

Drainage	<i>Chapter</i> Introduction
	<i>Subject</i> The Manual

DR 101-1 ORGANIZATION AND NUMBERING

Chapter Title – The subject matter in the manual is divided into chapters. The chapter title appears in the upper right-hand corner of the first page of a subject and in the upper left-hand corner of any subsequent page.

Subject Title – The title of a subject appears in the upper right-hand corner of the first page of a subject and in the upper left-hand corner of any subsequent page.

“DR” Prefix – Preceding each subject number, this prefix stands for the manual title *Drainage*.

Date – The latest issuance date of a subject appears at the bottom of each page of the subject. This date agrees with the latest issuance date shown for the subject in the Table of Contents.

Page Numbering – Each subject has its own page numbering, which appears at the bottom of each page.

DR 101-2 GENERAL

The KYTC Drainage Guidance Manual (herein referred to as the manual) is intended for use in the development of KYTC highway drainage design projects. The manual presents design concepts, policies and procedures, and criteria for performing drainage design and hydraulic analyses on projects which are the responsibility of KYTC.

The manual provides the designer with a basic working knowledge of hydrology and hydraulics based on state-of-the-practice highway drainage procedures. Basic design elements are included so that the designer can design highway drainage with minimal assistance. However, this manual cannot provide guidance on complex hydrologic or hydraulic problems, and it is no substitute for experience, formal training, or engineering judgment.

DR 101-3 CHAPTER OVERVIEW

➤ DR 100: INTRODUCTION – This chapter introduces the designer to the general

contents of the manual. Departmental policies are discussed, responsibilities are outlined, references are provided, and the design review process is discussed.

- DR 200: STORMWATER & FLOODPLAIN MANAGEMENT – General stormwater and floodplain regulations, considerations, and management practices are discussed.
- DR 300: DRAINAGE FOLDERS – An important product of the drainage design is the documentation of the design decisions in a permanent legal record, known as the Final Drainage Folder. Folder requirements and submittal requirements are discussed.
- DR 400: HYDROLOGY – This chapter explains the methods used to produce reasonable engineering estimations of peak runoff and runoff hydrographs.
- DR 500: OPEN CHANNELS – This chapter provides guidelines, procedures, and criteria for channels, including roadway ditches and stream relocations.
- DR 600: Culverts and Headwalls – The hydraulic design and physical standards of culverts are presented. End treatments and headwalls available for use with culverts are discussed.
- DR 700: INLETS AND STORM SEWERS – Guidelines, analysis procedures, and design practices are presented for storm drainage systems including curb and gutter, inlets, manholes and junctions, and storm sewer pipes.
- DR 800: BRIDGES – Design and environmental considerations, design procedures, and criteria are presented for the hydraulic analysis of bridges.
- DR 900: STORAGE – Design criteria and procedures are discussed for reducing peak flows by providing storage using methods such as culvert sizing and detention/retention basins.
- DR 1000: EROSION – This chapter discusses the erosion control measures and guidelines that are to be incorporated into roadway plans.
- DR 1100: MISCELLANEOUS – Additional subjects such as temporary drainage facilities, software recommendations, plan requirements, and field data collection are presented.

DR 101-4 MANUAL MAINTENANCE

The manual will be maintained by the Division of Highway Design, Drainage Branch. When changes are required, the manual will be revised on a per-subject basis. The date located in the footer of each page will be the primary tracking element for the new manual. Notification of any revisions or updates will be issued through Design Memorandums and made available electronically on the Drainage Branch's website.

DR 101-5 SUPPORT REFERENCES

The methodologies employed in this manual have been adopted through the review of many hydrologic and hydraulic programs and procedures available to the engineer today. Many of the references discussed below are available online for download. A current list of reference website links is available on the Drainage Branch's website

AASHTO Publications and Resources:

The American Association of State Highway and Transportation Officials (AASHTO) has several publications available that give an overview of drainage design issues and policies. They may be found at AASHTO's bookstore website.

Two publications that may be of particular use are:

"HIGHWAY DRAINAGE GUIDELINES, 4th Edition", AASHTO is a publication that provides a consolidated overview of highway hydraulic design and discusses possible hydrology problems.

