Modeling the Hydraulics of Expanded Floodways on the Lower San Joaquin River

Paul Frank, NewFields, pfrank@newfields.com
Mark Tompkins, NewFields, mtompkins@newfields.com

Past efforts to plan flood corridor improvements on a large-scale basis in the central valley have often relied on gross estimations of water surfaces outside of current levees rather than true hydraulic modeling. Modeling the hydraulics of the lower San Joaquin River and its floodplain is complicated by multiple distributary channels, built infrastructure affecting flow routing, and its multiple parallel channels. We conducted one-dimensional numerical modeling of river and floodplain hydraulics on the lower San Joaquin River using a newly updated and modified version of the Hydrologic Engineering Center - River Analysis System (HEC-RAS) model originally created for the Comprehensive Study. Novel modifications to the original model now allow predictions of floodplain hydraulics and the model has been extended longitudinally downstream in key areas. We developed an “existing conditions” configuration and multiple “expanded floodway conditions” that included modifications of levees, weirs, and flood bypasses. Output from this hydraulic modeling provided input to evaluations of ecosystem benefit, flood risk reduction, and water supply improvement associated with expanded lower San Joaquin floodways and allowed us to iteratively evaluate a range of alternative configurations to improve flood routing performance and restore critical habitat types.

Keywords: San Joaquin, Flood Management, Ecosystem Restoration

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Developing Alternate Hydrologies for the Lower San Joaquin River

Rich Walkling, Restoration Design Group, rich@rdgmail.com

We selected and designed multiple hydrologies to evaluate the sensitivity of ecosystem and flood risk performance of alternate floodway topographies to changes in flow. Hydrologies included 1) a post-Friant dam period record (1970-2011); 2) a hot and dry climate change scenario (2001-2099); and 3) an augmented flow scenario (60% unimpaired 1929-2011 flows). We developed the post-dam flow record using publicly available daily flow data for the Vernalis USGS gage, and for the hot and dry climate change scenario we used the Computational Assessments of Scenarios of Change for the Delta Ecosystem (CASCaDE) data. We created the augmented flow scenario by disaggregating March, April, and May monthly flood volumes equal to 60% of the unimpaired flows into hypothetical daily hydrographs that would maximize 7, 14, 21, and 28-day inundation on the floodplains of the proposed bypass. In any given year, we limited peak flows in the augmented flow scenario to the existing peak flows in the historical record (or 20,000 cfs, whichever was greater) so that the new hydrologic regime would not increase flood risk. We examined the plausibility of delivering 60% unimpaired flows for floodplain inundation at Vernalis without impairing water deliveries using a Water Evaluation and Planning (WEAP) model designed for the Stanislaus, Tuolumne, Merced and San Joaquin River systems. This presentation will focus on the development of the augmented flow record as this record showed the most significant improvements in ecosystem conditions.

Keywords: San Joaquin River Flood Corridors Hydrology

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Quantifying the Ecosystem Benefits of Restored Floodplain Habitat Connectivity on the Lower San Joaquin River

Mary Matella, UC Berkeley, mmatella@berkeley.edu
Katie Jagt, American Rivers, katiejagt@gmail.com

California's Sacramento-San Joaquin Delta was once a dynamic ecosystem that flooded seasonally, but topographic and hydrologic alterations for water supply and flood control have severed hydraulic connections, leading to habitat loss and declines in aquatic biodiversity. To evaluate the potential ecological benefits of floodplain reconnection, we used results from a one-dimensional hydraulic model of the lower San Joaquin River system with a statistical ecosystem functions model to quantify the potential habitat benefits resulting from floodplain reconnections and ecosystem friendly reservoir operations. We evaluated a range of corridor expansion alternatives and hydrologies. Our ecosystem benefit metrics quantify the potential floodplain habitat as a function of season, duration, and frequency in Area-Duration-Frequency (ADF) curves and as annualized expected habitat (AEH). We summarize the development and implementation of these metrics and present results for an expanded floodway that includes levee setbacks along the San Joaquin River, Paradise Cut, and Fabian Tract with historical, climate change-influenced, and augmented hydrologies. Under climate change, we see substantial floodplain habitat loss in a no-action scenario. The historical and augmented hydrologies show how the potential benefit of floodway expansion depends on available flows. This project presents a method for quantifying the impact of floodplain reconnection, bounding the range of benefits that a large-scale floodplain reconnection could provide along the lower San Joaquin River, and can help managers evaluate floodplain restoration projects as part of flood management planning.

Keywords: river-floodplain restoration; ecosystem functions model

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Evaluating Changes in Flood Risk with Changes in Floodway Size and Hydrology Along the Lower San Joaquin River

Katie Jagt, Consulting Engineer to American Rivers, katiejagt@gmail.com

We developed a method that uses output from a hydraulic model of the lower San Joaquin River, hydrologic statistics, levee failure curves, and GIS modeling to evaluate the potential flood-risk benefits of floodplain reconnection projects. We examined two physical configurations of the lower San Joaquin River in this analysis: the existing system with levees that closely follow the mainstem channel alignment, and an expanded floodway that would reconnect approximately 20,000 acres of historical floodplain. To quantify flood risk benefits we established metrics that describe the annualized probability of levee failure though the reach. This number represents the probability of a levee failure, within each reach of the project, in any given year. Starting with hydraulic model outputs and high resolution DEMs of the project area, we calculated the freeboard for each 10foot section of levee throughout the reach. Using previously published levee fragility curves we then correlated freeboard to a levee failure probability that accounts for geotechnical failures as well as overtopping. We found that the annualized probability of levee failure decreases by approximately 50 percent with an expanded floodway. Through this analysis we also were able to show substantial water surface elevation reductions and flood risk benefits to vulnerable areas such as the City of Stockton.

Keywords: Flood risk, levee failure, multiple benefits, hydraulic modeling.

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A Flow of Analyses to Evaluate Multiple Benefits of Floodway Expansion Along the Lower San Joaquin River

John Cain, American Rivers, jcain@americanrivers.org

Major ongoing water resources planning efforts including the Delta Plan, the Bay Delta Conservation Plan (BDCP), and the Central Valley Flood Management Plan (CVFMP) identify the creation of floodplain habitat as a critical element of success. However, a clear approach to 1) defining necessary modifications to existing river corridor conditions, and 2) systematically evaluating the three primary benefits (water supply, flood management, and ecosystem) of the modified system has remained elusive. We have developed a simple flow of analyses to evaluate these three benefits and have demonstrated its use through a pilot study of an expanded floodway on the lower San Joaquin River. Several related abstracts summarize the major components of this flow of analyses. Here we summarize the development, challenges, and novel advances that we experienced in completing this study, and implications of our primary finding that an expanded lower San Joaquin floodway could measurably improve flood management, increase water supply reliability, and improve ecosystem conditions.

Keywords: San Joaquin River, flood management, floodplain reconnection, restoration, water supply

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