CHAPTER 9

Guidelines for Alternative Hydraulic Models

9.1 Purpose

As explained in Chapter 8, the IDNR prefers the use of HEC-RAS for hydraulic modeling. However, circumstances occasionally arise where another hydraulic model program may be used in place of HEC-RAS. For example, a model may already exist in another format or study reach conditions may dictate the use of an unsteady flow model. The purpose of this chapter is to discuss some of the issues that should be considered when using other hydraulic models.

As of 2015, modern computer operating systems (Windows 7 and its successors), do not support DOS-based, 16-bit programs. Therefore, these programs are difficult to run without specialized emulator software, and many IT departments (including the State of Indiana) do not allow the use of this software. Therefore, the IDNR will no longer accept modeling using these DOS-based programs (HEC-1, HEC-2, TR-20 and others). If there are extenuating circumstances where options to using more modern programs is problematic, then discussion with IDNR staff prior to submittal is strongly recommended.

9.2 HEC-2

HEC-2 is the predecessor of HEC-RAS. In the process of converting HEC-2 to Windows, a couple of calculation methods were changed, which must be considered when converting models:

- Comparison of Conveyance at Cross Sections: HEC-2 computed conveyance at each coordinate point along the cross-section and summed these partial conveyances across the section. The default in HEC-RAS is to compute conveyance zone at breaks in Manning's "n" value across the section and then take the sum of all partial conveyances. While the differences between the two methods for the calculation of water surface profiles are not usually large, they will not match exactly.

  HEC-RAS has the option to compute the conveyance either way, but the "breaks at Manning's "n" values only" is the default. The practice of the IDNR is to use the default within HEC-RAS for new models, but if the purpose of the model is to replicate a previous HEC-2 model, then it is acceptable to use the HEC-2 style of conveyance calculations.

- HEC-2 "Special Bridge" Method Conversion to HEC-RAS: Often the conversion of the data for the "Special Bridge" method in HEC-2 will not be sufficient in HEC-RAS. Engineering judgment is needed for each bridge to determine if the converted bridge modeling is accurate.

- Road Fill at Bridge Sections: In HEC-2, the coordinate points for the base cross-section and coordinate points for the bridge fill had to match exactly for fill outside of the bridge opening. However, many times care was not taken in making sure that this was done, and the result was that "cracks" would occur between the road fill and the base cross-section. As a result, a large amount of wetted perimeter would be incorrectly added to a bridge section, without adding a comparable amount of area. HEC-RAS solves this problem by "clipping" the road fill using the base cross-section. Therefore, the "low chord" information should be deleted from a converted HEC-2 model outside of the actual bridge opening.

FEMA released guidance (dated April 30, 2001) regarding the conversion of HEC-2 models to HEC-RAS for Map Revisions. FEMA policy, which is acceptable for IDNR purposes, is:

- The complete effective HEC-2 model should be converted to a HEC-RAS model using the import routine within HEC-RAS.

- Switch to the HEC-2 style of conveyance calculations in HEC-RAS.

- Truncate the model to the study reach and complete the following. Study reach extents may need to be varied and this process repeated in order to achieve the required tie-in.

    - Check that HEC-2 Special Bridge data was completely reflected in the conversion to HEC-RAS.

    - If distance to bounding sections at bridges imported as zero, revise to 1 foot in order to allow HEC-RAS to run.

    - If differences in elevation between the HEC-2 and HEC-RAS still exist, check bridge calculations and critical depth issues to explain the differences. The Division of Water has a publication available on their website (the HEC-2 troubleshooting guide) that provides more detail into working with HEC-2 models.

    - If the HEC-2 floodway was computed with method 1.4, the actual encroachment stations computed should be input to allow floodway matching if base profile elevations change even slightly.

- In order for further revisions to the model to be done within HEC-RAS, the HEC-RAS elevations must tie in with the effective profile within 0.5 feet at the upstream and downstream ends of the study reach.

In other words, if the goal is to revise a portion of a HEC-2 model, it is not necessary to correct the entire model (as previously required). Instead, convert the entire model as described above, document the differences in conversion, select the reach of interest such that the 0.5 foot elevation tie-in difference is achieved at the upstream and downstream ends, and use the HEC-RAS model for further corrections and revisions.

9.3 Other One Dimensional, Steady State Models

9.3.1 WSPRO

WSPRO is the hydraulic model developed by the USGS and the FHWA to compute water surface profiles and losses at bridges. The WSPRO methodology for modeling bridges is somewhat different than HEC-RAS in terms of coefficients and cross-section locations. In a recent revision to HEC-RAS, the WSPRO methodology was incorporated as an option in the bridge loss calculation routines. Use of both the WSPRO model and WSPRO method within HEC-RAS are acceptable for IDNR modeling needs, but the differences between the two methodologies should be taken into account during the modeling. WSPRO does not have a floodway calculation routine. FWHA no longer supports WSPRO, and recommends HEC-RAS for hydraulic modeling at bridges.

