 435.0 Inv.(Out) 434.0
1 St’d. EW-1 Req’d.

STORM SEWER PIPE

(2-3) T0 (3-3) 195’-24” Conc. Pipe Req’d. (11’ Cover)
Inv.(In) 15.2 Inv.(Out) 14.5

BOX CULVERT DESCRIPTIONS

STANDARD (CAST IN PLACE)

- The standard description should be used where a cast in place structure can be used. However, the specifications allow the Contractor the option of substituting a precast structure with approval of the Engineer.

(4-3) 150’- 6’ X 8’ Box Culvert Req’d. (25’ Cover)(15° Skew)
Inv.(In) 60.0 Inv.(Out) 57.0
St’d. BCS-DT, BCS-30, & BCW-21
4 St’d. Type I Wings Req’d.
46 Tons Erosion Control Stone Class I, St’d. EC-1 Req’d. Rt.
527 Cu. Yds. Minor Structure Excavation

PRECAST

- The precast description should be used where a precast structure only is desired.

(4-8) 150'- 6' X 8' Precast Box Culvert Req'd. (25' Cover)(15° Skew)
Inv.(In) 60.0 Inv.(Out) 57.0
2 Headwalls Req'd. (Cost to be included in price bid for linear feet of box culvert) Reference St'ds. BCS-DT & BCS-30
4 Wings Req'd. Reference St'd. BCW-21, Type 1(K)
46 Tons Erosion Control Stone Class I, St'd. EC-1 Req'd. Rt.
527 Cu. Yds. Minor Structure Excavation

STRUCTURES

- When specifying precast structures, it is not necessary to identify, in the description, the applicable precast standard base, riser, and top units, unless a particular type of component is desired. The Contractor should, wherever possible, be allowed the option of determining the most economical units to utilize to assemble the desired structure.

- In addition to the standard information, the drainage description should include all information required to properly construct the structure. The description should be clear to the extent that there is no doubt as what is to be done at the location. Some examples of additional information to be included in a description would be:

  o *Connect To Existing 18" Conc. Pipe*

  o *Connect UD-4 TO DI*

- Standard IS-1 Inlet Shaping should be specified for manholes, drop inlets, or junction boxes where the main trunk line of a storm sewer changes direction or pipes of approximately the same size intersect and are carried forward in a single pipe.

- Standard SL-1 safety slabs shall be specified for manholes, drop inlets, or junction boxes in accordance with the guidance outlined in DDM1 and the standard drawing.

- All drop inlets (both curb and median), catch basins, junction boxes and other such structures that require a frame and cover or grate at finished ground 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 the concrete or masonry structure and is to be shown to the nearest 0.1 foot.

- Manholes should be shown as the number of linear feet required, measured from the invert to the top of the concrete or masonry structure. The linear feet of manhole specified should not include the height of the frame and cover.

CURB DROP INLETS

- The standard description assumes cast in place; however, the Contractor is allowed the option to substitute a precast structure.

  (3-1) 1 St'd. DI-4D Req'd.
  L=8', H=5.2' Inv. 197.6
  St'd. IS-1 Req'd.

- When the required structure height is greater than the maximum allowed for a cast in place structure, or a precast structure is desired, the description would be:

  (9-7) 1 St'd. DI-4DD (Precast) Req'd.
  L=8', H=25.0' Inv. 197.6
  2 St'd. SL-1 Req'd.

GRATE DROP INLETS

- Descriptions for Standard DI-5, DI-7, and DI-12 series grate drop inlets should specify the type of grate required, i.e., a Type I grate for areas where pedestrian access is unlikely or a Type III (DI-5 & 7) or Type II (DI-12) for pedestrian accessible areas. When a DI-7 inlet is to be located in areas subject to occasional traffic (e.g., shoulders, parking areas, etc.), a load carrying Grate B should be specified.

  (9-16) 1 St'd. DI-7 Req'd. Grate A Type II Req'd.
  H=5.3' Inv. 23.6

- Descriptions for Standard DI-5 inlets should include the type of cover. The Standard PG-2A cover type most closely matching the ditch configuration should be specified. The height of the structure is measured from the invert to the top of the concrete cover.

