To 2D or not 2D: An Opportunity for the USA

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Flood behavior information is a fundamental dataset requirement of a well-informed floodplain management plan. It defines the hazard which requires mitigation through a range of measures, such as, structural engineering works, land use controls, emergency response planning and flood insurance. The accuracy of flood data has a direct impact on the bottom line cost and success of flood mitigation projects. Poor flood data can cause expensive over design, or worse, under-design which has the potential to result in failure. Flood modeling is a cost effective way to define the flood behavior for a catchment.

The science of two-dimensional (2D) flood modeling has progressed immensely in the past two decades. Parallel advances in computer hardware have enabled 2D models to become the tool of choice for most hydraulic flood assessments in Australia and the United Kingdom. The perception that 2D models are too slow for large scale assessments is no longer valid. The fact that 2D modeling is now being trialed for real-time flood forecasting is a testament to this.

In comparison, one-dimensional (1D) flood modeling has traditionally dominated within the USA. This being said, the USA is currently in a transition phase. There is a general feeling of enthusiasm towards 2D modeling. This is particularly driven by:

- Workflow efficiencies resulting from flood modeling integration with GIS;
- The recent release of Flood Modeller Pro;
- Flood evacuation assessment output options in TUFLOW;
- Simulation speed of GPU software such as MIKE 21, TUFLOW or RiverFlow2D; and
- The imminent future release of HEC-RAS 2D.

More consultants and authorities are considering the benefits of 2D modeling instead of 1D. This is particularly the case in locations that have good LiDAR topography data. This is no surprise due to catchment scale 2D modeling being faster to establish (i.e. cheaper) and more accurate (see Figure 1).

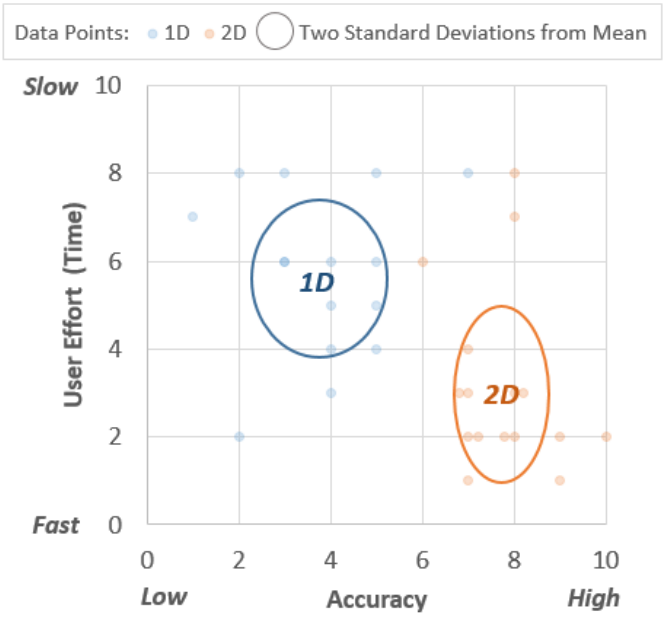


Figure 1: 1D 2D Modeling Comparison

America's Opportunity

Discussions during the recent modeling forum at the FMA conference in Rancho Mirage highlighted the industry concerns with 2D modeling. Most of the concerns are directly comparable to those felt and overcome by the floodplain management industry in Australia and the United Kingdom.

The delayed adoption of 2D modeling within the USA presents itself as a significant opportunity. The USA is placed in a fortunate position where it can learn from the breadth of knowledge that is available from overseas.

A brief summary of recent Australian and United Kingdom 2D modeling work is outlined in the following sections.

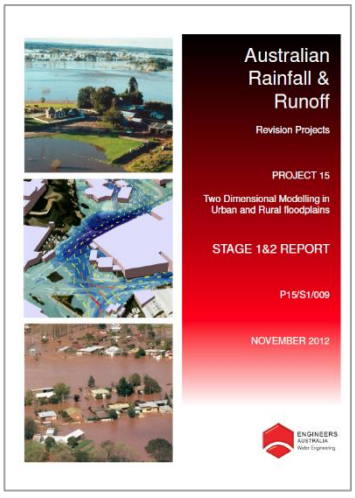
2D Modeling Guidelines - Australia

Australia is currently undertaking a full review of its hydrologic and hydraulic assessment guideline document, *Australian Rainfall and Runoff* (ARR). One of the 21 projects included in the revision focused entirely on 2D modeling.

