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CEMVD-PDP

21 August 2024

MEMORANDUM FOR CEMVD-PDP (*name redacted*)

SUBJECT: Recommend National Certification of Hydrologic Engineering Center's Ecosystem Functions Model (HEC-EFM) and HEC-GeoEFM

1. References:

- a. Engineering Circular 1105-2-412: Assuring Quality of Planning Models, dated 31 March 2011.
 - b. HEC-EFM 2.0 and 3.0 and HEC-GeoEFM 1.0 National Certification Memo, 10 April 2015 (Encl 1).
 - c. Final Planning Model Quality Assurance Review Report for HEC-EFM and HEC-GeoEFM, Battelle Memorial Institute and CDM Smith, 17 July 2012 (Encl 2).
 - d. HEC Software Release Process Memo, 14 October 2022 (Encl 3).
 - e. HEC-EFM Quick Start Guide, Version 5.0, September 2020 (Encl 4).
 - f. HEC-EFM Release Notes, Version 5.0, September 2020 (Encl 5).
 - g. HEC-GeoEFM User's Manual, Version 2.0, May 2024 (Encl 6).
2. The Ecosystem Restoration Planning Center of Expertise (ECO-PCX) recommends national certification of the HEC Ecosystem Functions Model (HEC-EFM) and HEC-GeoEFM.
 3. The USACE Institute for Water Resources Hydrologic Engineering Center (HEC) developed HEC-EFM and HEC-GeoEFM to support field offices designing ecosystem restoration projects and managing water and ecosystem resources. HEC is the USACE Center for Expertise in the area of surface and groundwater hydrology, river hydraulics, planning analysis, real-time water control management, and other closely associated technical subjects.
 4. HEC-EFM and HEC-GeoEFM are software tools that help analyze ecosystem responses to changes in flow regimes of rivers and connected wetlands. Together these tools enable project teams to visualize existing ecological conditions, highlight promising restoration sites, and assess different ecosystem restoration and management alternatives.

In USACE restoration planning, HEC-EFM and HEC-GeoEFM are used to predict habitat changes under different restoration alternatives. Resulting habitat areas would then be used in the incremental cost analysis required by USACE planning guidance during plan formulation to identify the most promising alternative.

HEC-EFM and HEC-GeoEFM help users assess the ecological implications of water resource decisions by focusing on questions such as:

- How much habitat is generated by a particular water management strategy or configuration of river channels and wetlands?
 - Where is the habitat?
 - Are habitat areas connected?
 - Where does it make sense to protect or restore habitat?
5. The process of applying HEC-EFM and HEC-GeoEFM involves three phases: statistical analyses, hydraulic modeling, and the use of Geographic Information Systems (GIS) to perform spatial analyses. Applications of HEC-EFM do not need to complete all three phases to produce meaningful output. It is helpful to think about the HEC-EFM applications as having two levels of detail: statistical and spatial.

Data requirements of HEC-EFM applications are related to the level of detail desired by the modeler. Statistical analyses alone require only hydrologic gage data and the relationships between hydrology and ecology. Spatial applications using HEC-GeoEFM require digital topography, a geo-referenced hydraulic model, and other site data displayed and assessed via GIS in HEC-GeoEFM.

HEC-EFM computes river flow and stage-related statistics to characterize ecosystem dynamics of the flow regime. Statistical criteria are defined as combinations of four parameters: season, duration, rate of change, and percent exceedance. Prior applications have used these features to define links between hydrology and ecology for both biota (vegetation, benthic macroinvertebrates, fish, and waterfowl) and processes (recruitment of large woody debris, depth to shallow ground water, and channel migration). Statistical results can be useful in determining the direction (positive, negative, or no change) and magnitude of ecosystem responses under different restoration or management alternatives.

