

Hydrologic and Hydraulic Model Review

A Review and Assessment of Software for Illinois Practitioners

Authored by the 2023 Ad Hoc Hydrologic and Hydraulic Modeling Sub-Committee

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Executive Summary

XPSWMM, developed by XP Solution then sold to Innovyze and now owned by Autodesk, is the predominant hydrologic and hydraulic (H&H) modeling software utilized for urban flood analysis, as well as many other stormwater and flood mitigation assessments, throughout Illinois. In 2022, Autodesk announced they will start phasing out the InfoCare support for the legacy Innovyze perpetually licensed products to Autodesk subscriptions and direct users to start migrating towards Autodesk InfoWorks ICM software. InfoWorks ICM is generally understood to be a powerful H&H software; it is also understood to be an expensive software.

In anticipation of XPSWMM being discontinued in the near future, Illinois Association for Floodplain and Stormwater Management (IAFSM) initiated an Ad Hoc Committee to assess software options and provide guidance to its members. The committee:

- Researched previously developed studies of similar nature;
- Researched available software;
- Developed a multi-tiered ranking process; and,
- Scored the software that made it to the final review stage.

Following this review process, the H&H modeling software that scored the highest, in order, are InfoWorks ICM, PCSWMM, and EPA-SWMM. The committee feels that each of these three top ranked software options fill a need, as:

- InfoWorks ICM has the most features and is the most expensive;
- PCSWMM is in the middle for both costs and features; and,
- EPA-SWMM has the least features, is the least expensive, and is the base engine of PCSWMM, XPSWMM, and an option in InfoWorks ICM.

Disclaimer:

The statements herein are the professional opinions of the members of the Ad Hoc Hydrologic and Hydraulic Modeling Sub-Committee. No one involved with the development of this publication has any formal association with any of the software companies included in this review, other than they may have purchased a license and used the software before. This publication presents the research and professional opinions of the authors and is not regulatory or a requirement for any practitioner. Each agency and/or practitioner will need to perform their own assessment.

Purpose & Goal

XPSWMM has been the predominant software for advanced urban H&H modeling within the state of Illinois for decades. In 2022, Autodesk announced their intent to discontinue their support of the XPSWMM software; Autodesk recommends that XPSWMM and InfoSWMM users migrate to InfoWorks ICM, also owned by Autodesk. Subsequently, in early 2023, Autodesk stated that they will “continue to support XPSWMM” until InfoWorks ICM achieves approval by Federal Emergency Management Agency (FEMA). This 2023 update presumably provides a little more time before XPSWMM is discontinued, however, it still leaves industry practitioners with the decision of what software to turn to. It is the goal of the IAFSM Ad Hoc Committee to review the available software options and develop a means by which to evaluate the different software packages.

The Ad Hoc Committee of local Illinois H&H modeling practitioners set forth the goal to collaboratively review and rank the available software. The ranking will allow industry practitioners to choose how best to move forward in an efficient and effective manner, which will save time and money for both consultants as well as local agencies.

We understand that without this review, many practitioners may lack the research and knowledge of available options go in many directions. It is the nature of our industry for practitioners to work with others’ models. In order to encourage uniform results, ease regulatory review and approvals, and save time and money, it would be best if practitioners have a consensus on a few modeling software options. A unified path forward, decided by a diverse group of representatives, would provide greater efficiency hydrologic and hydraulic modeling work within Illinois.

Background

Water resources engineers use a wide variety of programs to complete H&H studies. Historically, the most widely used programs have been developed and are supported by federal agencies. Examples include the HEC suite of software developed by the US Army Corps of Engineers and the Storm Water Management Model (SWMM) developed by the EPA (Environmental Protection Agency). XPSWMM has been widely accessible, user-friendly modeling tool used by a robust modeling community to perform small site-level analyses to major masterplan studies.