  (4-5) 1 St'd. DI-5 Req'd. Type I Grate Req'd.
  St'd. PG-2A Type E Cover
  H=4.8' Inv. 13.6

MANHOLES

- If a cast in place structure only is to be allowed, show only the MH-1 designation. Show only the MH-2 designation if a precast unit only is to be allowed. The option of utilizing cast in place as well as precast manholes should be allowed at all locations except for those where placement is limited due to existing pipelines, utilities, the size of pipe, etc. Most locations should permit the Contractor the option to utilize either and the descriptions should specify both the cast in place and precast standard.

  (3-1) 14.6 Lin. Ft. St'd. MH-1 or 2 Req'd.
  1 St'd. MH-1 Frame & Cover Req'd.
  Inv. 83.4
  1 St'd. SL-1 Req'd.

JUNCTION BOXES

(8-3) 1 St'd. JB-1 Req'd.
H=12.8', W=4', D=5'
Type A Tower Req'd.
1 St'd. MH-1 Frame & Cover Req'd.
Inv. 121.4
1 St'd. SL-1 Req'd.

STORMWATER MANAGEMENT STRUCTURES

- In those instances where the stormwater management basin is to be utilized as a temporary sediment basin, the description should be so noted with a reference to Standard SWM-DR for details.

  o SWM DRAINAGE STRUCTURE

  (14-7) 6.7' St'd. SWM-1 Req'd.
  Bottom Elev. 23.8
  3" Diameter Water Quality Orifice Req'd., Inv. 26.8
  10" Diameter Orifice Req'd., Inv. 28.8
  See Sheet 2G For Details.

  o STORMWATER MANAGEMENT DAM

  (11-9) 1 SWM Dam Req'd.
  See sheet 2E for details.

o MANUFACTURED WATER QUALITY STRUCTURES

(7-7) 1 Water Quality Structure Req'd.
Top Elevation 26.3
Inv. Pipe (In) 20.3, Inv. Pipe (Out) 20.0
Minimum WQV=2,345 Cu. Ft.
Minimum WQQ=8.5 CFS

EXISTING STRUCTURES

- "Modify" should be used when a major work effort is required (e.g., connecting or removing pipes, adjusting height more than 1 foot, etc.).

(4-11) Modify Existing Drop Inlet
Adjust To Grade. Raise 2.3'
Add DI-3B, L=6' Top.
Proposed Top Elev. 153.6
See Sheet 2K For Details.

- "Adjust" should be used when a minor work effort is required (e.g., adjusting height 1 foot or less).

(5-18) Adjust Existing MH
Adjust To Grade. Raise 0.5'
1 St'd. MH-1 Frame & Cover Req'd.
Proposed Top Elev. 234.3

- All work to be performed to modify the structure should be clearly stated in the drainage description. Other such information would be:

o *Modify To (Accept/Remove) 15" Conc. Pipe*

o *Connect UD-4 To Structure*

o *Convert Existing DI to Manhole*

o *To Be Cleaned Out*

- The necessary standard items for completing the work should be specified (e.g., precast units, manhole frame and cover, etc.). The structural condition of an existing structure should be field evaluated to determine the suitability for modification. Those structures found to be structurally deficient or in poor condition should be replaced in lieu of being modified. The cost of total replacement versus modification should also be evaluated to make sure the most economical solution is being proposed.

DDM3

Minor Structure Excavation

VIRGINIA DEPARTMENT OF TRANSPORTATION

LOCATION AND DESIGN DIVISION

DRAINAGE DESIGN MEMORANDUM

GENERAL SUBJECT: MINOR STRUCTURE EXCAVATION	NUMBER: DDM 3.1
SPECIFIC SUBJECT: Measurement of Excavation for Pipe and Box Culverts and Appurtenances	Date: September 1, 2005
	SUPERSEDES: DDM3 & IIM-LD-91 (D) 71.8
ADMINISTRATOR APPROVAL: *R. T. Mills* State Hydraulics Engineer	

POLICY

- Quantities for minor structure excavation will be computed for pipes and box culverts with a diameter or span of 48 inch and larger. 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. Minor structure excavation will be computed to a point 18 inches outside the periphery of the barrel section, or to a point bound by vertical planes coincident with the bedding limits shown on the Standard PB-1 drawings.

