NOAA’s National Weather Service
California-Nevada River Forecast Center

Forecast Methods, Products, and Services for the San Joaquin River Basin

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Hydrologist in Charge

Mission of NWS
Hydrologic Services Program

• Provide river and flood forecasts and warnings for the protection of lives and property.

• Provide basic hydrologic forecast information for the nation’s environmental and economic well being.
NWS River Forecast Centers

CNRFC Customers

- NWS Field Offices
- Federal Water Management Agencies
- State Water Management Agencies
- City / County Flood Control Operations
- Public / Private Utilities
Staffing

**NWS/CNRFC**
- Hydrologist in Charge
- DO Hydrologist
- 4 Senior Hydrologists
- 3 Hydrologists
- 1 Senior HAS Forecasters
- 2 HAS Forecasters
- 1 Information Tech. Officer
- Administrative Assistant

**DWR/DFM**
- Hydrology Branch Chief
- 7 Engineers/Forecasts

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CNRFC Program Areas

- Flash Flood Support
- Dam Break Support
- Flood Forecasting
- Snowmelt Forecasting
- Water Supply Forecasting
CNRFC Hydrologic Modeling

Short Range ……… ……… Long Range

NWSRFS – OFS
6 hour time step
modular, deterministic

NWSRFS - ESP…………………
NWSRFS configuration
probabilistic (ensemble)

Statistical
simple, efficient, inflexible

Available CNRFC Forecasts

<table>
<thead>
<tr>
<th>Forecast</th>
<th>Duration</th>
<th>Season</th>
<th>Frequency</th>
<th>Probabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flood / Routine</td>
<td>5 Days</td>
<td>Year-round</td>
<td>Daily +</td>
<td>No</td>
</tr>
<tr>
<td>Ensemble Streamflow</td>
<td>User selectable</td>
<td>Year-round</td>
<td>Daily</td>
<td>Yes</td>
</tr>
<tr>
<td>Prediction</td>
<td>to 1 year</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spring Snowmelt</td>
<td>20 Days (4 x 5 days)</td>
<td>Early April thru snowmelt peak</td>
<td>Weekly +</td>
<td>Yes</td>
</tr>
<tr>
<td>Water Supply</td>
<td>April - July</td>
<td>January – May</td>
<td>Monthly +</td>
<td>Yes</td>
</tr>
</tbody>
</table>
**Operational River Forecasting**  
(Hydrology)

- **HAS River Forecast System**
  - Parameters
  - Calibration
  - Model guidance
  - Hydrologic expertise & judgment
- **Observing Systems**
- **Flood Forecast Guidance**
  - Bulletins graphics

**Operational HAS Function**  
(Meteorology)

- **10 NWFOs**
- **NCEP - HPC**
  - Local collaboration as required
  - 3-Day Forecasts
  - Updated every 6 hours
- **HAS**
  - 5-Day Forecasts
  - (6 hour interval)
  - Precipitation
  - Temperature
  - Snow Level
- **Atmospheric Models**
- **Local Models**
- **Surface Observations**
- **Remotely Sensed Data**
Flood / Routine River Forecast Process

Preprocessing → Processing → Post-processing

- Data collection
- Data QC
- Mean Areal computations
- Run model(s)
- Make adjustments
- Move downstream
- Text Forecast
- Graphical Forecast

Preprocessing Data Collection

- California Cooperative Snow Survey
- State & Local Resource Management Agencies
- Bureau of Reclamation
- Corps of Engineers
- California Data Exchange Center
- AWIPS text products
- NRCS (SNOTEL)
- ASOS
- 11 WFOs (ALERT)
- ALERT Reception
- Domsat (GOES)
Preprocessing
Data Quality Control

- Precipitation
- Surface air temperature
- River stage and discharge
- Reservoir elevations and storage

Preprocessing
Rating Table Management

- DWR CDEC
- USGS NWIS
- LDAD
- ascii tables (ap11)
- WFOs
- IHFSDB
- NWSRFS

automatically sent
ftp request
ftp request
processing (load)
exports
storage retrieval
Preprocessing
Scheduled Reservoir Releases

- Reservoir Operators
- River Modeling System
- Forecasters

future path

traditional path

Processing
NWSRFS Operations (Models)

- Rain-Snow Elevation
- Snow-17
- Soil Model (SAC-SMA)
- Unit Hydrograph
- Reservoir Models
- River Routing Models

- Lumped (not distributed)
- Mountainous basins
  - Subdivided into
    - Upper / Lower
    - Upper / Middle / Lower
CNRFC’s NWSRFS Implementation

- 250+ simulated watersheds
- ~90 flood forecast locations
- ~50 reservoir inflow locations

- Model time step = 6 hrs
  - Hourly discharge observations used in routings
- Routine forecast duration = 5 days
- Updates: every 6 hours during flood events

Upper San Joaquin Configuration
Lower San Joaquin Configuration

Processing

Forecaster Experience

- Watershed characteristics
- Model idiosyncrasies
- Data and gage issues
- Customer and partner needs
Post-processing
River Guidance (Flood Forecast Points)