In Illinois, as well as in many neighboring states, HEC programs have been the preferred modeling package for waterway and floodplain studies, while SWMM has been the basis for most sewer studies in urban areas. EPA’s summary of SWMM is as follows:

¹EPA's Storm Water Management Model (SWMM) is used throughout the world for planning, analysis, and design related to stormwater runoff, combined and sanitary sewers, and other drainage systems. It can be used to evaluate gray infrastructure stormwater control strategies, such as pipes and storm drains, and is a useful tool for creating cost-effective green/gray hybrid stormwater control solutions. SWMM was developed to help support local, state, and national stormwater management objectives to reduce runoff through infiltration and retention and help to reduce discharges that cause impairment of waterbodies.

¹ <https://www.epa.gov/water-research/storm-water-management-model-swmm>

In the 1990s, XP Solutions developed a customized version of SWMM that included an upgraded interface and customized features. Although several other software developers have also prepared customized versions of SWMM, XPSWMM continues to be the only aftermarket SWMM-based program that is included in FEMA's list of numerical models meeting the minimum requirement of the National Flood Insurance Program.

Illinois water resources engineers found XPSWMM to be an affordable and effective tool that provided value through its enhanced interface and capabilities. The developer made frequent updates and continued to expand the model's capabilities, such as adding 2D modeling.

In 2017, Innovyze and XP Solutions merged and XP Solutions products, including XPSWMM, were presented under the Innovyze name. While this resulted in some changes to pricing and packages, in general, the operation and use of XPSWMM did not change significantly for end users. Although Innovyze offered other similar modeling packages (e.g., InfoSWMM and InfoWorks ICM), Innovyze expressed a commitment to XPSWMM and continued to release program updates.

In 2021, Autodesk acquired Innovyze. Then, in 2022, Autodesk announced they will start phasing out the InfoCare support for the legacy Innovyze perpetually licensed products to Autodesk subscriptions and direct users to start migrating towards Autodesk InfoWorks ICM software. Subscription based XPSWMM licenses would be discontinued within the next several years. Perpetual licenses (software or hardware based) would continue to function without support until they become corrupt.

Autodesk intends for InfoWorks ICM to become the future home of the XPSWMM modeling community. InfoWorks ICM is expensive and may be cost prohibitive to small consulting firms or municipalities that want to run or maintain small modeling projects. While InfoWorks ICM is a powerful tool, it may not be a cost-effective option for all types of projects involving urban sewer and watershed modeling in Illinois.

Approach

The XPSWMM expiration issue was brought to the IAFSM Stormwater Committee by Matt Moffitt. After an initial meeting to discuss the outline of how to proceed upon the expiration of XPSWMM support, a request for input and to join the Ad Hoc Committee was placed in the IAFSM newsletter. Members who responded to the request were added to the committee with a limit of one contributor per organization and each are listed as supporting authors.

The Committee met monthly between the 2022 and 2023 IAFSM conferences to collaborate on the purpose, approach, and recommendations. The committee first investigated previous studies of software similar to XPSWMM. Once the software was identified, a matrix of capabilities for the various software was developed. Many programs were eliminated from consideration after identifying the required capabilities the software needed, and the remaining software was further analyzed as part of a detailed review. A ranking system for the software was developed that led to the identification of the top three programs that could be utilized in lieu of XPSWMM. This effort will encourage consistency in software use throughout Illinois for the required attributes. In addition to the ranking system, the pros and cons of each software evaluated were also developed to provide insight into how values associated with the ranking system were assigned.

Research

The Committee performed Google searches and reached out to various vendors to find similar studies ranking the various software alternatives available. Only two similar studies were found. One was ²“Software Evaluation and Analysis for Stormwater Infrastructure Modeling” performed by Halff Associates on behalf of the City of Houston. This analysis included an initial screening of 15 software programs. Of these, seven programs were considered further. These programs were then analyzed in more detail and scored on a variety of parameters. The report recommended InfoWorks ICM be used for development of a Citywide stormwater infrastructure model. Another similar evaluation was the ³“Model Platform Selection” performed by Freese and Nichols for the City of Fayetteville, NC. Six software programs were considered for the development of the City’s watershed masterplan, which would involve the modeling of both open channels and collection systems. Freese and Nichols recommended HEC-RAS for main channels and InfoWorks ICM for pipes and local drainage.

