High Resolution Modeling of Flood Inundation

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This project aims to advance the state of the art in urban flood inundation modeling by tailoring multi-dimensional flood inundation models to increasingly available high-resolution geospatial datasets including LiDAR DEMs, aerial imagery and many other datasets characterizing urban landscape features.

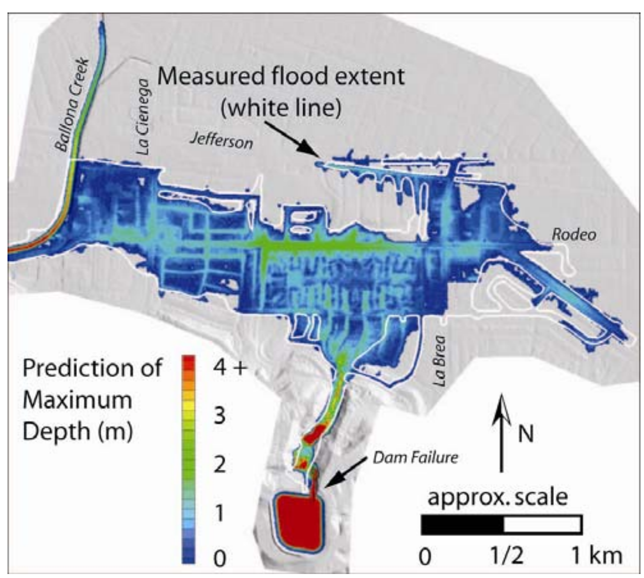
RESEARCH MOTIVATION AND OVERVIEW

Government at all levels is increasingly investing in Geographical Information Systems (GIS) to archive, access and regularly utilize a wide range of important data resources. These data are particularly rich in urban areas due to the density of infrastructure, and data characterize a vast array of features ranging from parcel boundaries and building footprints, land cover attributes, critical lifeline infrastructure and census data, to name just a few. Flood risk management efforts increasingly rely upon economic, social and environmental factors to measure the consequences of flooding. By combining data archived in government GIS with flood inundation predictions, it becomes possible to make highly resolved damage assessments required for decision making. However, flood inundation modeling technology has not kept pace with the changes in data resources, and many of today's models are not well suited to the challenge of routing flow through urban areas, nor the diverse flooding threats that stem from infrastructure failures such as levee breaks. Research led by Professor Sanders at UC Irvine is aiming to advance a new generation of high-resolution, multi-dimensional flood inundation models that leverage the data resources described above and build upon fundamental advances made in the computational sciences over the past decade. The goal of this research is to enable decision makers to better understand and predict the consequences of flooding, and to do with greater speed, frequency and precision than is possible with today's modeling technology.

Funding this year supported a modeling study of the Baldwin Hills dam-break flood, which occurred in Los Angeles in December, 1963.

BALDWIN HILLS STUDY

The Baldwin Hills reservoir was placed into service in April, 1951 to support water supply and distribution in the southwestern portion of Los Angeles. Situated over the Newport-Inglewood Fault, the reservoir was constructed of flexible earthen materials including an extensive drainage system in anticipation of settlement and seepage. Unfortunately, surface faulting directly under the reservoir compromised the integrity of the system. Under high pressure, channelized flow through the fault eroded and expanded the



fill material below the reservoir and ultimately breached the dam. The resulting flood caused extensive damage downstream including destruction of homes, apartment buildings, roads and flood control infrastructure. The surface faulting that caused failure was later attributed to regional subsurface fluid injection associated with oil recovery and waste disposal activities.

This study focuses on the predictability of dam-break flooding in highly urbanized and relatively flat terrain, as is found below the Baldwin Hills reservoir. The highly urbanized Los Angeles basin, like many developed areas, is surrounded by dozens of reservoirs; and dam operators must plan for the possibility of failure using model predictions of flood extent and flood arrival times. Advances in computational models and improvements in terrain mapping offer the potential for improved predictions.

Here, a two-dimensional overland flow model is a coupled to a model for sub-surface sewer flows and applied to the study site to predict flood inundation. Various aspects of the modeling approach including the terrain data resolution, the resistance parameter distribution, the magnitude of sewer flows, and the dam beach configuration are considered relative to the overall accuracy of the model.

To support this project, high resolution Light Detection and Ranging (LiDAR) terrain data and orthoimagery were obtained from the Los Angeles Region – Imagery Acquisition Consortium (LAR-IAC). In addition, flood extent data and Ballona Creek stream flow data were obtained for model validation purposes.

The results of this study show that urban flooding can be predicted on a street by street basis if a robust numerical flow solver is used and parameterized with high-resolution terrain data that depicts the detailed topography of urban landscapes. In particular, streets may be depressed relative to neighboring parcels and it is imperative that street flows be resolved by at least three computational cells for flood extent and stream flow accuracy. Results also show that sewer flows are important relative to flood extent and should be modeled. Results show that resistance parameters have relatively little effect on flood extent, but are important relative to arrival time predictions.

The broader implication of this study is that dam owners and emergency response agencies would be well served to revisit the modeling studies that support dam-safety plans (e.g., evaluation zones and warning times) to obtain more realistic flood predictions. Existing safety plans are likely based on simplistic inundation models and relatively crude data such as 10 m resolution (7 m vertical accuracy), National Elevation Data (NED). In this study, use of NED caused a significant overprediction of flood extent. A full account of this study appears in Gallegos et al. (2009).

Publications

Gallegos, H.A, Schubert, J.E. and Sanders, B.F. Two-dimensional, high-resolution modeling of urban dam-break flooding: A case study of Baldwin Hills, California. *Advances in Water Resources* 2009, 32, 1323-1335.

Professional Presentations

Sanders, B.F. Hydrodynamic routing of flood inundation over urban landscapes: Effective utilization of geospatial data and efforts to improve run-time efficiency, *Fluid Mechanics and Hydrology Seminar Series,* Department of Civil and Environmental Engineering, UC Berkeley, November 7, 2008.

Sanders, B.F. High resolution modeling of urban dam-break flooding: A case study of Baldwin Hills, California, *Los Angeles County Department of Public Works*, June 16, 2009.

High resolution modeling of flood inundation, *Noblis*, Falls Church, VA, June 23, 2009.

Improved Flood Inundation Modeling with LAR-IAC LiDAR Data and Orthoimagery, *Los Angeles Region Imagery Acquisition Consortium (LAR-IAC)*, July 30, 2009.

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