2-Dimensional Model Challenges
Floodplain Management Association

MODEL **Challenge 3 – Non Urban Riverine with Levees**
Challenge 3+ - Transmission Losses due to Infiltration

1. **Challenge Description Brief:**

   Challenge Model 3 represents a typical non-urban stream of the California Central Valley, originating near the Sierra Nevada Foothills and conveying runoff to the West into the Central Valley Flood Management System. These streams tend to be natural, with large amounts of conveyance in their upper reaches. As the streams progress downstream, their conveyance capacity gradually reduces. At some point nearing the valley floor, typically levees have been constructed to contain normal floods within the conveyance systems.

   Data for this model is provided via mailed DVD. The terrain data for this challenge was too large to assemble in a downloadable format.

2. **Datum Notes –** The original data for this analysis has been modified from its original datum and original elevations have been altered and corrupted such that the data would not be usable for real world modeling, analysis and mapping. Datum data has been stripped from the files provided. If your software requires that you specify a datum for the data, assign UTM Zone 9 FEET. You are correct if you are finding that the coordinates of this data are not within UTM Zone 9 boundary, but assigning this zone will result in all data being located in the same spatial location. All data provided for this challenge is in STATUTE FEET units for both horizontal and vertical measurements.

3. **Instructions To Modelers**

   - Assignment of all parameters for this analysis are at the discretion of the modeler. A high resolution aerial image is provided so that land cover details can be inspected. Several stream photographs and structure photographs are also provided. Several Data sets are also provided to assist the modeler in determining model parameters. A starting set of overland N-Values is provided in the land use data set, however, the modeler can modify these as needed.
   - The modeler is to assume that the terrain data provided represents the ground conditions at the time the runoff event occurs, and that the ground conditions will not change during the event. Terrain data is provided in a number of data sets. "BARE EARTH" ASCII files are provided that were developed from the original LiDAR LAS files (the original files are too large to transmit). We are also providing a processed set of high resolution Gridded Regular Network based files in the GMG directory(this data is an alternative format to the ASCII files which may load easier for some users. In addition to this point data, there are also several additional sets of provided including: breakline data and supplemental survey points which the modeler should also consider in their establishment of model base terrain data. **Terrain point data for this model set should be ordered by sending an email requesting**

Submitted by: BMT WBM (TUFLOW Software) **Date:** Aug 24, 2012

"Challenge 3 Point Data DVD's" to 2-DSymposium@floodplain.org. Please provide a mailing address in the email.

- The Inflow Hydrograph is provided in the EXCEL spreadsheet contained in the "Boundary Conditions" directory. The stream being modeled is the center stream in the analysis. The streams at the northwest boundary and the southeast boundary are not a part of this analysis, and any water escaping the floodplain and entering these streams should be considered to exit the system analysis (model domain). Levees along these adjacent streams are to be included in the analysis and the LAMP guidelines will apply. The conveyance along the southwest boundary of the model will form the downstream boundary condition. The modeler should establish a water surface for this conveyance that is 3 feet below the top of the levee of this conveyance.
- Flows are expected to overtop the levees in some places. Provided are the FEMA DRAFT LAMP guidelines. The modeler is to assume that the levees, while not accredited, are structurally stable for overtopping, and will resist failure when overtopped (this is not necessarily the real condition of these levees, just the assumed condition for this challenge). Flows escaping into the floodplain are expected to accumulate against levees, and could(depending on your analysis) achieve depths such that levee overtopping could occur, and should be evaluated if it does.
- NRCS soils data sets are provided to assist with the modelers development of "Challenge 3+" evaluation data for the transmission loss option if it will also be provided.
- In the case that standards and specifications need to be referenced, please refer to FEMA guidelines, assuming the event described in this challenge represents the 100-year event. (Except, you are not limited by FEMA's approved software list, and may use any software you have available for the numerical analysis of this Challenge)

4. **Deliverables:** Deliverables will be due to be electronically delivered to FMA prior to August 24th, 2012. All parties(individuals, agency representatives, private parties and corporations) are welcome to submit challenge model results to FMA that they performed themselves. The Modeling Challenge results received from participating modelers will be presented at the September 4, 2012 Modeling Symposium (Sacramento). FMA will preserve the anonymity of modelers who are providing information in response to this Modeling Challenge, and will therefore compile and present at this Symposium such information on an anonymous basis for the purpose of showing variability in results. All parties submitting challenge models will be acknowledged in the symposium program separately.

    - Please provide a shape file (contents including areas) mapping the maximum extent of floodplain which occurred in your simulation.
    - Please provide an Outflow Hydrograph (Excel Spreadsheet)
    - Please define the limits of levee overtopping which occurred in your analysis (Shape file – linework)

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5. **Challenge 3+:** As an additional optional task, the modeler could choose to apply transmission losses due to infiltration by a method they deem appropriate, and provide the same deliverables for this alternative analysis with an additional Questionnaire form. In addition, please provide a summary of the percentage of total inflow volume that is lost in transmission.