From the two studies, and the committee’s collective knowledge, the following software programs were identified as viable H&H modeling software. XPSWMM is excluded from the analysis as it will soon no longer be supported. The owner/developer of each program is also listed.

- InfoWorks ICM; Innovyze (Autodesk)
- EPA SWMM; US Environmental Protection Agency
- HEC-RAS; US Army Corps of Engineers
- HEC-HMS; US Army Corps of Engineers
- PCSWMM; CHI
- ICPR; Streamline Technologies
- Mike+; DHI Group
- TuFlow; BMT
- Flo-2D; Flo-2D Software
- PondPack; Bentley Systems
- StormCAD; Bentley Systems
- HydroCAD; HydroCAD Software Solutions
- InfoSWMM; Innovyze (Autodesk)
- SRH-2D; Aquaveo
- OpenFlows; Bentley Systems
- Autodesk SSA; Autodesk

The studies discussed above offered useful guidance and outlines for how the Committee could structure the analysis of software programs. Since both studies were done for specific clients and neither were in Illinois, the Committee analyzed and scored the programs independent of the results of either study.

² [Services - Halff](#)

³ [Urban Planning + Design - Freese and Nichols](#)

Initial Review

Through collaborative discussion, the Committee compiled a list of categories for which the software programs would be ranked. The list was divided between required and preferred categories. The required categories are those deemed necessary to perform basic modeling tasks common to most projects.

- **Unsteady Flow Regimes** – must be able to model hydrographs as opposed to a constant flow input
- **Open Channel 1D** – must be able to model 1D open channel flow (rivers, streams, etc.)
- **Storm Drains 1D** – must be able to model 1D closed conduit flow (pipe network)

The preferred categories are those that add value to model setup, visualization, and analysis but are not required to complete most projects.

- **Rain-on-Mesh** – allows rainfall data to be applied directly to a 2D surface rather than calculating hydrographs at discrete locations
- **2D** – able to integrate 1D pipe and/or channel flow with a 2D surface to show the interaction between surface flooding and sub-surface drainage systems
- **XPSWMM Conversion** – able to import an existing XPSWMM model
- **FEMA Approved** – on FEMA's list of nationally and locally accepted hydraulic models that meet National Flood Insurance Program (NFIP) requirements for flood hazard mapping activities.
- **Local Knowledge** – considers how well known the software is among modelers, clients, and government entities in Illinois. Models that are not well known have a higher learning curve
- **Free** – no cost to use the software

Only those software programs that met all required categories were allowed to continue past the initial review. Of the preferred categories only those software programs scoring at least 3 out of 6 made it to the detailed review: InfoWorks ICM, PCSWMM, ICPR, Flo2D, and EPA-SWMM.

	Infoworks ICM	PCSWMM	ICPR	Mike+	Bentley Openflow	TUFlow	FLO-2D	EPA-SWMM
Unsteady Flow Regimes	x	x	x	x	x	x	x	x
Open Channel 1D	x	x	x	x	x	x	x	x
Storm Drains 1D	x	x	x	x	x	x	x	x
Rain-on-Mesh	x		x	x	x	x	x	
2D	x	x	x	x	x	x	x	
XPSWMM Conversion	x	x						x
FEMA Approved			x				x	x
Local Knowledge	x	x						
Free								x
	4	3	3	2	2	2	3	3

Software Further Considered

The committee selected five software options for further consideration after conducting an initial review. To evaluate the advantages and disadvantages of these software programs, the committee compared their capabilities, performance, and limitations. A summary of the pros and cons, as identified by the committee, of each software is provided below:

