Development of Flow & Stage Frequency Curves in the San Joaquin Basin for the 2017 Central Valley Flood Protection Plan

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A Stressed System, the Need for Action

- Central Valley people, property and assets at risk
- Current flood risk management path unsustainable
- Lack of funding for capital works and for ongoing operations and maintenance of existing infrastructure
- In 2008, the Legislature enacted the Central Valley Flood Protection Act, which authorized and required development of the Central Valley Flood Protection Plan (CVFPP) to address these issues
2017 Update to the CVFPP

- CVFPP is a dynamic, programmatic plan, updated in five year cycles – CVFPP first adopted in 2012, first “Update” in 2017
- 2017 Update has same goals 2012 CVFPP
- The planning horizon is the 30 years
- Refines and updates the State Systemwide Investment Approach (SSIA)
- Adds specificity about recommended near and longer-term investment and financing approach
- Provides broad guidance about more resilient risk management
- Coordinated and aligned with other major flood management efforts
Technical Work to Support CVFPP Goals

• Technical analyses informing a reasonable, balanced and cost-effective approach

• Emphasis on sustainable, integrated flood management

• Diverse array of actions to improve flood protection

• CVFPP Public Draft December 2016

CVFPP GOALS
Primary Goal: Improve flood risk management
- Reduce the chance of flooding
- Reduce damages once flooding occurs
- Improve public safety, preparedness, and emergency response

Supporting Goals
- Improve Operations and Maintenance
- Promote Ecosystem Functions
- Promote Multi-benefit Projects
- Improve Institutional Support
Today’s Discussion

Riverine Hydraulics Modeling

- Why are we doing this?
- How are we doing this?
- What are we doing with this?
Why Are We Doing This

New Hydraulic Modeling Tools

New Hydrology

Sea Level Rise & Climate Change
New Hydraulic Modeling Tools

- Central Valley Floodplain Evaluation and Delineation (CVFED) Models
  - Task Order 34 San Joaquin River Basin Systemwide HEC-RAS Model
  - Task Order 32 Stockton HEC-RAS Model
  - FLO2D Floodplain Models
New Hydraulic Modeling Tools

TO34 San Joaquin River Basin HEC-RAS Model
New Hydraulic Modeling Tools

TO32 Stockton HEC-RAS Model

New Hogan Reservoir

2017 ROADMAP
New Hydraulic Modeling Tools

- CVFED Model Refinements
  - Stability modifications to run in HEC-RAS 5.0.1
  - Flow splits based on actual operations
  - Refinements along Firebaugh
  - Added breaching at 95 locations
New Hydraulic Modeling Tools

• Breach Parameters
  – Triggers set at 85% probable failure stage
  – Breach widths set to 20x breach height
New Hydrology

• Central Valley Hydrology Study (CVHS)
  – DWR/USACE partnership and funded by DWR to support the CVFED Program
  – Unregulated flow and volume frequency curves for 200+ locations
  – Uses USACE approved procedures and not a re-do of the Comprehensive Study
Sea Level Rise & Climate Change

- Future climate different from historical climate
  - Warmer temperatures
  - Increasing precipitation extremes
  - Sea level rise

- Flood planning, long-term planning for resiliency
How Are We Doing This

Development of Frequency Curves
Development of Frequency Curves

- Flood Risk Evaluation Process
  - Regulated Flow Frequency Curve
  - Flow-Stage Transform
  - Stage Frequency Curve
Development of Frequency Curves

• Run CVHS Hydrology in CVFED Model
  • Four historical events: 1951, 1956, 1986 and 1997

• Historical events are scaled to define fully the required range of the unregulated to regulated flow transform

• Total of 132 scaled events simulated (33 event scale factors for each event)

• Post-process results into a single DSS file

• Extract stage and flow results to the Information Processing and Synthesis Tool (IPAST)
Development of Frequency Curves

- IPAST generates event specific flow-frequency curves

- Adjust raw curves to create final user modified curves
  - Modify critical durations
  - Forward smoothing trend
  - Exclude data points

- Critical duration - unregulated volume that “drives” peak regulated flow.
Development of Frequency Curves

IP SJ27 Baseline Combined Regulated Flow Frequency Curve

Event Weights

- 1997: 0.48
- 1986: 0.14
- 1956: 0.32
- 1951: 0.06

Combined Curve
- 1951 Based Curve
- 1956 Based Curve
- 1986 Based Curve
- 1997 Based Curve

Regulated Flow (Thousand cfs) vs. Annual Exceedance Probability
Development of Frequency Curves

- Climate change scaling ratios applied to unregulated flow in IPAST

IP SJ27 Baseline Combined Regulated Flow Frequency Curve

<table>
<thead>
<tr>
<th>1/AEP</th>
<th>Flow (cfs)</th>
<th>1/AEP</th>
<th>Flow (cfs)</th>
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<tr>
<td>500</td>
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</table>
Development of Frequency Curves

IP SJ27 Flow-Stage Transform

- HEC-RAS Scaled Event Data Points
- Fit Transform

Peak Stage (ft) vs. Peak Regulated Flow (cfs)
Development of Frequency Curves

IP SJ27 Stage Frequency Curves

Stage Frequency Existing Conditions
Stage Frequency Future w/Climate Change

Annual Exceedance Probability

<table>
<thead>
<tr>
<th>Annual Exceedance Probability</th>
<th>Stage Frequency Existing Conditions</th>
<th>Stage Frequency Future w/Climate Change</th>
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<tbody>
<tr>
<td>1/AEP 2</td>
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<td>1/AEP 200</td>
<td>40.2</td>
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<tr>
<td>1/AEP 500</td>
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<td>44.1</td>
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</tbody>
</table>
Development of Frequency Curves

• Development of Recommended Plan Curves
  • Modify CVFED Model Geometry to include system elements
    • Modify breach parameters as needed
    • Re-run CVFED models with modified hydrology
    • Re-run IPAST and frequency curve procedures
  • Compare results and quality check
Development of Frequency Curves

IP SJ27 Stage Frequency Curves

- Baseline - Existing Conditions
- Baseline - Future w/Climate Change
- Recommended Plan - Future w/Climate Change

Annual Exceedance Probability

Stage (ft)

2017 ROADMAP
Development of Frequency Curves

- 79 CVFPP Index Points in the San Joaquin Basin
  - Flow/Stage frequency curves at each one
  - Quality control at every step of the process
  - Lower San Joaquin delta is tidally influenced
What Are We Doing With This

Flood Risk Analysis

Riverine Map Atlas

Floodplain Inundation
Flood Risk Analysis

- Calculate expected annual damage (EAD)
- Calculate life loss
- Calculate annual exceedance probability
- Compare performance of alternatives
• Use IPAST results to select an approximate scaled event to represent return period

- Firebaugh – 100Yr WSE Profile

• Retrieve results from HEC-RAS model runs for selected event

Riverine Map Atlas

Firebaugh – 100 Year WSE Profile

Thalweg

Firebaugh Levee Bank

WSE Profile

Elevation (ft)

Station (Thousands ft)
Floodplain Inundation

- Use stage frequency results with interior/exterior floodplain mapping results
- Use RAS mapper with existing model information
- Modify model with 2D flow areas
The Path Forward

• Need to change how we think about flood risk management

• 2017 Update will refine the 2012 CVFPP and provides a holistic path forward to a different approach

• The refined SSIA enables the State to integrate and prioritize investments in multi-benefit flood risk reduction projects

• CVFPP will take 30 years to implement
Questions?

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