- The minor structure excavation quantity for wingwalls and other appurtenances will be based on the "ratio" of the plan area of the wingwalls or appurtenances to the plan area of the barrel.

PROCEDURE

- For single line culverts, the width of the barrel will be the nominal span or opening of the pipe or box culvert; for multiple spans, the barrel width will be the overall distance between inner faces of the outermost barrel openings. This dimension is defined by the S+2D value noted on the standard drawings for endwalls for multiple barrel culverts in the Road and Bridge Standards. The length of all culverts will be from end to end of the culvert. The outside wall thickness and the 18 inches outside the neatlines of the periphery of the culvert are not to be included in the computing the "ratio."

- Once the "ratio" has been determined, it is used to compute the total cubic yards of Minor Structure Excavation for the structure and appurtenances, by using the excavation quantity for the barrel section and increasing this quantity by the "ratio."

- The sketch below denotes the area to compute the typical plan area for determination of box culvert "ratio." For computation of "ratio" for pipes see Appendix D, Table D-28 through D-31 in the Road Design Manual.

- Where End Sections are required and the pipe option of metal or concrete is allowed, use the area of the ES-2 (metal) end section for computing the "ratio."

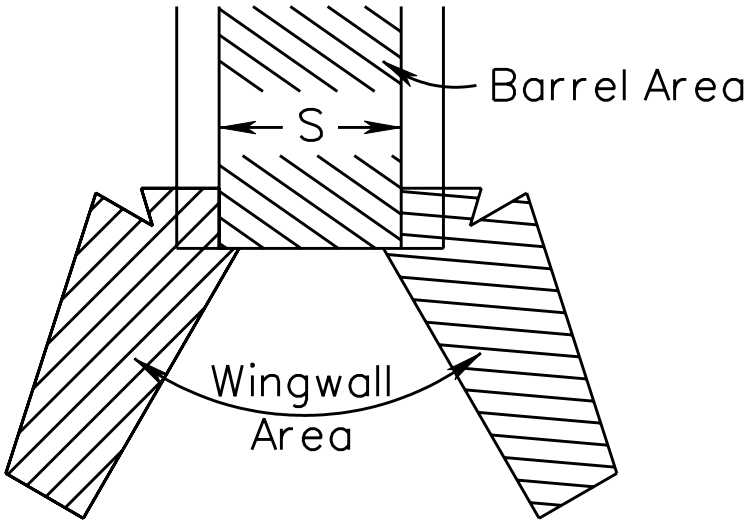
- Where there is not sufficient survey data to accurately determine minor structure excavation quantities, additional survey must be secured and incorporated before making final quantity determinations.

MEASUREMENT/PAYMENT

- Minor Structure Excavation will be measured in cubic yards and paid for on a Plan Quantity basis.

- Excavation for wingwalls and other appurtenances will be based on the "ratio" of the plan area of the wingwalls or appurtenances to the plan area of the barrel.

- A separate entry is to be shown on the Drainage Summary Sheet for cubic yards of Minor Structure Excavation for Pipes and cubic yards of Minor Structure Excavation for Box Culverts.



TYPICAL BOX CULVERT

DDM4

Drainage Design At Railroads

VIRGINIA DEPARTMENT OF TRANSPORTATION

LOCATION AND DESIGN DIVISION

DRAINAGE DESIGN MEMORANDUM

GENERAL SUBJECT: DRAINAGE DESIGN AT RAILROADS	NUMBER: DDM4
SPECIFIC SUBJECT: GUIDELINES AND CRITERIA FOR DRAINAGE DESIGN UNDER OR ADJACENT TO RAILROADS	DATE: September 1, 2005
	SUPERSEDES: IIM-LD- 229
ADMINISTRATOR APPROVAL: *R. T. Mills* State Hydraulics Engineer	

OVERVIEW

- On VDOT projects, where there is a need to install a culvert or a storm sewer pipe within railroad right of way, either under or adjacent to the tracks, the Hydraulic Engineer should contact the Department of Rail and Public Transportation to determine the specific design and construction criteria required by the Railroad Company and to initiate the process for obtaining any approvals needed from the Railroad Company. Railroad Companies generally follow engineering practices recommended by the American Railway Engineering and Maintenance-of-Way Association (AREMA) in their Manual of Recommended Practices for Railway Engineering, Volume I, Chapters 4 & 5. Railroad Companies reserve the authority to adopt and use more stringent design requirements, as they deem necessary. Some of the basic criteria for culverts and storm sewers that are to be located on railroad right of way are presented in this memorandum.