"MODEL DRAINAGE MANUAL, 3rd Edition", AASHTO is a publication that compiles generic design policies and state-of-the-practice design procedures, including example problems. It is intended to provide a foundation on which any Federal, State, or local agency can produce its own customized drainage policy and procedure manual.

FHWA Publications and Resources:

The Federal Highway Administration (FHWA) has developed a number of documents and programs relating to highway drainage that are available at their website. The full list of documents, programs, publications, and resources available for download are too numerous to be listed here. But they include HEC (Hydraulic Engineering Circulars), HDS (Hydraulic Design Series), hydrology and hydraulic software applications, and other information on the subjects of:

- Hydrology
- Highway Drainage
- Culvert Hydraulics
- Bridge Hydraulics
- Scour Technology
- Environmental Hydraulics
- Conferences
- Software
- Policy and Memos
- Publications
- Research

Specific FHWA references that are frequently used by designers are:

- HDS 5, Hydraulic Design of Highway Culverts
- HEC 14, Hydraulic Design of Energy Dissipators for Culverts and

Channels

- HEC 15, Design of Roadside Channels with Flexible Linings
- HEC 22, Urban Drainage Design Manual

USGS Publications and Resources:

U.S. Geological Survey (USGS) publications specific to Kentucky are summarized on the USGS Kentucky Publications website. Publications that may be of particular use, and are available for download, are:

“Estimating the Magnitude of Peak Flows for Streams in Kentucky for Selected Recurrence Intervals,” Water-Resources Investigations Report 03-4180, is a publication of the USGS that gives estimates of, and presents techniques for estimating the magnitude of peak flows for streams in Kentucky for various return intervals using regionalized regression equations.

“Estimation of Peak-Discharge Frequency of Urban Streams in Jefferson County, Kentucky,” Water-Resources Investigations Report 97-4219, is a publication of the USGS that develops regression equations for estimating peak-discharge frequencies for ungaged streams in Jefferson County having a specific range of basin characteristics.

The USGS has developed a computer program, the National Streamflow Statistics (NSS) program, to provide simple methods of estimating flood-peak discharges and low flow frequency/duration discharges. The NSS program compiles all current USGS regional regression equations for estimating streamflow statistics at ungaged sites. The program can be found at the USGS Water Resources website.

The USGS operates many gauging stations throughout Kentucky. “USGS Real-Time Water Data for Kentucky” is a website that may be used as a starting point to obtain real-time and historical data for those locations. The historical data can be exported to a data file, and used for computing maximum peak flows for a range of recurrence intervals using the USGS software, PEAKFQ. Documentation regarding the PEAKFQ software can be found at the USGS Water Resources website.

Archived Annual Water Data Reports supplement direct access to real-time and historical data. Beginning with Water Year 2006, the Annual Water Data Report is available as a national report only, and local state reports were discontinued. From 1962 until 2005, reports were published by State as paper documents, although most reports since the mid-1990s are also available in electronic form. Annual Water Data Reports are available at the USGS Water Resources website.

NRCS Resources:

Hydrologic and hydraulic-related programs have also been developed by the Natural Resources Conservation Service (NRCS). These include the TR-55 program, as well as several others. Documentation and program download can be found at the NRCS website.

Soil survey information is also available at the NRCS website. The interactive Web Soil Survey application provides online access to soil maps and data nationwide. It allows the user to define an area of interest and obtain information such as soil type, curve number (CN), pH, infiltration rates, and more.

HEC Resources:

The Hydrologic Engineering Center (HEC), an organization within the Institute for Water Resources, is the designated Center of Expertise for the US Army Corps of Engineers in the technical areas of hydrology and hydraulics. The Center has developed and maintains programs that compute runoff and flood profiles, the most familiar being HEC-HMS and HEC-RAS. Documentation and software download information for these and many others can be found at the US Army Corps of Engineers' Hydrologic Engineering Center website.

NOAA Resources:

The National Oceanic and Atmospheric Administration (NOAA) has developed sets of precipitation depth and intensity data for many locations throughout the state. This data can be used to develop project-specific IDF curves and more accurately estimate runoff when using the Rational equation. This data can be found at NOAA's Precipitation Frequency Data Server website.