InfoWorks ICM

Pros:

- The software is maintained by a stable company with responsive customer support
- Multiple users can work on the same model simultaneously
- The software has a strong graphical user interface, excellent review capabilities, and 3D viewing options
- It has good model run times and strong GIS (Geographic Information System) integration
- It can use either the InfoWorks ICM or SWMM engine and has built-in support for Huff and Bulletin 75 distributions
- XPSWMM models can be converted to InfoWorks ICM
- It allows for an unlimited number of nodes and has a 2D mesh feature
- InfoWorks ICM models can be set up to allow import from and export to EPA-SWMM

Cons:

- The software has a high price point
- It has a moderate learning curve, uses British terminology, and defaults to a different equation engine
- It is not yet widely accepted by FEMA (though Autodesk has stated that they are currently seeking approval) and does not have a floating license option

PC-SWMM

Pros:

- The software is maintained by a stable company with responsive customer support and offers an open SWMM resource and discussion forum as well as virtual and in-person training sessions
- It is an affordable option that has most of the same functionality as XPSWMM
- The learning curve is small if the user is already familiar with XPSWMM or EPA-SWMM
- The software runs EPA-SWMM but has a better graphical user interface and built-in GIS-based model development tools
- It has strong graphical output options and allows for an unlimited number of nodes and has a 2D mesh feature
- PC-SWMM models can be opened and run in EPA-SWMM if the PC-SWMM engine or 2D are not used
- The software allows for the creation and use of Python scripts for additional functionality
- The software is widely accepted for urban stormwater modeling, and can model pressure flow and pumps

- It is easy to customize how model elements are rendered/displayed
- PCSWMM models can be set up to allow export to EPA-SWMM

Cons:

- The software does not offer a floating license option
- It does not have all the features and capabilities of XP-SWMM
- It is not widely accepted by FEMA
- It is not well-suited for plan and profile development or CAD integration
- Reporting results with the software requires significant manual effort and is not easily automated

EPA-SWMM

Pros:

- EPA-SWMM is free to use and open source, which makes it accessible to a wide range of users
- It has a large user base, which means you can benefit from the experience and insights of other users
- Most other software can export data to the .ini format that EPA-SWMM uses, which makes it easy to use data from multiple sources
- EPA-SWMM is used by many clients, which demonstrates its credibility and reliability
- It is the only software on this list that has been fully approved by FEMA

Cons:

- The user interface of EPA-SWMM is basic, with limited data management tools
- The graphical output is reasonable but may not be as advanced as some other options
- The hydraulic engine of EPA-SWMM is slightly slower than some other software
- There is no formal support for EPA-SWMM, although there is a SWMM Users List server where subscribers can ask questions and exchange information
- EPA-SWMM does not have a 2D function

ICPR

Pros:

- The software has a reasonable graphical user interface and reasonable graphical output options
- It is great for urban detention and storm sewer design, is easy to use, and is compatible with GIS/CAD systems
- It includes 1D H&H and fully integrated 2D surface water and groundwater flow and is widely accepted by Departments of Transportation

Cons:

- The software is not widely used locally and is not widely accepted by FEMA
- It has a high price per user

FLO-2D

Pros:

- FLO-2D has the lowest price among XPSWMM alternatives
- There is a free version of the software available that includes limited software functions
- The free version can convert data from GIS to an EPA-SWMM file
- 1D inputs and results are written in EPA-SWMM format, which can be accessed by review agencies without the need for FLO-2D software

Cons:

- QGIS (locally unfamiliar) is required to use FLO-2D
- The software does not have the capability to generate internal point hydrographs
- FLO-2D is not well known locally
- FLO-2D is not widely accepted by FEMA

Detailed Review

The Committee performed a detailed review of the six software programs selected during the initial review. The software programs were scored based on eleven categories including:

