

Introduction to the HY-8 Quick Start Guide

This Quick Start Guide is intended to provide basic information for downloading and running version 7.3 of the HY-8 Culvert Hydraulic Analysis Program (HY-8 7.3). HY-8 is a computerized implementation of FHWA-endorsed culvert hydraulic analysis approaches and protocols. The HY-8 program is available free of charge.

The FHWA has been sponsoring development of computerized culvert hydraulic software since the early 1960's (beginning with the HY-1 program). The FHWA released the initial DOS version of the HY-8 program in the early 1980's and released a Windows version (7.0) in March 2007. The HY-8 program has successfully operated on all current "flavors" of the Windows operating system.

HY-8 7.3 represents the third phase of the FHWA's multi-phase culvert hydraulic software upgrade plan. The plan calls for incremental upgrades and additions of features, based on available time, budget, and adoption of new hydraulic research and techniques. The following state Departments of Transportation have contributed to the pooled-fund project, which made the development of version 7.3 possible: Alabama, Iowa, Minnesota, Nebraska, Ohio, South Dakota, Texas, and Wisconsin. The FHWA offers these Departments its sincere thanks. The software development work was completed by Aquaveo, LLC.

What's in this Quick Start Document

This document includes information about:

- technical methods,
- downloading the software,
- file management,
- new features in version 7.3, and
- getting help.

Technical Methods

The technical methods incorporated in the updated HY-8 program are based on the following research efforts and FHWA publications:

- "Hydraulic Design Series 5: Hydraulic Design of Highway Culverts" (HDS 5), Third Edition, February 2012
- "Hydraulic Engineering Circular 14: Hydraulic Design of Energy Dissipators for Culverts and Channels" (HEC-14), Third Edition, July 2006
- "Effects of Inlet Geometry on Hydraulic Performance of Box Culverts," December, 2006
- NCHRP Project 15-24, Hydraulic Loss Coefficients for Culverts, 2011

HDS 5 and HEC-14 are the primary technical references for the software, and PDF versions can be downloaded from the FHWA Hydraulic Engineering website:

https://www.fhwa.dot.gov/engineering/hydraulics/library_listing.cfm.

FHWA certifies that HY-8 7.3 continues to represent reviewed, tested, and accepted software for the purposes of performing FHWA culvert analyses regulated under 23 CFR 650 Subpart A and meeting 44 CFR 65.6(a)(6) in the FEMA NFIP regulations.

Downloading

The installation package executable file can be obtained by downloading from the FHWA Hydraulic website at: <https://www.fhwa.dot.gov/engineering/hydraulics/software/hy8>.

As stated in the FHWA Hydraulics website, by downloading the software, the user is agreeing to and accepting the following conditions and limitations:

- FHWA does not provide user assistance or support for this software.
- The application of this software is the responsibility of the user. It is imperative that the responsible engineer understands the potential accuracy limitations of the program results, independently cross checks those results with other methods, and examines the reasonableness of the results with engineering knowledge and experience.
- There are no expressed or implied warranties.
- The installation package can be downloaded to any location (for example, folder “C:\Temp”) on the user’s computer.

Prior to Installation

The development team modified this release so that older versions of HY-8 can remain on the user’s system. In doing so, users may end up with multiple versions (version 7.1, version 7.2 etc.) on their computers.

If users wish to remove older Windows versions, they can go to the Windows Control Panel and use the “Add/Remove Programs” command. When doing so, user-created project files will not be deleted, but will remain in the program folder.

Installation Location and Files

The default location for program installation is folder: “C:\Program Files\HY-8 7.30”. As well as installing program files, the setup program also adds a tutorial (“HY-8 7.3 QuickTutorial.pdf”), sample input files, and PDF versions of HDS 5 and HEC-14 to the system. The user also has the option to change the file location to any directory without affecting the performance of the program.