- Projects that have railroad involvement generally are not advertised for construction until the Rail/Highway Agreement is fully executed. The execution of the Agreement by the Railroad Company is contingent upon their review and acceptance of the project design, especially the drainage design, as it relates to or affects their facilities. It is important that the Railroad Company be provided a complete and current set of plans and drainage computations for their review. The plan review and comment period by the Railroad Company can typically take three months or more for each submittal. Many projects take two or more reviews to address comments or correct plan omissions or errors. The time needed for review and coordination with the Railroad Company should be taken into consideration when establishing project schedules.

CRITERIA

HYDRAULIC DESIGN CRITERIA

- Culvert design follows the same FHWA methods used for VDOT highway projects with the following minimum criteria:
    - The 25 year discharge shall produce a headwater elevation at the culvert entrance no greater than the top of the pipe (HW/D = 1.0).
    - The 100 year discharge shall produce a headwater elevation at the culvert entrance no greater than 1.5 times the height of the culvert (HW/D = 1.5) or 2.0’ below the elevation of the bottom of the rail, whichever is less.
- Where field conditions do not permit installation of pipes sizes meeting this criteria, “pre and post construction ” computations must be provided showing the headwater elevations for the 25 year and 100 year floods and demonstrating that there will be no increase in headwater depth due to the proposed construction. The Engineering Department of the Railroad Company must approve such designs.

PIPE SIZE AND COVER

- The minimum pipe size for use under the track is 36” diameter. A smaller size pipe may be allowed with the approval of the engineering department of the railroad.
- The maximum pipe size for use under the track is 72” diameter. A larger size pipe may be allowed with the approval of the engineering department of the railroad.
- The minimum pipe cover is to be 5.5’ as measured from the outside top of the pipe (casing pipe if used) to the bottom of the rail. Since survey crews often obtain the elevation of the top of the rail, an assumed rail height of 7 ½” may be used in determining the elevation of the bottom of the rail. Cover may also be determined by using the top of the cross tie elevation if the top of the rail elevation is unknown. In locations where the minimum cover cannot be obtained, a request must be made to the Railroad Company for an exception, with a complete explanation of the need for the exception.

PIPE MATERIALS AND INSTALLATION

- Pipes to be installed under existing tracks will generally require the bore and jack or tunneling method of installation and must be so noted on the construction plans. An exception to this may be granted by the Railroad Company for spur tracks or tracks with infrequent use. Special circumstances, such as minimum cover, or other restrictions may sometimes necessitate that a pipe or box culvert be installed by the open cut method. These sites should be carefully reviewed by VDOT, the Department of Rail and Public Transportation and the Railroad Company to decide the appropriate methods and materials to be specified in the construction plans.

  o SMOOTH WALL STEEL PIPE

    - The Railroad Company's standard pipe material for the bore and jack installation method is smooth wall steel pipe capable of supporting the Cooper E-80 loading. A structural analysis that is consistent with the Cooper E-80 loading requirements must be available for the Railroad Company's review and approval should they desire. Section 105 of the Road and Bridge Specifications outlines the procedures that should be followed for this process.

    - The smooth wall steel pipe may function as the carrier pipe (i.e., used to convey the stormwater run-off) or function as a casing pipe for the actual carrier pipe. If installed as the carrier pipe, the smooth wall steel pipe must conform to the criteria set forth in the appropriate notes for uncoated galvanized steel pipe shown in Table A & A1 of the "Allowable Pipe Criteria for Culverts and Storm Sewers" in Standard PC-1 of the Road and Bridge Standards. The State Location and Design Engineer and the District Materials Engineer must approve any deviation from the noted criteria. The drainage description for smooth wall steel pipes installed under the railroad by the bore and jack method should specify:

      Jacked Smooth Wall Steel Pipe Req'd.
      Pipe shall be designed to support Cooper E-80 loading in accordance with Section 105 of the Road and Bridge Specifications and installed by the bore and jack method. Smooth wall steel pipe shall have a minimum wall thickness of (See Table A).