6. **Enjoy!:** While there are serious reasons behind FMA presenting these modeling challenges, and we do hope modelers will take them seriously, FMA would also like this to be an enjoyable experience for all of those that choose to participate.

7. **Questions and Contact Information:** Question and Answers on the Challenge models are being addressed in a public forum format at the following link: http://www.floodplain.org/pages/floodplain-modeling-forum. Representatives from FMA, FEMA and other interested parties are monitoring and responding to postings made in the challenge forums. If you really need a quick answer to a question, or find a mistake in the data, you can email us at 2-DSymposium@floodplain.org.

8. **CONDITIONS FOR PARTICIPATION IN THE MODELING CHALLENGE**
   By submitting any information to FMA in response to the Modeling Challenge, I agree to all of the following:

   INTELLECTUAL PROPERTY RELEASE
   I give permission to FMA (including all FMA officers, directors, employees, volunteers and contractors) to publish, distribute and/or present information I provide in response to the Modeling Challenge free of charge, and copies may be distributed worldwide, in perpetuity, in whole or in part, in any form of media, without compensation to me.

   LIABILITY RELEASE
   I agree to indemnify and hold harmless FMA (including all FMA officers, directors, employees, volunteers and contractors) of and from any and all claims, demands, losses, causes of action, damage, lawsuits, judgments, including attorneys' fees and costs associated with these, in connection with the use, publication, distribution and/or presentation of information I provide as part of the Modeling Challenge or part of the September 4 2012 2-D Modeling Symposium activities.

9. **Data Confidentiality:** The data provided for this challenge model is not to be considered as public domain materials. The data's owner, has authorized FMA to distribute this data for this sole purpose. Redistribution of this data by an end user may only be done for the purpose of performing this challenge model. All other use of this data is prohibited.

10. **Methods/Software allowed:** There are no restrictions, you may use any means you have available to perform these challenges.

Submitted by: BMT WBM (TUFLOW Software) **Date:** Aug 24, 2012

Model Submittal Questionnaire – Challenge 3

Modeler Name/Agency or FIRM: Phillip Ryan & Bill Syme / BMT WBM (TUFLOW Software)

Data Prepared Date: 23/08/2012

☑ I agree to keep any data I received for this Challenge Model Confidential

☑ I agree to comply with the Conditions for Participation in this Challenge Model

☑ I would be willing to provide my model data to FMA in the future for additional review (Confidentially) (Not required)

Contact me for this information @: Bill Syme or Phillip Ryan at support@tuflow.com

Challenge 3 Model Information:

SELECT THE MODEL TYPES USED IN YOUR ANALYSIS (select more than one if applicable to your analysis and describe as needed in space below)

☐ 1-D Network ☐ 1-D Cross Sections ☐ 2-D GRID ☐ 2-D MESH

☐ 3-D ☑ Coupled 1-D/2-D ☐ OTHER_____

Indicate the cross section spacing, grid size, mesh element size characteristics of your computational domain Explain if the effects of Hydraulic Structures were modeled, How was that performed?:

The model was set up as a TUFLOW 1D/2D model. Two different resolutions for the floodplain were simulated using 100ft and 200ft cell sizes.

1D sections spacing were generally between 500ft and 1000ft (except at structures). Structures were modeled with additional energy loss, to simplify the model a value of 1.0 $V^2/2g$ was used for all structures in the main creek.

Linking between 1D/2D was along the top of the levees.

All outflow from the model was assumed to be only via the main creek (ie. there was no water level boundary applied to the 2D overbank domain).

Indicate the number of cross sections, grids, or mesh elements used: See table below

2D Cell Size	Active 2D cells
100ft	338,020
200ft	84,818

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Describe the processes used to assemble your computational domain, execute it, and post process it into floodplain limits files. Indicate anything else you want us to know about your data and methods:

The provided DEM via GMG format was too coarse for hydraulic modeling as key hydraulic features (such as levee crests) were not adequately represented. The first step was therefore to process the 20Gb of LiDAR data into a higher resolution DEM. A 10ft DEM was created, a small part of which is illustrated below.

Cross-sections were extracted from the 10ft DEM, with Manning's n values extracted from the provided GIS land use layer shown in the image below.