The guideline document, titled "Two Dimensional Modelling in Urban and Rural Floodplains" included contributions from 17 individuals, all of whom are considered the leading experts in 2D modeling within Australia. They come from a range of backgrounds; including government, universities, consulting and software development. The industry experts collectively recognized the industry need for these guidelines, and more importantly the follow on benefits that would result within the community. They provided their time on an in kind basis during the project (i.e. received no payment for their efforts).

The 226 page guideline is extremely thorough. It covers the full range of modeling related topics, including:

1. Discussion outlining the development history of 2D models;
2. The fundamental mathematics which underlie the modeling;
3. The required steps when executing a 2D modeling project;
4. Data requirements and their accuracies;
5. Detailed model schematization information;
6. The importance of model calibration and recommendations in terms of data collection, event selection and definition of what is an acceptable calibration;
7. Interpretation of results; and
8. Modeling issues that engineers should be aware of.



The document aims to provide guidance to all levels; modelers and also to those who commission studies and use model results though have no interest in learning the software. Anyone who is involved in 2D modeling is encouraged to print the report and have a read. It can be downloaded from the ARR website: http://www.arr.org.au/wp-content/uploads/2013/Projects/ARR_Project15_TwoDimensional_Modelling_DraftReport.pdf

2D Model Benchmarking - United Kingdom

The United Kingdom Environment Agency conducted a desktop review of 2D hydraulic models in 2009. The Environment Agency followed up the review with a 2D Model Benchmark Study in 2010 and 2012. The studies aimed to provide evidence to ensure that 2D hydraulic modeling packages used for flood risk management, by the Environment Agency and their consultants, are capable of adequately predicting the variables upon which flood risk management decisions are based.

An open invitation to participate in the exercise was issued to all developers of 2D flood inundation software known to be applied in the United Kingdom. This resulted in a positive response from the suppliers of fourteen software packages.

Eight benchmark test cases were used to assess the suitability of each software for the following applications:

1. Large scale Flood Risk Mapping;
2. Catchment Flood Management Planning;
3. Flood Risk Assessment and detailed flood mapping;
4. Strategic Flood Risk Assessment
5. Flood Hazard Mapping;
6. Contingency Planning for Real Time Flood Risk Management; and
7. Reservoir Inundation Mapping.

Table 6: Suitable Packages for Environment Agency applications.

Application	Predictions required	Suitable packages identified in study
National scale probabilistic flood risk assessment (e.g. NaFRA)	i. inundation extent	Usable predictions could be obtained using all packages discussed above, although computational efficiency of RFSM (Direct) is a significant advantage.
Strategic / broad-scale flood risk assessments, rapid reservoir inundation mapping and contingency planning for real time flood risk management	i. inundation extent ii. maximum depth	Appropriate predictions will be obtained using packages based on the shallow water equations or simplified equations. The need for detail mitigates against the use of RFSM (Direct).
Detailed flood hazard assessments, detailed reservoir inundation mapping and site-specific FRAs	i. inundation extent ii. maximum depth iii. maximum velocity	The most suitable packages for this task are those based on the shallow water equations. If sub-critical to super-critical or super-critical to sub-critical flow transitions exist there may be benefit in using codes based on shock capturing numerical schemes, see Table 3

The model results from all the benchmark tests and the conclusions of the agency assessment are fully documented and freely available for downloaded from the United Kingdom Environment Agency website.

2D Model Benchmark Study (2010): http://evidence.environment-agency.gov.uk/FCERM/Libraries/FCERM_Project_Documents/SC120002_Benchmarking_2D_hydraulic_models_Report.sflb.ashx

Conclusion

2D modeling will become the dominant hydraulic modeling platform within the USA in the not too distant future. America is still in the early stages of developing a framework which integrates 2D modeling with the policy environment unique to this country. As a preliminary step, the framework should draw off the available international experiences and resources, such as the Australian modeling guidelines and UK 2D Benchmark Study. FMA needs to be central to this process. The breadth of experience of its members and the variety of their origins mean with their collective input, there is an opportunity to create something which suits the needs of all levels of the floodplain maangement industry; local, state and federal government, consulting and education. The end product of this style of collaboration will be a more flood resilient community, which is fundamentally the primary objective of all floodplain management.