Table A

Smooth Wall Steel Casing Pipe Minimum Wall Thickness For Installation Under Railroads	
Pipe Size Inches	**Minimum Wall Thickness Inches**
24	0.500
30	0.500
36	0.500
42	0.625
48	0.625
54	0.750
60	0.875
66	0.875
72	1.000

o CONCRETE PIPE

- Under certain conditions, CSX Transportation, Inc. will allow concrete pipe Class V to be installed beneath the tracks without a casing pipe. In these cases, Class V concrete pipe may be used up to a cover height of 14'. For cover heights greater than 14', a Special Design Concrete Pipe must be used. A structural analysis that is consistent with the Cooper E-80 loading requirements must be provided to the Railroad Company for their review and approval. Section 105 of the Road and Bridge Specifications outlines the procedures that should be followed for this process. The drainage description for such pipes should specify:

  For cover heights 14' or less

  Jacked Concrete Pipe Req'd. Class V
  Pipe shall be installed by the bore and jack method.

  For cover heights greater than 14'

  Special Design Jacked Concrete Pipe Req'd.
  Pipe shall be designed to support Cooper E-80 loading in accordance with Section 105 of the Road and Bridge Specifications and installed by the bore and jack method.

  The note referencing the Cooper E-80 loading and Section 105 of the Road and Bridge Specifications should also be included on the appropriate Drainage Summary Sheet.

0 CORRUGATED STEEL PIPE

- For pipes to be installed under proposed or relocated tracks to be constructed on a new location, the open cut method of installation should be used. The pipe material generally accepted by the Railroad Company for this type of installation is corrugated steel capable of supporting the Cooper E-80 loading requirements. Aluminized Type 2 or Polymer Coated are the standard types of corrugated steel pipe allowed by VDOT. A structural analysis that is consistent with the Cooper E-80 loading requirements must be available for the Railroad Company's review and approval should they desire. Section 105 of the Road and Bridge Specifications outlines the procedures that should be followed for this process. The drainage description for such pipes should specify:

  Corrugated Steel Pipe Req'd.
  Pipe shall be designed to support Cooper E-80 loading in accordance with Section 105 of the Road and Bridge Specifications.

- The note referencing the Cooper E-80 loading and Section 105 of the Road and Bridge Specifications should also be included on the appropriate Drainage Summary Sheet. For locations where VDOT does not normally allow corrugated steel pipe (see Allowable Pipe Type Tables in Standard PC-1 of the Road and Bridge Standards), concern should be expressed to the Railroad Company about the use of this type of pipe material. Railroad Companies generally require that VDOT own and maintain any drainage structures that VDOT installs on railroad right of way. Therefore, we should endeavor to use the type of material that has proven to provide an appropriate life expectancy for specific site conditions. However, the Railroad Company will have final approval on the type of material and the installation method.

DROP INLETS

- Drop inlets should generally not be located on the railroad right of way. When determined necessary to locate drop inlets on railroad right of way, they should be located no closer than 18' from the track centerline. Railroads have a responsibility to their employees and customers to provide a hazard free operating corridor and are concerned with the hazard potential presented by grate inlets, especially those located in ditches. Any grate inlet that must be located within 18' from the track centerline, or in an area where there is concern with a hazard potential due to grate openings, should have the bar spacing of the grates specified as would be required for pedestrian accessible areas. Where a Standard DI-5 or DI-7 inlet is proposed in these areas, a Type III grate shall be specified.

DITCHES

- Drainage ditches on railroad right of way that will convey VDOT roadway or bridge deck run off must be analyzed for the effects of the 100 year frequency discharge. This does not necessarily mean that the ditch must contain the 100 year storm but rather the effects of the 100 year storm must be documented. The analysis must be submitted to the Engineering Department of the Railroad Company for their review and approval. The analysis should present a factual scenario that is clear and easily understood. A computer printout that is not clearly presented or explained is not usually acceptable to the Railroad Company.