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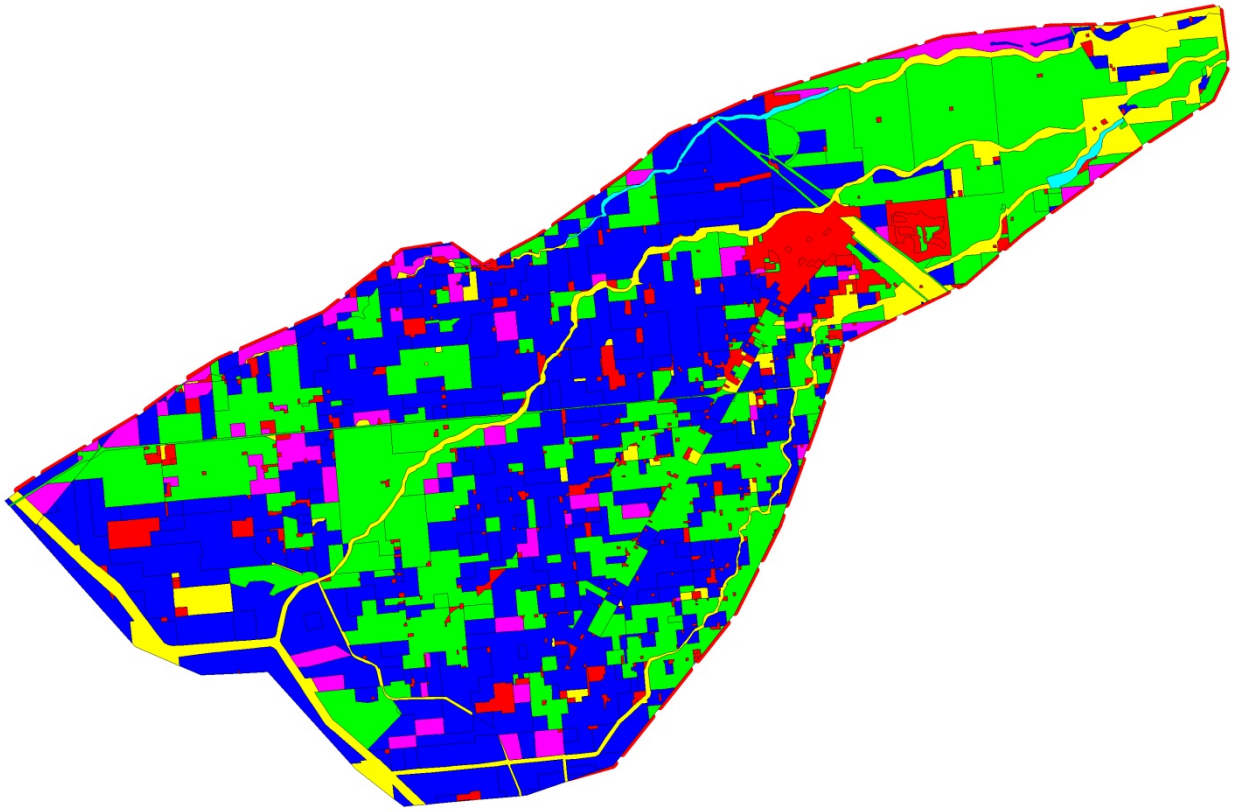


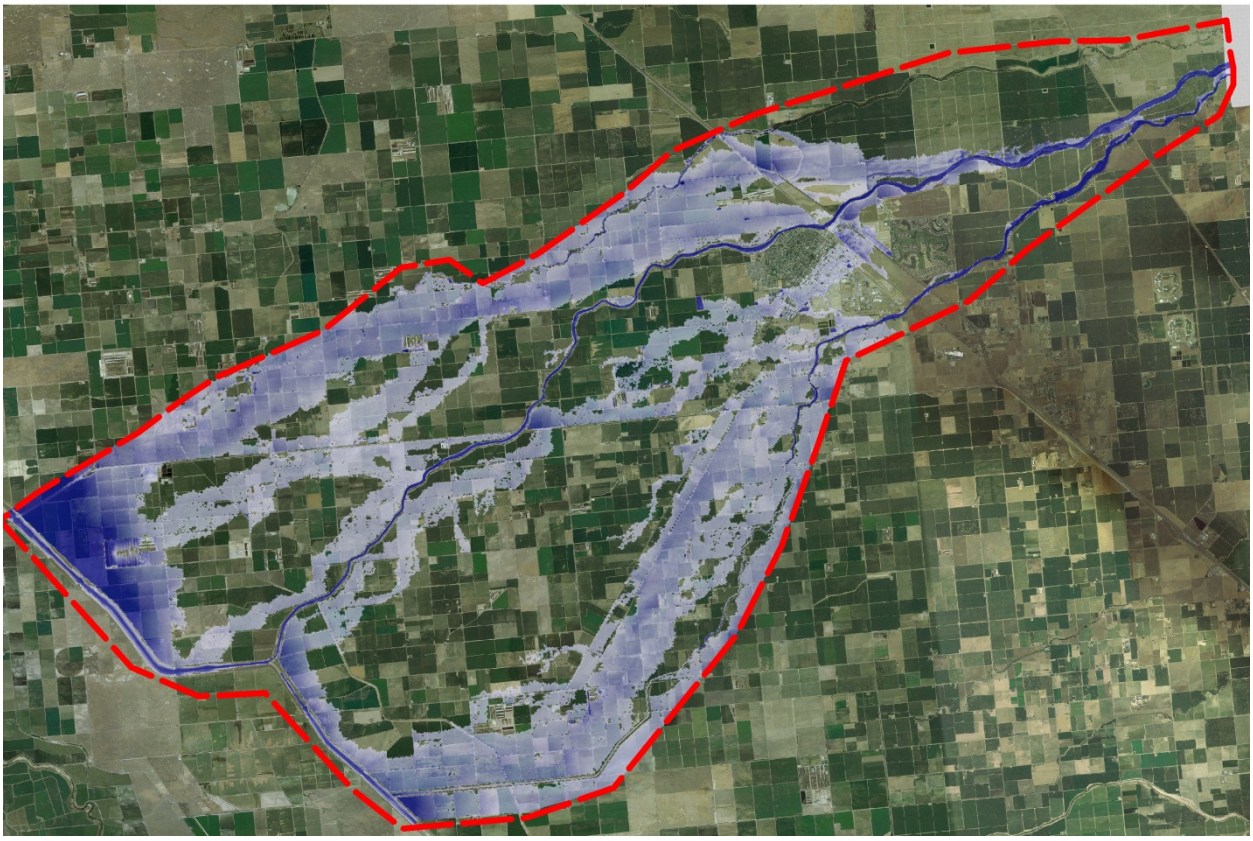
The Manning's n values adopted were as provided and are tabulated below with comments on their applicability.

