17.0 Computer Applications

17.1 Introduction

Computer applications can be tools for achieving greater efficiency and increased accuracy of engineering analysis and design. This Chapter presents general guidelines that encourage the use of computerized applications as an extension of, rather than a substitute for, technical analysis. The guidelines presented herein are designed to preserve, rather than obscure, the relationship between engineering theory and computerized computation, and ensure calibration of standardized methodologies against project-specific analysis requirements.

17.2 Submittal Requirements

Documentation of computerized applications shall be provided in hard copy and in electronic format to the City of Greenwood Village (Village). Hard copy of all input and output files shall be included in an appendix of the drainage studies, preferably using computer-generated summaries where available and where appropriate. Relevant intermediate computations should be summarized in the appendix of the drainage studies to assist the Village in review. All software packages shall be clearly identified by name, vendor, version, and date.

17.3 Software Verification

This Section presents guidelines for verifying the accuracy of the computer code with respect to theoretical models, equations, and design procedures adopted in this Drainage Criteria Manual.

17.3.1 Documentation

The Village will not accept the use of any software package that is not commercially available, and not provided with vendor-supplied theoretical documentation and user documentation. Use of proprietary software is subject to approval by the Village. The applicant is responsible for reviewing the theoretical documentation to verify that the fundamental models and equations, as defined and adopted for analysis and design in this Drainage Criteria Manual, have been included in software algorithms with consistency and accuracy. The Village will not accept any software without theoretical documentation. The applicant is also responsible for proper application of the software in accordance with the criteria presented in the user documentation.

17.3.2 Testing

The Village encourages in-house verification of new software applications and revised versions. The Village recognizes that not all software capabilities can be tested but recommends verification of software capabilities specifically required for a proposed project and verification of formally documented revisions to existing software. Minimal recommended testing protocol

should include duplication of design examples provided in the user documentation or duplication of project-specific applications generated by previously verified software.

The Village recommends establishing and maintaining a system of records to document the testing protocol and the project applications for each software package. Software should be consistently referenced by name, vendor, version, and date.

17.4 Software Calibration

This Section presents guidelines for establishing the applicability of the theoretical models and equations to the specific requirements of the project, assuming accurate translation into computer code has been verified in accordance with the criteria presented in the previous Section.

17.4.1 Theoretical Assumptions and Limitations

The applicant shall verify that the simplifying assumptions and limitations used to develop the theoretical models and equations are applicable to the specific project. Source documentation used to establish project applicability shall be the theoretical documentation provided with the software or direct communication with the vendor to resolve technical issues not addressed within the documentation. The Village emphasizes that resolution of ambiguous technical issues requires practical software-generated verification of all verbal communication and written documentation. The following two examples illustrate the type of theoretical calibration required to ensure theoretical correlation between a standardized algorithm and a specific project.

1) Surface Water Hydrology. Rainfall-runoff models typically offer a variety of routing methodologies for use in generating a project-specific model. The applicant shall be familiar with the restrictions governing the application of routing methodologies in modeling and shall select a procedure that is appropriate for the project.
2) Open Channel Hydraulics. Most backwater computations use the standard step method, which is limited to one-dimensional, steady-state, fixed-bed flow conditions and is therefore inappropriate, or requires modification, for use in two-dimensional flow situations, hydrographic analysis of unsteady flow, or in channels with significant sediment transport.

17.4.2 Empirical Calibration

The applicant shall pay close attention to algorithms requiring definition of empirical coefficients, such as loss computations for infiltration, hydraulic friction losses, abutment losses, and culvert entrance losses. Empirical algorithms are restricted in application to the quantitative limits of the source data. When using non-standard configurations, such as culvert entrance designs, computations should be manually verified and it may be necessary to substitute default values for computer-generated values.

17.5 Approved Software

The following engineering software packages have been approved for use:

1) Rainfall-Runoff Models
   a. Colorado Urban Hydrograph Program (CUHP). The CUHP program generates the Colorado Urban Hydrograph in accordance with criteria developed and refined over nearly 30 years for the Denver region. The CUHP software is available through the Urban Drainage and Flood Control District (UDFCD).
   b. Urban Drainage Storm Water Management (UDSWM). UDSWM is the UDFCD modification of the Runoff Block of the Storm Water Management Model (SWMM) sponsored by the U.S. Environmental Protection Agency (EPA). UDFCD modified the SWMM program to accept the Colorado Urban Hydrographs generated by CUHP
   c. HEC-1. HEC-1 is a single-event surface runoff model with numerous simulation options for designing storm events, routing runoff hydrographs through channels and routing runoff hydrographs through storage reservoirs. The model is widely used in planning studies for watersheds which require network modeling to establish design discharges at selected locations. The model includes a kinematic wave routing option that is applicable for watersheds with no significant storm sewer drainage system. HEC-1 is commercially available through third party software vendors.
   d. TR-20 / TR-55. TR-20 is a single-event surface runoff model developed by the Soil Conservation Service (SCS) for use with the 24-hour SCS runoff hydrograph. TR-55 is an abbreviated version of TR-20 appropriate for application to smaller watersheds not requiring modeling options available in TR-20. The simulation options in TR-20 are very similar to those available in HEC-1 with one exception. The use of variable storm locations required for some larger watersheds is more easily implemented in TR-20. TR-20 and TR-55 are commercially available through third party software vendors.
2) Hydraulic Analysis - Open Channels and Bridges.
   a. HEC-2. HEC-2 is a one-dimensional, steady state, fixed bed model of open channel flow that has defaulted into the industry standard for floodplain delineation and open channel hydraulic analysis. HEC-2 is applicable for use in a wide variety of artificial and natural channelized flow situations that do not violate the stated constraints.
   b. HEC-Riverine Analysis System (HEC-RAS). HEC-RAS is a remodeled version of HEC-2 that employs the same or similar theoretical algorithms with sophisticated graphics and interactive file management capabilities. Some of the hydraulic options have been improved or expanded, such as determining friction loss around bridge abutments. HEC-RAS eliminated the cross-sectional sequencing of data associated with subcritical and supercritical flow regimes, greatly improving the ease of modeling hydraulic systems subject to both types of

flow.

c. Water Surface Profiles (WSPRO). The WSPRO program is a one-dimensional, steady state, fixed-bed model nearly identical to HEC-2. Historically, before HEC-RAS was introduced, the WSPRO model included more diverse options for bridge abutment friction losses and eliminated the need for sequencing cross-sectional data with respect to subcritical and supercritical flow regime.

3) Hydraulic Analysis - Culverts
   a. Culvert analysis should be performed using software packages derived from the equations and procedures presented in "Hydraulic Design of Highway Culverts".
4) Hydraulic Analysis - Urban Drainage Systems
   a. UDSWM (see above)
   b. AutoCAD Hydraulic Design Modules. Hydraulic design of larger and more complex storm sewer drainage systems can benefit from incorporating the design into the three-dimensional topographical base mapping for the project and using the CAD Hydraulic Design Module for facilities layout, hydrologic modeling and hydraulic routing. This approach can be especially efficient when conveyance properties change as larger storms, which exceed the storm sewer capacity, are routed through the total drainage system.
5) Hydraulic Analysis –Local Detention
   a. UDSWM (see above)

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