FEMA Resources:

National Flood Insurance Program (NFIP) Flood Maps and Flood Insurance Studies are available from the Federal Emergency Management Agency (FEMA). The interactive Map Service Center on FEMA's website allows the user to browse FEMA's product catalog or to search for available information.

KYTC Resources:

KYTC's Drainage Branch has developed several spreadsheet solutions for runoff and hydraulic calculations. These can be downloaded at the Drainage Branch's website. On this website, there is also a compiled list of recommended hydrologic tools and software, including links to websites where they may be obtained.

The Drainage Branch also will make available, upon request, archived drainage folders. See DR 304 for more information about archival considerations for drainage folders.

KYTC has a wide variety of maps that have transportation-related information that may be useful in drainage design. These may be accessed at the Division of Planning website. Maps more directly related to drainage design, such as digital ortho images, USGS Quadrangle images, digital elevation models (DEM), wetland maps, and more can be found at the Kentucky Division of Geographic Information (DGI) website. Additional GIS-related information and data sets are also available at the Kentucky DGI website.



Drainage	<i>Chapter</i> Introduction
	<i>Subject</i> Policies

DR 102-1 GENERAL

Drainage concerns are one of the most important aspects of highway design and construction. Two general policies define an adequate drainage structure:

- The design of the structure meets or exceeds KYTC's standard engineering practice, and
- The design is consistent with what a reasonably competent and prudent designer would do under similar circumstances.

To achieve an adequate drainage design, normally a hydrologic and hydraulic analysis and an engineering evaluation of selected alternatives are conducted. The drainage design process includes the following policies:

- It is the designer's responsibility to provide an adequate drainage structure. The designer is not required to provide a structure that will handle all conceivable flood flows under all possible site conditions.
- The detail of design studies should be commensurate with the risk associated with the encroachment and with other economic, engineering, social or environmental concerns.
- The overtopping and/or design flood may serve as criteria for evaluating the adequacy of a proposed design. The overtopping flood and the design flood may vary widely depending on the grade, alignment and classification of the road and the characteristics of the water course and floodplain.
- The predicted value of the 100-year or base flood serves as the present engineering standard for evaluating flood hazards and as the basis for regulating floodplains under the National Flood Insurance Program. The designer must make a professional judgment on the degree of risk that is tolerable for the base flood on a case-by-case basis.

DR 102-2 FEDERAL POLICIES

Numerous pieces of Federal legislation have been enacted containing Federal policies that might affect drainage design and construction. Chapter 3 of

AASHTO's Model Drainage Manual (2005) provides a list of legislation covering various topics such as environmental, health, historic and archaeological preservation, and land and water usage. For detailed information on specific Federal policies, the applicable legislation should be consulted.

DR 102-3 KYTC POLICIES

The drainage design of any highway project shall conform to KYTC policies, procedures, standards, and specifications, as well as other Federal, State and Local requirements. The goals of highway drainage design are to:

1. Remove water from the highway;
2. Prevent surface water from reaching the highway;
3. Drain potential ponding areas caused by highway fills;
4. Consider impacts to and protection of insurable structures outside of the right-of-way;
5. Drain areas undercut by highway excavation;
6. Release these waters at an adequate outlet; and,
7. Allow existing streams to pass through the highway.

These goals shall be accomplished in the most economical means while disturbing the surrounding environment as little as possible. For this purpose, KYTC's drainage design policies are:

- Determine the existing flow conditions at a site; and
- Design a drainage system for the proposed condition that does not significantly change the quality or quantity of flow as compared to the existing condition.

The post-development discharge and velocity should not significantly exceed the pre-development discharge and velocity. In some instances this will require the use of energy dissipaters and/or detention basin storage before disposal.

Consideration should be given to potential maintenance problems and traffic hazards that may result due to clogged inlets and sediment deposition. Also, careful planning and design for adequate temporary drainage measures should be employed to ensure not only the protection of the environment, but also of the project itself.