Apparent Land Use	n	Colour (in image above)	Comment
Urban Areas	0.04	Red	Acceptable value when representing the combination of roads (0.02) and buildings, gardens and fences (0.08 to 0.30), especially if the roads are wide.
Cropping/Cultivation	0.10	Green	Representative of established medium density crops.
Cropping/Cultivation	0.12	Blue	Representative of established medium to high density crops.
Cropping/Cultivation	0.15	Magenta	Representative of established high density crops.
Creek	0.20	Yellow	Would consider this value very high. A quick inspection of the creek photos taken near structures would indicate that maybe in the upper reaches where there seems to be reasonably dense vegetation in the creek that this value is representative, but

			even so we still consider this value to be high in this case. In the lower reaches the creek seems quite open with little vegetation (more representative of an n value from 0.04 to 0.08).
Creek	0.25	Cyan	See comment above.

The 1d/2d linking was along the top of the levee. The elevations along these levees were extracted from the 10ft DEM, these and other significant features were included in the TUFLOW model as 3D GIS breakline layers, ensuring the hydraulic control is represented in the grid regardless of cell size.

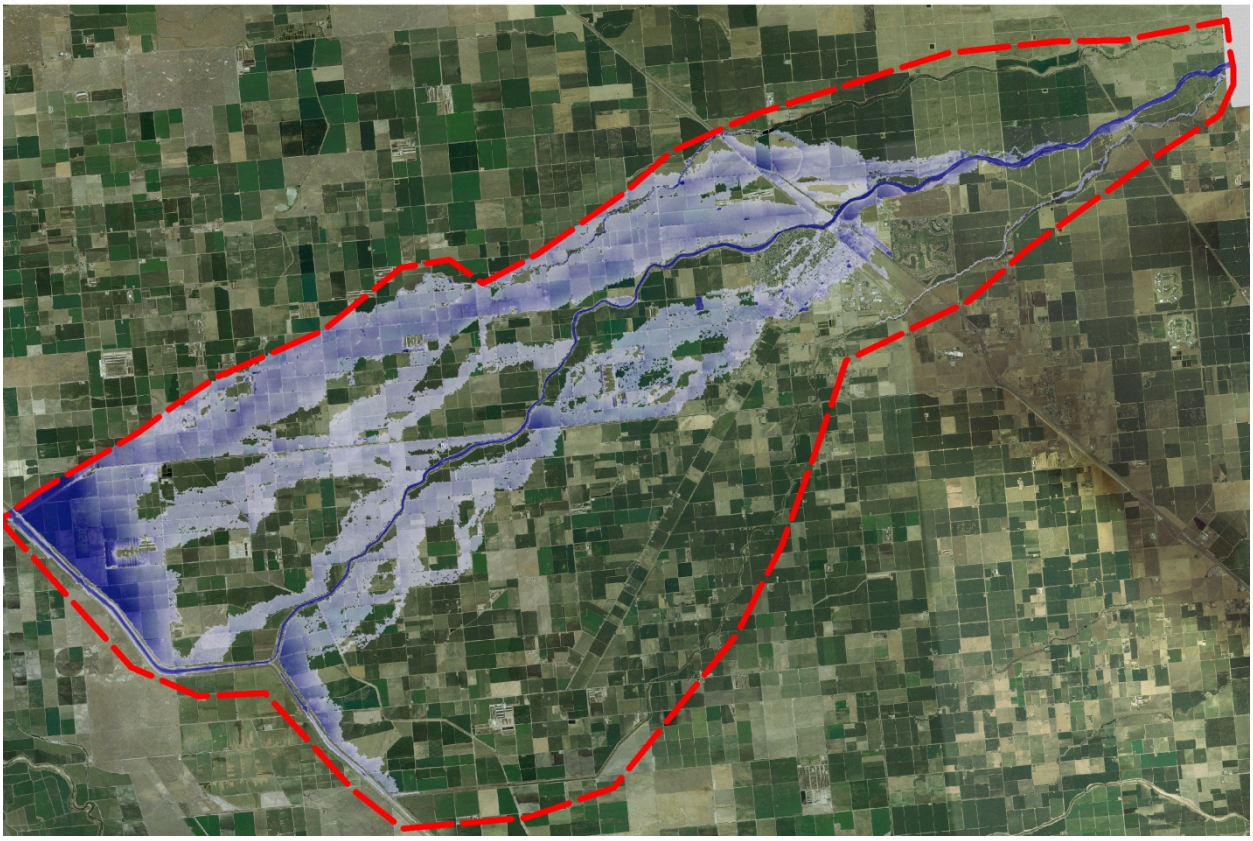
The flood extent from the 100ft 2D grid model is shown below.