- **GIS Integration** – Capability of the program to edit, import, and/or export GIS-based data files to use for data pre-processing, post-processing, and/or visualization. Programs with better GIS integration capability were assigned a higher score.
- **XPSWMM Conversion** – Capability of the program to read and/or import XPSWMM based files. Programs that have this capability were assigned a higher score.
- **Cost** – Fee or cost to use and run the program. Some of the programs evaluated are proprietary and have a license fee and a maintenance/technical support fee while some others are free. Programs with a higher cost were assigned a lower score.
- **2D Capability** – Program's capability to simulate hydraulic parameters such as flow, water surface elevations, and velocities in a 2-dimensional domain (X, Y, and Z directions). Programs that have this capability were assigned a higher score.
- **Local Knowledge** – Programs that are either required by municipalities or agencies in Illinois and/or are commonly used by engineering practitioners in Illinois. Programs that are most widely used in Illinois were given a higher score.
- **GUI** – All programs evaluated have a Graphical User Interface (GUI); however, some of the GUIs are more user-friendly than others and allow the user to easily visualize results, navigate throughout the program functions, and set up model simulations. Programs with a stronger GUI were given a higher score.
- **SCS Hydrology** – Capability of the program to simulate runoff using the Soil Conservation Service (SCS) Curve Number method. Programs that have this capability were assigned a higher score.

- **Results Reporting** – Capability of the program to automate the reporting of results with minor manual effort. Programs that easily automate the reporting of results were given a higher score.
- **FEMA Approval** – Some of the programs have been approved by FEMA for floodplain analysis. Programs that have been approved by FEMA in all states were given a higher score.
- **Learning Curve and Technical Support** - Programs that require a higher learning curve and/or do not have technical support were given a lower score.
- **Rain-on-Mesh** – Capability of the program to apply rainfall data directly to a 2D surface rather than calculating hydrographs at discrete locations. Programs that have this capability were assigned a higher score.

A score between 1 and 3 was given to each category and software program, with a score of 1 having a low performance/capability, a score of 2 having a medium performance/capability, and a score of 3 having a high performance /capability. In addition, weights were assigned to each category, with a higher weight designated to categories that the committee considered to be more important and relevant. The table below shows the weights assigned and the scores given to each of the six software programs. The scores were totaled for each software program, and the three highest scoring programs were InfoWorks ICM, PCSWMM, and EPA-SWMM.

	Weight	Infoworks ICM	PCSWMM	ICPR	TUFlow	FLO-2D	EPA-SWMM
GIS Integration	15	3	3	3	3	2	1
XPSWMM Conversion	15	3	3	1	1	2	3
Cost	15	1	2	2	2	2	3
2D Capability	10	3	2	3	3	3	1
Local Knowledge	15	2	2	1	1	1	3
GUI	5	3	2	3	2	2	1.5
SCS Hydrology	5	3	3	3	1	1	3
Results Reporting	5	3	2	2	2	2	2
FEMA Approved	5	2	2	2	2	2	3
Learning Curve/Support	5	2	3	2	2	2	3
Rain-on-Mesh	5	3	1	3	3	3	1
	300	245	235	210	195	195	227.5

Summary

The three software programs that scored the highest in the detailed review are InfoWorks ICM, PCSWMM, and EPA-SWMM. The committee discussed these three software programs and concurred that they should be ranked as the top three viable options as alternates to XPSWMM. Additionally, it should be noted that each model has different strengths and weaknesses, and thus different applications in hydrologic and hydraulic modeling.

- EPA-SWMM offers the fewest features for the lowest cost (free)
- PCSWMM, which runs EPA-SWMM as the base engine, offers a middle package of features at a moderate price
- InfoWorks ICM is the most expensive software option that offers the most features, including the option of running the software utilizing EPA-SWMM as the base engine

Each of the three modeling software programs is a strong and appropriate alternate to XPSWMM. All three models are compatible with internal model setup. In addition, InfoWorks ICM and PCSWMM can export and import EPA-SWMM files.