DR 102-4 LOCAL POLICIES

Many local governmental bodies have developed ordinances, codes, guidelines, or other requirements that may influence roadway drainage design. Generally, the state is not legally required to comply with local ordinances except where compliance is required by specific state statute. However, KYTC shall coordinate

with local agencies to minimize specific concerns.

Specific coordination is necessary with the following local agencies when projects are located in their jurisdictions: Louisville and Jefferson County Metropolitan Sewer District (MSD), Lexington Fayette Urban County Government (LFUCG), or any other local governments that have specific drainage criteria (See DR 202-10).

DR 102-5 DESIGN FLEXIBILITY

Designers should keep in mind that the procedures and methodologies in this manual are guidelines. It is understood that there are other acceptable engineering techniques and technologies for drainage design.

Therefore, this manual places an emphasis on design flexibility. The goal is to be permissive by default and explicit where needed. Sufficient flexibility should encourage independent designs tailored to particular situations. This manual should not supersede the application of sound engineering principles by experienced design professionals. When deviations from guidelines are deemed appropriate for a particular situation, an explanation of the deviations shall be included in the drainage design documentation.



Drainage	<i>Chapter</i> Introduction
	<i>Subject</i> Responsibilities

DR 103-1 GENERAL

Drainage design personnel should be familiar with the responsibilities of various parties involved in the drainage design and review process.

DR 103-2 THE DRAINAGE BRANCH

The primary purpose of the Division of Highway Design, Drainage Branch is to review the drainage design of all projects that either directly or indirectly affect Kentucky's system of highways.

This Branch is made up of the Chief Drainage Engineer, other Drainage Engineers, and support personnel. The Drainage Engineers are each assigned highway Districts. It is the responsibility of each Drainage Engineer to assure that all drainage design follows current Departmental practices, standards, specifications, and applicable Federal, State, and Local regulations.

The Drainage Engineer shall attend and/or conduct all meetings, inspections, or other drainage related reviews that take place during the project development process. This Engineer will provide expertise in all areas related to the proposed project drainage design or system; offer comments and/or recommendations; and determine where corrections should be made when current practices, methodologies, or procedures are violated.

The Drainage Branch will aid the highway Districts in the implementation of drainage design in order to maintain a consistent interpretation of the drainage requirements throughout the state. The level of coordination required between the Drainage Branch and the Districts will be determined on a project-specific basis.

The Drainage Branch shall maintain close communication with the Division of Structural Design, the Districts, and consultants to ensure coordinated and prompt review of projects.

DR 103-3 THE DISTRICT

Each District shall be responsible for managing their internal drainage design as they deem appropriate. For consultant projects, it is the District's responsibility to

perform an initial review of all drainage folders and Advance Situation Folders to verify that they are complete and meet the requirements set forth in this manual. The District shall then coordinate with the Drainage Branch to obtain their review and approval of the folders.

The District is also responsible for coordinating with the Drainage Branch when scheduling project development team meetings. For projects requiring FHWA oversight, the District is responsible for including them in the review process (See DR 304)

DR 103-4 THE DESIGNER

The Designer's primary responsibility is to provide an adequate drainage design. This includes the responsibility to become familiar with the policies, procedures, and accepted methodologies as outlined in this manual. It also includes maintaining a current version of the manual as revisions or updates are issued (see DR 101-3).

As discussed in DR 102-5, flexibility in design is encouraged. However, when the Designer elects to use other avenues of drainage design, with which the Cabinet is not familiar, delays in processing drainage designs and submittals may occur. It is the Designer's responsibility to inform and educate the Cabinet in all areas of the procedures employed in a drainage design not covered in this manual. This is especially true when the Designer uses computer applications that are not on the Cabinet's list of recommended applications (See DR 1102). Full documentation of all procedures that differ from those discussed in this manual shall be provided by the Designer at no expense to the Cabinet. The Cabinet reserves the right to reject the use of any procedures and/or computer applications that the Drainage Branch deems to be inappropriate, unproven, or flawed.

The Designer is responsible for documenting the drainage design by compiling and preserving all pertinent information on which the design and decisions were based (See DR 300). The Designer is also responsible for developing the documentation for applicable permits, FEMA "No-Rise" Certifications, FEMA map revisions, or any other special drainage requirements on a project.