Sensitivity Creek Manning's n Test (Scenario 100ft n0.1)

As discussed in the Manning's n table above, the main creek n value of 0.20 is considered very high, especially in the lower reaches of the study area. A sensitivity analysis was carried out by lowering all the Manning's n values in the main channel (modeled as 1D cross-sections) to 0.10.

The image below shows the flood depths and extent, and the outflow is included in the ftp download. Of particular interest is that reducing the n value to 0.1 has a significant effect on the arrival time of the flood waters at the model outlet (much earlier), and reduces the volume of water flowing onto the floodplain by around 20% due to the higher conveyance of the creek. Also of interest is that for the n=0.2 scenario, some overbank floodwaters return to the main creek near the model outlet causing a delayed second rise in the outlet flow hydrographs as illustrated in the chart further below. This effect does not occur for the n=0.1 scenario, with all overbank floodwaters remaining on the floodplain.



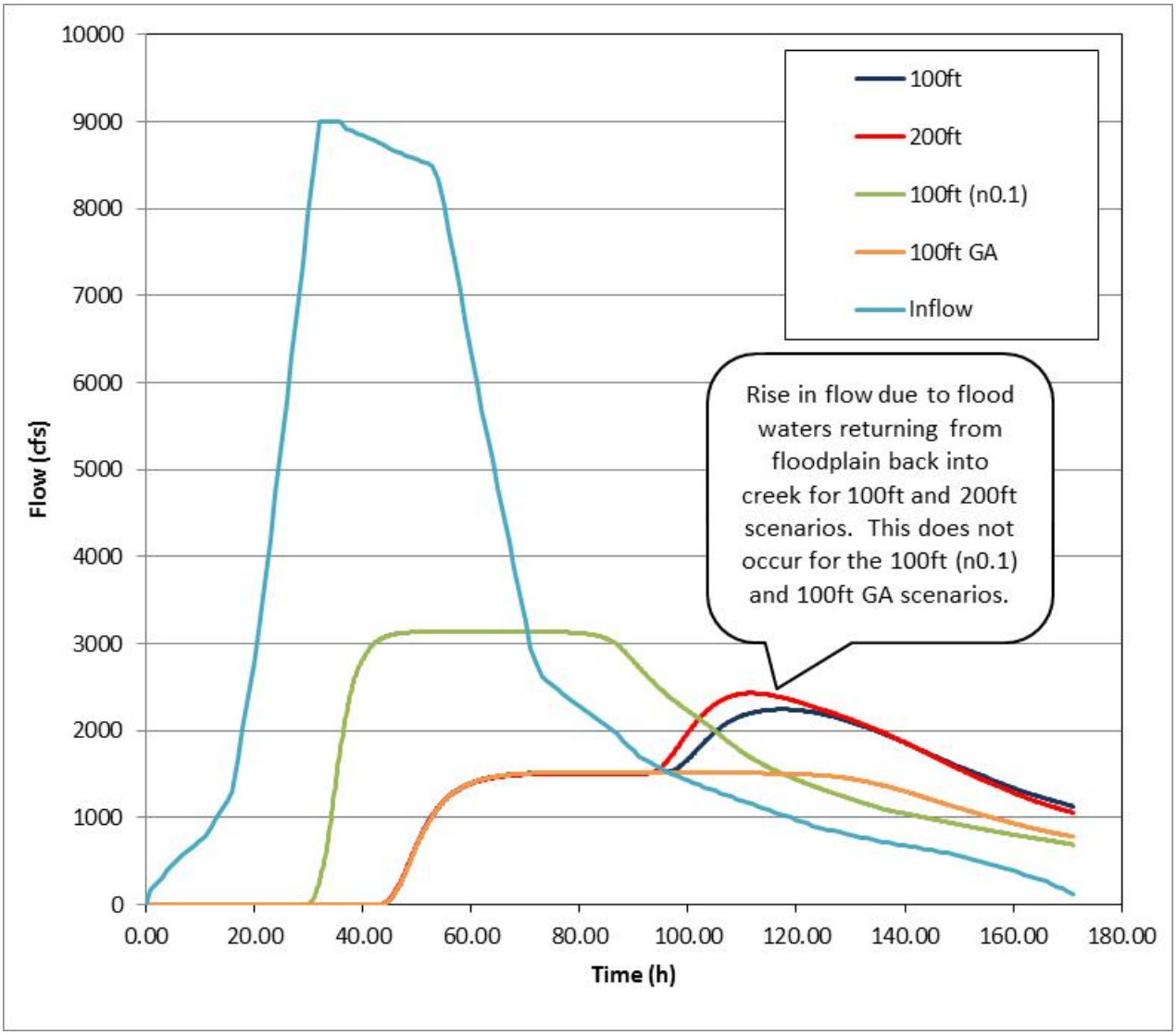


Chart of flow out of the model for the different scenarios simulated.
Note that "100ft GA" is the infiltration scenario modeled for Challenge 3+.

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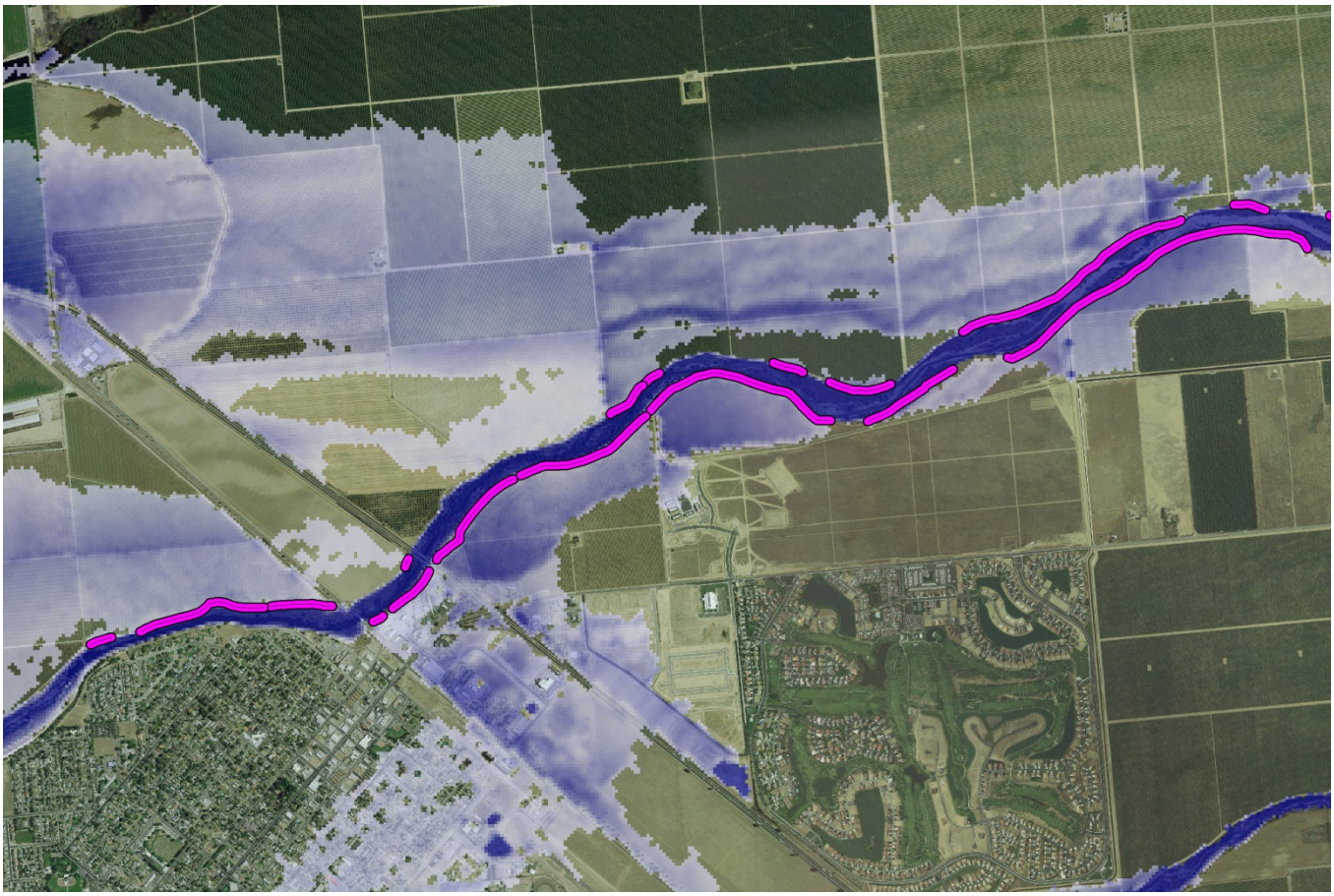
The sections of levee that were overtopped were post-processed using GIS for the 100ft with n=0.2 scenario as illustrated by the magenta lines in the image below. The GIS layer showing the overtopped sections is provided as part of the ftp download.