FOUNDATIONS FOR SIGNALS

- The location of proposed drainage structures may conflict with the foundations of proposed Railroad Company installed warning devices at rail crossings. The location of the warning device is prescribed by federal regulations and varies according to the typical section of the roadway and the alignment of the rail crossing. The location of proposed drainage structures in these areas should be reviewed with the Department of Rail and Public Transportation to determine any possible conflicts.

ENDWALLS AND OTHER STRUCTURES

- For construction detail requirements when placing pipe endwalls, manholes and other such structures adjacent to railroads, see Section 2E-24 of the VDOT Road Design Manual.

GUIDELINES

- The following general guidelines are presented to assist the Drainage Designer in developing a design that is acceptable to the Railroad Company. These guidelines are representative of the comments received from Railroad Companies on past VDOT projects.

    - For projects that are rebuilding an existing crossing, the existing drainage patterns should not be altered and documentation (a narrative with hydrologic and hydraulic computations) should be provided to the Railroad Company that indicates no increase in volume, velocity or flow depth/headwater depth is caused by the project on railroad right of way.

- Railroad Companies do not generally allow new drainage outfalls to discharge onto railroad right of way. Any existing outfall that is to be replaced or altered should be acceptable provided the documentation as previously noted for volume, velocity and flow depth/headwater depth is provided to the Railroad Company.

- When a constructed outfall (ditch or pipe) must be directed into a railroad ditch paralleling the rail bed, the constructed ditch or pipe should intersect the railroad ditch at an angle, in lieu of perpendicular, in order to lessen concerns with potential erosion. The appropriate erosion control measures should be applied at the intersection point to ensure stability of the rail bed and the existing railroad ditch.

- Proposed storm drain pipes paralleling the railroad tracks are not generally permitted to occupy the railroad right of way.

- Proposed roadway culverts and storm drains are not generally permitted to connect to existing railroad culverts. For situations where such a connection is unavoidable, the Railroad Company usually requires that VDOT assume maintenance responsibility for the railroad culvert.

- Scuppers, deck drains, drop inlets or other concentrated flow outlets from bridge decks are generally not allowed to drain directly onto the railroad right of way.

- Primary and emergency spillways and outfall structures of stormwater management basins, as well as the basin itself, are generally not allowed to be located on the railroad right of way. Where flow from a stormwater management basin is directed onto railroad right of way, documentation should be provided to the Railroad Company that indicates no increase in volume, velocity or flow depth/headwater depth is caused by the project on railroad right of way.

DDM5
Underdrains

VIRGINIA DEPARTMENT OF TRANSPORTATION

LOCATION AND DESIGN DIVISION

DRAINAGE DESIGN MEMORANDUM

GENERAL SUBJECT: UNDERDRAIN	NUMBER: DDM 5.1
SPECIFIC SUBJECT: DRAINAGE FOR PAVEMENT STRUCTURE; UNDERDRAINS IN GORE AREAS	DATE: September 1, 2005
	SUPERSEDES: DDM5,IIM-LD-01 (D) 130.8, IIM-LD-89 (D) 74.1
ADMINISTRATOR APPROVAL: *R. T. Mills* State Hydraulics Engineer	

GUIDELINES

- When a Standard Underdrain UD-3, UD-4 or UD-7 passes through a commercial entrance, “non-perforated” pipe is required between the limits of the curb returns. This “non-perforated” pipe is to be summarized with the applicable underdrain. (See Standards UD-3, UD-4, and UD-7 and Sample Summary)

- Standard underdrains will provide drainage for pavement structures as recommended by the Materials Division.

- Standard EW-12 shall be used at outlet ends of all underdrains which do not tie to other drainage structures (inlets, manholes, etc.).

- When ramp gore areas are above and sloping toward rigid pavement, abutted by asphalt shoulders, UD’s will be provided at the gore to collect and drain water under the pavement.

- Designers are cautioned that special attention must be given to superelevated curves and transitions to assure that the underdrain is properly located to provide drainage for subbase material.

DESIGN PROCEDURES

- The Roadway Designer will submit Form LD-252 to the Materials Division, requesting preliminary pavement design and underdrain type and location recommendations. Form LD-252 will be submitted during the early stages of project development so that the requested information will be available to the Drainage Designer during the drainage design phase prior to the Field Inspection.