File Management

The Project File Approach

HY-8 versions 7.0 and newer adopt a *Project File* approach. These project files are implemented into the *Project Explorer* – allowing quick selection and application of a specific culvert system¹. HY-8 saves these project files using a “.hy8” extension and allows any file name format and length permitted by Windows.

As described below, the addition of this approach adds utility in: (1) organizing and applying culvert systems within multiple drainage crossings, and (2) analyzing different design configurations and materials.

Multiple Drainage Crossings

In HY-8 version 7.0 and newer, any number of crossings can be defined within the *project file*. Users now have the option of performing an analysis on several crossings and grouping them together. Of course, the Windows version retains the older version’s ability to consider only a single drainage crossing. This single crossing can also still consist of multiple culvert systems (e.g., three circular barrels at one invert [system 1] and a box culvert at another invert [system 2] at the same roadway crossing).

Design Alternatives

HY-8 versions 7.0 and newer provide a means to consider separate design alternatives of the same crossing within the same project file.

HY-8 provides the user the option of “copying” a culvert and associated crossing information. With this “duplicate crossing” the user can make any change(s) they wish to evaluate. The project explorer then makes it easy to toggle back and forth between the alternative crossing designs.

Order of Input

In the Windows version of HY-8, a single input screen presents all of the input necessary to analyze a single crossing.

However, there are some important subtleties - the grouping of the information has been organized into “crossing” information and the “culvert” information. The discharge, tailwater, and roadway data are unique to the crossing while the culvert shape, inlet conditions, and site data define a culvert within the crossing.

¹ As in prior versions of HY-8, a *culvert system* is considered as a collection of culverts, having the same type, material, inlet, dimension, and layout (invert elevations, length) characteristics. So a single barrel corrugated metal pipe or a box culvert with cell barrels (cells) would be considered a system, whereas, if a crossing had both a circular HDPE AND a pipe arch, these would be considered two systems. A potential reason for multiple culvert systems at a crossing would be to allow “critter crossings” in one system and normal discharge through the other system.

Report Generation

HY-8 includes report generation tools that are customizable, allow many options for plots, and are saved in rich text format (RTF) or portable document format (PDF). The primary target for the report is an MS-Word document; however, an rtf format is readable by many word processing programs.

A few issues related to Report Generation remain in this version. Each time a table or graph is written to the report, the report starts a new page. This can make reports longer (wasting paper). The HY-8 7.3 QuickTutorial document describes how to edit a RTF formatted HY-8 report in Word to condense the number of pages and make the document more concise. HY-8 also has the capability to write energy dissipation reports from the energy dissipation dialog.

What's New in Version 7.3

Notable new features completed for version 7.3 include analysis of:

- Discharge values, which can now be entered in three ways
- Hydraulic jumps that form within the culvert barrel
- Broken back culvert profiles for all HY-8 barrel shapes
- Horizontal and adversely sloped barrels
- Additional culvert shapes

Summaries of the new features follow, and additional detail may be found in the HY-8 User Manual for version 7.3, available from the Help menu within HY-8.

User Selection of Method for Entering Discharge Values

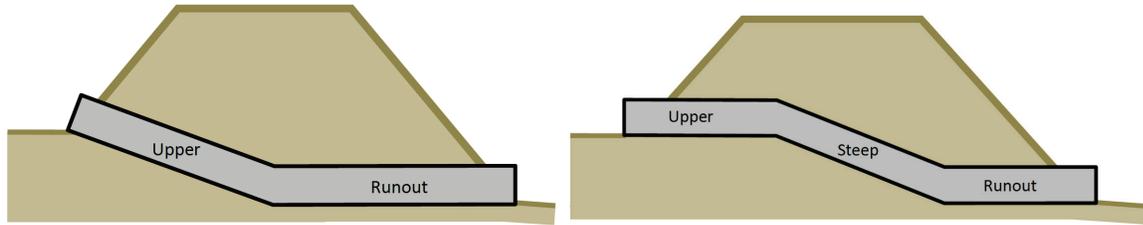
HY-8 7.3 now has three options to enter discharge data into HY-8: "Minimum, Design, and Maximum", "User-Defined", and "Recurrence". The "Minimum, Design, and Maximum" is the default option and historically was the only option available.