6. HEC-EFM and HEC-GeoEFM went through a thorough ECO-PCX review process in 2012. The ECO-PCX contracted the review by experts in hydrology and hydraulics, stream and river ecology, GIS, and software programming/design. The model review panel found that the model system has great potential to be a very useful tool and is generally appropriate for the intended purpose of evaluating alternatives for project planning. Some issues

regarding the technical quality, system quality, and system usability of HEC-EFM and HEC-GeoEFM and the usability of the outputs were noted. The reviewers found that the HEC-EFM and HEC-GeoEFM documentation should be more detailed, clearly describe how to use the models and their outputs, and identify the assumptions and limitations of the model system. The reviewers also recommended that additional testing and validation of HEC-EFM and HEC-GeoEFM be performed to identify any remaining bugs that could cause unexpected and unexplained error messages. All reviewer comments were addressed to the satisfaction of the reviewers and the ECO-PCX and HEC-EFM and HEC-GeoEFM were certified for national use on 10 April 2015 (Encl 1). The complete record of the original review process can be found in Enclosure 2.

7. HEC software development processes follow a standardized protocol (Encl 3) to ensure HEC only releases the highest quality software products within available budgets and timelines. The Continuous Integration and Continuous Deployment (CI/CD) process HEC implements for its software products includes automation of the development process, emphasizes the importance of shorter release cycles with fewer new features, stresses the importance of customer feedback, and exploits technology developments. Accordingly, HEC-EFM and HEC-GeoEFM have been continuously and rigorously updated and improved since the original certification process and have been reviewed, tested, and verified under standard HEC good-modeling practices. Written user guidance documents (Encl 4-6) are available to help users with application of HEC-EFM and HEC-GeoEFM. HEC technical support is available to assist model users and HEC encourages users to report any bugs encountered during model application to facilitate resolution.
8. HEC-EFM and HEC-GeoEFM meet USACE technical quality standards. They are based on well-established contemporary theory regarding ecosystem response to changes in flow regimes. Key analytical requirements include daily mean flow and daily mean stage data and defined relationships between system hydrology and ecology. Key assumptions are defined and are acceptable. The models comply with USACE policies and procedures. The model development team conducts rigorous testing to ensure formulas and model computations are correct.
9. HEC-EFM and HEC-GeoEFM meet USACE system quality standards. The software and GIS integration are appropriate platforms and are available to most users. The model developers acknowledge the challenge associated with maintaining compatibility with software languages, programming platforms, and related software tools, which are continually being updated by others. The model developers periodically update the software to address compatibility issues. As stated above, the models are tested and validated.

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10. HEC-EFM and HEC-GeoEFM meet USACE usability standards. Input data is readily available and results are understandable and useful in project analysis. A User's Manual, Quick Start Guide, and Release Notes are available for user download.
11. Model application requires above-average computer knowledge. Technical review teams should include a senior-level hydraulic engineer and a senior-level biologist/ecologist with experience in stream restoration associated with modified flow regimes. Technical review teams should evaluate relationships between hydrology and ecology that are defined as model inputs.
12. Regarding the individuals who apply the model, Districts are entrusted to confirm that the modeler(s) who are using the model have the experience needed to apply the model correctly and interpret the model outputs. In addition, if the modeler(s) have any uncertainties with the application and/or interpretation of the model, then he/she should engage HEC and the ECO-PCX.
13. The ECO-PCX recommends certification of HEC-EFM and HEC-GeoEFM. The models apply sound contemporary theory, are computationally correct, comply with USACE policies, have acceptable system quality, and meet usability criteria. It is the position of the ECO-PCX that the continuous, rigorous, standardized software development protocol employed by HEC to update and release new versions of HEC-EFM and HEC-GeoEFM meets the intent of the model review processes to determine technical quality, system quality, and usability required by EC 1105-2-412. Accordingly, the ECO-PCX recommends national certification of current and future versions of HEC-EFM and HEC-GeoEFM that follow the HEC software development protocol. Should protocols change or user feedback dictate otherwise, this recommendation would be revisited.

Encls (6)

Signed (name redacted)

Operating Director, Ecosystem
Restoration Planning Center
of Expertise

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CEMVD-PDP (*names redacted*)

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