- The Materials Division will provide the Roadway Designer with recommendations for the preliminary pavement design and the type and location of underdrains for the project. Underdrain recommendations will include Standard UD-2, UD-4, UD-5, UD-6 and/or UD-7 underdrains, as appropriate. Recommendations will include Standard UD-1 underdrains when sufficient data exists to determine locations.

- Prior to submitting a request to the Hydraulics Unit for drainage design, the Roadway Designer will depict the underdrains on the drainage layer of the electronic files and /or hard copy of the plans at the locations recommended by the Materials Division. The Roadway Designer will depict only those underdrains that parallel the roadway centerline. A copy of the Materials Division's report will be included in the data forwarded to the Hydraulics Unit with the request for the drainage design.

- The Roadway Designer will depict Standard UD-3 Sidewalk Underdrains on the drainage layer of the electronic files and/or hard copy of the plans at the locations recommended by the District Construction Engineer.

- The Drainage Designer will:

    - Determine the locations for CD-1 or CD-2's at:

        - Down grade end of cut to fill transitions.
        - Sag points in roadway grade.
        - Bridge approach slabs.

- Determine outlet pipe locations for all parallel underdrain systems. Unless otherwise approved by the State Materials and the State Hydraulics Engineer, the following criteria will apply to spacing of outlet pipes:

  - UD-1 – Variable spacing
  - UD-2 – 500 feet maximum spacing
  - UD-3 – 1000 feet maximum spacing
  - UD-4 – 350 feet maximum spacing
  - UD-5 – 350 feet maximum spacing
  - UD-7 – 350 feet maximum spacing

- For Rural (shoulder/ditch design) projects:

  - Determine the modifications required (If any) to the ditch typical section in order to provide a minimum 12 inches of freeboard (vertical clearance) between invert of outlet pipe and invert of receiving ditch.
    Or
  - Design a storm sewer system under the ditch line for the connection of underdrain outlet pipes that provide for the minimum 12 inches of freeboard between the invert of the outlet pipe and the invert of the receiving structure.

- For Urban (curb and gutter/storm sewer design) projects:

  - Design the storm sewer system to provide the minimum 12 inches of freeboard between the invert of the outlet pipe connection and the invert of the receiving structure.

- Specify EW-12 Endwall at end of outlet pipe or specify connection to another structure (manhole, drop inlet, etc.)

- Depict the required underdrains and/or outfall systems on the drainage layer of the electronic files or on redline prints of the plans. The information will be transmitted to the Roadway Designer along with the normal drainage design for the project.

TYPES AND USAGE

- Drainage for Pavement Subbase:

STANDARD	**USAGE AND PURPOSES**
UD-1	As recommended by materials division to lower ground water table in cuts
UD-2	Drains raised grass median strips as recommended by Materials Division
CD-1 & 2	Drains subsurface water from cuts and fills according to road and bridge standards and as recommended by Materials Division
UD-3	Drains area under sidewalk
UD-4	Provides drainage for pavement structure as recommended by Materials Division
UD-5	Same as UD-4; more easily added to previously constructed projects
UD-7	Provides pavement structure drainage as recommended by Material Division for existing pavements
EW-12	Used at outlet ends of all underdrains which do not tie to other drainage structures (inlets, manholes, etc.)

- Underdrains in Gore Areas

    - Ramp gore areas on down grades are prone to retaining water that may spill over the pavement. This may result in slippery pavement and icing if the pavement structure is not adequately drained. See Standard UD-4 for method of installation.

PLAN DETAILS

- When showing EW-12's on plans, label as follows showing appropriate slope:

  1 – St'd. EW-12 Req'd. (4:1 Slope)

SUMMARY

- Following is a typical method of summarizing underdrains:

UNDERDRAIN SUMMARY							
STA. to STA.	UD-1	UD-4		CD-1	OUTLET PIPE	EW-12	
		Perforated	Non-Perforated			2:1	4:1
	L.F.	L.F.	L.F.	L.F.	L.F.	Each	Each
20+00 To 31+00 Rt.	1100				500	1	1
25+00 To 51+00 Rt.		2350	250		400	2	
31+50 Lt.				200	250	1	1
TOTALS	1100	2350	250	200	1150	4	2