9.3.2 E431

E431 is the predecessor of WSPRO. It is no longer supported and is not available for a personal computer. However, a number of FISs were completed using E431 and would need to be converted or HEC-RAS before they can be revised. Programs are available for performing a limited conversion of a E431 model to HEC-2. The HEC-2 should then be converted to HEC-RAS.

9.3.3 WSP2

WSP2 is the water surface profile program developed by the NRCS and used for FISs completed by the NRCS. The NRCS developed WRAS, which will convert WSP2 models to HEC-RAS. The WSP2 model should be converted to HEC-RAS.

9.4 Unsteady State Models

Hydraulic modeling has traditionally been based on the assumptions of steady state flow and minimal effects of storage along the stream reach. However, there are some situations in Indiana where both of these assumptions cause problems when trying to reasonably model a stream. Examples of these cases are flat streams with wide overbanks that act as storage areas for flood waters; in-channel dams, gates, weirs or control structures; and regional detention facilities.

In the past, the computing power required to solve the complex equations of unsteady state flow models made their use prohibitive. With advances in personal computers, running an unsteady state flow model has become a feasible option. While it may be desirable to use the unsteady state model to more accurately determine regulatory BFEs, these models are very complex and a wide base of knowledge and experience has not yet developed within the engineering community. Users should recognize that an unsteady state model requires much more review and scrutiny than traditional steady state models. Therefore, these models should be used with caution and coordination with the IDNR prior to using these models is essential.

If unsteady state modeling is used, there will still be the issue of floodway development criteria. This has not been addressed by any agency at any level of government. The concepts of floodway definition and delineation outlined in previous chapters cannot be directly applied to unsteady state flow situations. In the development of these models, interpretation of the floodway should be done in a manner consistent with the intent of the floodway surcharge criteria for steady state flow (i.e., equal to or less than 0.14 feet), but drawing a floodway that is "smooth with consistent topwidths" and which has "excessive velocities" may not be possible with the inclusion of storage areas.

The Association of State Floodplain Managers released a paper (*One-Dimensional Unsteady and Two-Dimensional Models: issues for Regulatory Use*) on regulatory issues with both 2-D and unsteady state models which is recommended reading before deciding to use 2-D or unsteady state models.

Unsteady state models that may be acceptable are described below.

9.4.1 HEC-RAS (Unsteady State Flow Routine)

Beginning with the release of HEC-RAS 3.0, unsteady state flow computation modules were available in HEC-RAS. These computation routines are borrowed from the model UNET. With the inclusion of these routines in a Windows environment and using the same section editing scheme as previous versions of HEC-RAS, compiling and running an unsteady state model is now easier.

9.4.2 UNET

UNET can be viewed as the unsteady state version of the USACE HEC-2; however, it was developed separately from HEC-2. UNET can be used to model items such as levees (including levee failures), ponds, tunnels, gates, weirs and natural storage areas. Unless an engineer is working with an old model already done in UNET, there is little reason not to use HEC-RAS instead.

9.4.3 ICPR

ICPR (Interconnected Pond Routing Model) was developed by Streamline Technologies for modeling stormwater ponds in series, with full incorporation of tailwater effects. It also has the ability to model other types of structures, such as bridges and culverts, and to model overbank storage.

ICPR combines the hydrologic and hydraulic analyses within the same model. Discharge hydrographs are generated using alternative rainfall-runoff transformation methods and alternative rainfall distributions. The unsteady flow capabilities of ICPR allow for routing of the actual generated subbasin hydrograph at specified nodes rather than just the peak discharge. A node may represent the confluence of a subbasin with another subbasin, a detention facility, a channel reach (open or pipe), or a diversion location, etc.

9.4.4 XPSWMM

XPSWMM is also a modeling software suite that combines the hydrologic and hydraulic analysis within the same model. XP-SWMM is a dynamic unsteady flow model rather than a steady state or standard step model. Dynamic models allow the effects of storage and backwater in conduits and floodplains and the timing of the hydrographs to yield a representation of the Hydraulic Grade Line at any point in space and time.

9.5 2-D models

There are a number of software packages available that can be used to model a river system in 2 dimensions using a gridded network of elevation points. Many of these modeling solutions are "quasi" 2-D, in that they require a 1-D solution for the channel areas. Given the complexity of the solution methods, applying these solutions to address regulatory and floodway applications is not straightforward, and more experience with these types of models is necessary before making decisions about the acceptability of their use in regulatory situations.