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Describe the "Challenges" you encountered in preparing this floodplain analysis and in mapping the flood limits:

A very interesting floodplain with very interesting dynamics! Is there any calibration data to verify the provided Manning's n values or are they based upon a calibrated model? – would be interesting to know.

No "challenges" to report.

Estimate computation time required for the analysis execution: __:___:__:__ DHMS

	Typical Run time (dd:hh:mm:ss) (Based on using a single CPU on a 3GHz chip)
2D Cell Size	**171 hours Simulation**
200ft	00:00:35:00
100ft	00:04:15:00

Challenge 3 Model Results:

- ☑ I am providing a shapefile containing the maximum flood inundation area which occurred in my model
- ☑ I am providing an Excel Spreadsheet containing the discharge hydrograph of the model stream at the downstream end
- ☑ I am providing a shapefile showing the extents of the levee overtopping which occurred in my model

Notes: (Please provide any feedback you would like us to consider on this Challenge Model. You could explain your element size selection, N Value selection, model type/software selection or anything else you would like us to know about how you assembled this model)

Please see discussions above.

Should you require any further outputs, please don't hesitate to contact us.

Submitted by: BMT WBM (TUFLOW Software) **Date:** Aug 24, 2012

To submit your model results, email this completed form to **2-DSymposium@floodplain.org** and provide FTP instructions for downloading your deliverables in the space below:
FTP Location (example: ftp://ftp.somedomain.com):

User name for FTP access:

Password:

Submitted by: BMT WBM (TUFLOW Software)

Date: Aug 24, 2012

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Modeler Name/Agency or FIRM: Phillip Ryan & Bill Syme / BMT WBM (TUFLOW Software)

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☐ 3-D ☑ Coupled 1-D/2-D ☐ OTHER_____

Indicate the cross section spacing, grid size, mesh element size characteristics of your computational domain Explain if the effects of Hydraulic Structures were modeled, How was that performed?:

Same model as used for Challenge 3.

Indicate the number of cross sections, grids, or mesh elements used: Same as Challenge 3

Describe the processes used to assemble your computational domain, execute it, and post process it into floodplain limits files. Indicate anything else you want us to know about your data and methods:

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The Challenge 3 100 and 200ft models were used with the Creek Manning's n value set to 0.2.

The soils layers provided were roughly classified into two soil types for the purposes of demonstrating the Green-Ampt infiltration feature in TUFLOW. The soils are shown in the image below where:

1. Red indicates a Sandy Loam.
2. Green is Sand.
3. The blue cross-hatched areas are the Urban land use zones modeled in Challenge 3. These areas were assigned a 90% impervious parameter that restricts the rate of water entering the underlying soils.

The Green-Ampt parameters used were the USDR soil type classifications which are built into TUFLOW's internal soils database. The parameters for the two soils are tabulated below.

USDR Soil Type	Suction (inches)	Hydraulic Conductivity (inches/h)	Porosity (fraction)
SANDY LOAM	4.3	0.43	0.412
SAND	1.95	4.6	0.417

The underlying soil was assumed to have an infinite depth to saturation (saturation depths/levels can be specified as 3D surfaces in TUFLOW if known). The soils were also set to have an initial moisture content of zero.

The 100ft and 200ft simulations were re-run with the Green-Ampt infiltration switched on. The resulting peak flood depths map for the 100ft simulation is shown in the image below. As can be seen, the extent of inundation is significantly reduced with floodwaters infiltrating before reaching the model extents or returning to the main channel.

The mass balance reporting from TUFLOW indicates over half (58%) of the water infiltrates into the ground during the 171 hour simulation. For the flow out of the model see “100ft GA” in the chart of flow out of the model presented in Challenge 3.