Hydraulic Jumps

When hydraulic jumps are calculated to occur, they are reflected in both the water surface profile plot and summary table. To determine if a hydraulic jump exists, HY-8 calculates the supercritical and subcritical water surface profiles that form within the culvert using a direct step profile computation. At each location along the two profiles, HY-8 computes the sequent depths of the supercritical profile and compares these sequent depths to the subcritical profile's computed depth.

Broken-Back Culverts

Broken-back culverts have one or more changes in slope along the length of the culvert barrel. HY-8 7.3 supports single and double broken-back culverts, meaning one or two changes in slope.



Horizontal and Adversely Sloped Barrels

HY-8 7.3 has the ability to analyze culverts with horizontal and adverse (inlet invert elevation less than the outlet invert elevation) slopes.

Additional Culvert Shapes

HY-8 has a shape/coefficient database. This database allows FHWA² to add new or update older shapes or materials to the HY-8 interface. The database also allows FHWA to modify the analysis coefficients used to compute inlet control depths. New shapes/coefficients added to version 7.3 of HY-8 are for concrete open-bottom arches, circular embedded culverts, and South Dakota prefabricated reinforced concrete box (RCB) shapes. Details about the research resulting in the coefficients for these shapes is discussed in the HY-8 7.3 user manual.

HY-8 Version 7.3 has coefficients for computing inlet control depths for concrete open-bottom arch (commonly called Con/Span) culverts. Concrete open-bottom arches have unique geometric configurations, and multiple sizes and shapes are available. The exact coordinates used in HY-8 to compute areas and other geometric cross section parameters for these structures are available in the HY-8 7.3 user manual.

In HY-8 version 7.3 for embedded circular culverts, HY-8 uses the 5th-degree polynomial to determine the inlet control depth. The coefficients used are derived from the NCHRP 15-24 report. This report gives coefficients for a circular culvert that is embedded 20%, 40%, and 50%. HY-8 will linearly interpolate between the coefficients for the level of embedment specified; however, if the embedment is outside the range of data, the closest set of coefficients is used.

The document "Effects of Inlet Geometry on Hydraulic Performance of Box Culverts" (FHWA Publication No. FHWA-HRT-06-138, October 2006) describes a series of tests that were performed to obtain design coefficients for various inlet configurations of reinforced concrete box culverts commonly used by the South Dakota DOT. The following variations in inlet configurations were tested: wingwall and top edge bevels and corner fillets, multiple barrels, different culvert span-to-rise ratios, and skewed headwalls. These test results were modified and incorporated into HY-8 as 10 sets of inlet configurations under the label "South Dakota Concrete Box Culvert."

Getting Help

Beyond this Quick Start Guide, HDS 5, and HEC-14, the majority of the HY-8 documentation is self-contained within the program. The functional use of the program is documented in the

² To ensure adherence to FHWA HDS-5 approaches, only FHWA will have the ability to access this file. The file and the contents are still considered to be under development and remain proprietary.

hyper-linked help file available from the Help menu or by selecting help buttons or icons () from the graphical user interface. The help file is formatted as a user manual and can be printed as a hard copy.

Additionally, the National Highway Institute has a design course, 135056 – “Culvert Design,” which heavily features application of the HY-8 software to complete in-class design problems. (135056 – “Culvert Design”). For more detail on this and other courses, please visit the NHI website: <https://www.nhi.fhwa.dot.gov/default.aspx>.

While FHWA does not offer any user support (as described in the Terms and Conditions for downloading and using the program), comments and bug reports may be sent to:

CommentsOnHY8@dot.gov.