DR 103-5 FHWA

The oversight responsibilities of the Federal Highway Administration (FHWA) on federally funded projects are outlined in the current KYTC and FHWA Stewardship Plan. While Federal law allows a State Transportation Agency to assume certain project approvals and authorities, the FHWA is ultimately accountable for ensuring that the Federal-aid Highway Program is delivered consistent with established requirements.

Table 103-1 lists the specific project oversight responsibilities as described in the Stewardship Plan.

Table 103-1, Federally Funded Project Oversight	
Type of Project*	Primary Oversight Responsibility
Interstate	FHWA
Non-Interstate NHS	KYTC
Non-NHS	KYTC
Appalachian Development Highway System (ADHS) (new construction only)	FHWA

* In addition, other projects may be selected by mutual agreement of the FHWA and KYTC for FHWA oversight.

The FHWA will be responsible for reviewing those projects for which they have oversight responsibilities. In particular, the FHWA will be responsible for the following project approval actions:

- Unusual or complex bridges or structures on the Interstate System will require FHWA Headquarters review and approval of the preliminary Type Size and Location (TS&L) report.
- Unusual, complex, or large bridges or structures located off of the Interstate or NHS system may be designated for FHWA oversight, if requested by KYTC. In this case, FHWA Headquarters review and approval is not required but FHWA Headquarters will provide technical assistance when requested.

Specific to drainage design, unusual structures include hydraulic structures that involve complex stream stability countermeasures, or designs or design techniques that are atypical or unique.

When FHWA oversight is required, the preliminary drainage folder and/or Advance Situation Folder should be submitted to the FHWA for review.

More details about the FHWA responsibilities are available in the Stewardship Plan, which is available on KYTC's website. More details about the definitions of "unusual bridges and structures" are described in the FHWA memorandum on Project Oversight of Unusual Bridges and Structures, which can be found at the FHWA website.



Drainage	<i>Chapter</i> Introduction
	<i>Subject</i> The Review Process

DR 104-1 GENERAL

The Drainage Branch shall be notified of all project development team (PDT) meetings to ensure that a Drainage Engineer may attend. The drainage review process is integrated into the project development process as described in the Highway Design Manual chapter HD 200. Key milestones in the project development process that are relevant to the drainage review process will be discussed in this section, and are listed below.

1. Pre-Design Conference
2. Selected Alternative Meeting (this meeting is often referred to as the Preliminary Line and Grade Inspection)
3. Preliminary Drainage Folder
4. Drainage Inspection and Report
5. Advance Situation Folder
6. Final Drainage Folder

See Exhibit 100-1 for a flowchart of the drainage review process.

DR 104-2 PRE-DESIGN CONFERENCE

The Pre-Design Conference is necessary when a consulting engineering firm is awarded a contract for the design of a project. The pre-design conference will begin to establish the purpose and need of the project and finalize the scope of the work to be performed by the consultant. Major drainage items requiring special attention, such as stream impacts, existing FEMA flood studies, etc., should be identified. The District's project manager shall coordinate with the Drainage Branch to determine the Drainage Branch's level of involvement at this stage.

DR 104-3 SELECTED ALTERNATIVE MEETING

During the Selected Alternative Meeting (Preliminary Line and Grade Inspection), the PDT meets to select a preferred alternative from the alignments studied during Phase I, the conceptual design phase.

No formal drainage submittal is required. However, key drainage issues should be identified and preliminary sizes may be determined. Consultation with the

Division of Structural Design may be required. The “Water-Related Impacts Summary” form is required for all projects and shall be included as an attachment to the meeting minutes. See section DR 202-18 and Exhibit 200-3 for further explanation and discussion of this document.

DR 104-4 PRELIMINARY DRAINAGE FOLDER

The preliminary drainage folder is the initial document for presenting the proposed drainage design. It shall be submitted prior to the Drainage Inspection to provide ample review time prior to the inspection. See DR 300 for more information about preliminary drainage folders.

The preliminary drainage folder will be reviewed by the District project manager and the Drainage Branch to ensure that the proposed drainage design is consistent with current procedures, accepted methodologies, policies, standards, and specifications. DR 304 contains more information related to submittal requirements and specific review responsibilities.