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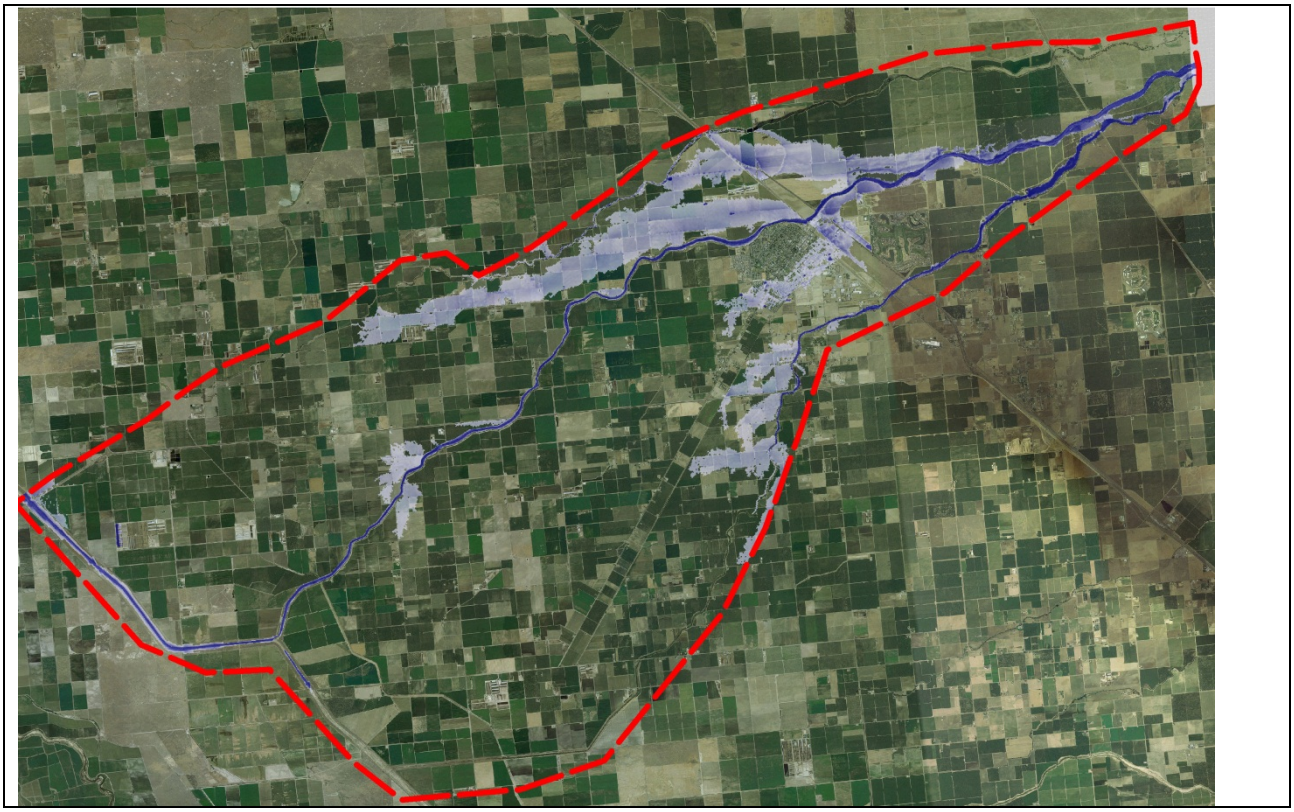

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Date: Aug 24, 2012

Describe the "Challenges" you encountered in preparing this floodplain analysis and in mapping the flood limits:

The soils GIS layers were difficult to work with. There is a lot of detail, but no clear way to correlate the different soils with Green-Ampt parameters (porosity, hydraulic conductivity, suction, etc).

Estimate computation time required for the analysis execution: __:___:__:__ DHMS

	Typical Run time (dd:hh:mm:ss) (Based on using a single CPU on a 3GHz chip)
2D Cell Size	**171 hours**
200ft	00:00:30:00
100ft	00:03:20:00

Challenge 3+ Model Results:

- [x] I am providing a shapefile containing the maximum flood inundation area which occurred in my model
- [x] I am providing an Excel Spreadsheet containing the discharge hydrograph of the model stream at the downstream end
- [ ] I am providing a shapefile showing the extents of the levee overtopping which occurred in my model
- [x] The percentage of total inflow lost in transmission to infiltration was: 58 %

Notes: (Please provide any feedback you would like us to consider on this Challenge + Model. You could explain your element size selection, N Value selection, Loss Method of analysis, model type/software selection or anything else you would like us to know about how you assembled this model)

Submitted by: BMT WBM (TUFLOW Software) **Date:** Aug 24, 2012

It would be interesting once again to know if there is any calibration data to calibrate the infiltration given that it is potentially very significant!

Should you require any further outputs, please don't hesitate to contact us. For example, we didn't submit the levee overtopping layer for the infiltration scenario, but if you require this please let us know.

To submit your model results, email this completed form to **2-DSymposium@floodplain.org** and provide FTP instructions for downloading your deliverables in the space below:
FTP Location (example: ftp://ftp.somedomain.com):

User name for FTP access:

Password:

Submitted by: BMT WBM (TUFLOW Software)

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