DR 104-5 DRAINAGE INSPECTION AND REPORT

The Drainage Inspection is usually held concurrently with the Final Inspection. The Drainage Branch may waive the Drainage Inspection for any project after reviewing the preliminary drainage folder. This waiver would normally apply to projects that are very minor in scope.

When the Drainage Inspection is held with the Final Inspection, then the Drainage Inspection Report should be included in the Final Inspection Report. In this case, the drainage comments shall be grouped at the end of the inspection report. This includes drainage comments and recommendations made by any member of the inspection team. When the Drainage Inspection is held at a different time than the Final Inspection or when otherwise deemed appropriate by the project manager, a separate Drainage Inspection Report shall be written. See HD 204 for more information about Final Inspections.

The Drainage Inspection Report shall be divided into general comments and specific comments:

- General comments and recommendations are those which apply to the entire project. They apply to the plans in general, or they are applicable to the drainage folder in general. General comments may also arise from proposed designs that contradict guidance contained in this manual.
- Specific comments are those that are applicable to individual drainage structures on the project. These comments and recommendations are obtained from a combination of the drainage folder and plan review. Every drainage structure on the project shall be included in the specific comments. They shall be listed by station, length, size, structure type and skew, and they shall be organized in order as they appear on the mainline stationing. Specific comments, or a note of approval, are then shown for each structure. Group items such as storm sewers, inlet spacing, ditch analyses, and

entrance pipes may be listed by the group name following the individual structures. Only those items which merit comments within the group need to be listed. The remainder of the items within the group can be approved by using a statement such as, "Remainder of _____ Group is approved as presented."

For projects with proposed structures requiring sounding layouts, the location and span arrangements should be reviewed at the inspection to expedite the scour review. The recommended location, span arrangement, abutment type, and the sounding layout should be documented in the inspection report. At this point, the District project manager should consider ordering the geotechnical investigation.

Inspection reports shall be submitted electronically to the project manager, who shall then forward them to all inspection team members for comment and/or endorsement. Failure to provide comment will constitute an approval of the document. See HD 204 for more details about submittal of inspection reports.

Upon approval of the Drainage Inspection Report, the Designer shall incorporate the recommendations and/or changes into the drainage design and folders as applicable. Unless specifically requested, further submittals other than the Advance Situation Folder and Final Drainage Folder are not required.

DR 104-6 ADVANCE SITUATION FOLDER

The Advance Situation Folder is considered the "order form" from the project manager to the Division of Structural Design (DSD) to begin structure design. It should be submitted after the Drainage Inspection Report has been approved and before the submittal of the right-of-way plans. All applicable inspection comments should be reflected in the folder.

The Advance Situation Folder will be reviewed by the District project manager and the Drainage Branch to ensure that the proposed hydraulic analysis is consistent with current procedures, accepted methodologies, policies, standards, and specifications. This review will also verify that all comments from the review process have been addressed. The Drainage Branch's approval of the Advance Situation Folder serves as the notification to the Division of Structural Design that final structural design can begin.

The DSD will review the Advance Situation Folder for conformity to structural layout and design criteria. A folder is required for all bridges (wet or dry), box culverts, 3-sided culverts, retaining walls, and special structures. However, the Drainage Branch is only required to review folders that contain drainage calculations (wet structures). Advance Situation Folders shall never include small drainage structures (see DR 601-4), ditch calculations, or other non-structural drainage calculations.

See DR 304 and the Structural Design Manual, Section SD 202 for more specific information related to the Advance Situation Folder, submittal requirements and specific review responsibilities.

DR 104-7 FINAL DRAINAGE FOLDER

The Final Drainage Folder is the legal document that will be archived for the project drainage design. It should be submitted prior to the submittal of final plans. See DR 300 for more information about final drainage folders.

The final drainage folder will be reviewed in a similar fashion as the preliminary folder. The project manager and the Drainage Branch's Drainage Engineer should make a final review of the folder to ensure compliance of content and to ensure that all comments from the review process have been addressed. DR 304 contains more information related to submittal requirements, specific review responsibilities, and folder archival considerations.