- ~90 locations
- Updated w/each model run
  - 2x / day winter weekdays
  - 1x / day summer weekdays and weekends
  - 4x / day during flood events

(www.cnrfc.noaa.gov)
Post-processing

River Guidance (Flood Forecast Points)

- Graphical
  - +/- 5 days
  - Obs + Forecast + Guidance
- Available
  - CNRFC Website
  - CDEC Website
- Interpretation
  - Online help
  - 1 page flier

(www.cnrfc.noaa.gov)

Post-processing

River Guidance - Verification

- +/- 5 days
- Observed and Forecast
  - precipitation
  - streamflow
- Select by
  - date
  - next/previous
  - looping
- Available
  - All flood forecast locations
  - CNRFC Website
- Interpretation
  - Online help
- All since Fall 2003
Post-processing

River Guidance (Flood Forecast Points)

- Text
  - New format this year
  - Issued with each model run
  - + 5 days
  - Summary table and shelf encoded data
- Available
  - CNRFC Website
  - CDEC Website
- Basis of WFO issued flood warnings
- Issued for 10 areas
- Same frequency as graphics

Post-processing

River Guidance (Other Points)

- ~80 Non-flood locations

(www.cnrfc.noaa.gov)
Post-processing
River Guidance (Other Points)

- Generated during normal forecast process
- Various uses
- Same format as flood points

(www.cnrfc.noaa.gov)

Post-processing
River Guidance (Reservoir Inflows)

- 50 Reservoirs
- Restricted access
- Same format as river locations
- Updated w/ each model run
- Tabular data sent directly to operators
Ensemble Streamflow Prediction

- Use same forecasting infrastructure as Flood/Routine forecasts (NWSRFS)
  - Same models, observed data, model states
- Modeling system run with multiple scenarios of future precipitation and temperature
  - Scenarios are
    - Spatially and temporally coherent
    - Equally likely
- Resulting streamflow scenarios form a set that can be statistically sampled and analysed

Ensemble Streamflow Prediction
ESP Product Generation

- Significant flexibility
  - User selectable time aggregation
    - 6 hrs to 1 year
  - User selectable window
    - Days, weeks, months or multiples thereof
  - Information on
    - Peaks
    - Number of days to critical thresholds (e.g. Flood Stage)

Sample ESP Products
CNRFC Ensemble User Interface

- “Create Your Own”
- Ensembles run nightly
- Assumes knowledgeable user
- Online help and interpretive tools available

20-Day Spring Snowmelt Forecasts

- Issued on Wednesdays
  - Early April through the peak
  - Updates as requested
- Four 5-Day volume periods (20 days total)
  - 90%, 50%, 10% exceedance volumes (KAF)
- 1st period – primary use of single value forecast with QPF and forecast temperatures
- 2nd – 4th periods – primary use of ESP tools with blending of QPF and temperature forecasts into climatology
- 27 locations, 21 include peak forecasts

(www.cnrfc.noaa.gov)
20-Day Spring Snowmelt Forecasts
(www.cnrfc.noaa.gov/products/snowmelt/snowmelt.pdf)

CNRFC Statistical Water Supply (SWS) Modeling

- Topics
  - Comparison of SWS and ESP attributes
  - Overview of CNRFC SWS environment
  - CNRFC SWS data requirements
  - CNRFC SWS calibration program and approach
  - CNRFC Operational process
  - Review of CNRFC Millerton Lake procedures
  - Description of CNRFC Water Supply products and locations
Statistical Models vs. Ensemble Techniques

- **Statistical Models**
  - Low data requirement
  - Easy to calibrate and maintain
  - Perform better for seasonal volume forecasts
  - Inflexible (use/output)
  - May have difficulty in extreme years
  - Difficult to integrate weather and climate forecasts
  - Dominate model in the past

- **ESP Techniques**
  - High data requirement
  - More difficult to calibrate and maintain ($$)
  - Perform better for partial season forecasts
  - Flexible (use/output)
  - Should work reasonably well in extreme years
  - Easier to integrate weather and climate forecasts
  - Dominate model in the future

CNRFC SWS System Design

- **Relational Database**
  - Station characteristics
  - Historical observations
  - Real-time observations
  - Equations
    - Stations and coefficients
    - Historical performance

- **Programs**
  - Calibration Programs
  - Maintenance Programs
  - Operational Programs
CNRFC SWS Data Requirements

- Types
  - Adjusted monthly streamflow
    - Account for affects of diversions and reservoirs
    - Useful as a carryover term in some areas
  - Monthly precipitation
  - Snow course/pillow observations
  - Other
    - Climatic indexes, etc.

CNRFC SWS Calibration Program

- Developed by USDA/NRCS in late ‘80s
- Up to 49 “independent” variables
- Dependent variable transformation
- Principal components analysis (PCA)
- Cross validation standard error
- Combination analysis
- Yields “best” 20 equations (lowest CVSE)
SWS Calibration Approach

- Equations developed for each forecast month
  - Care taken to keep stations as consistent as possible from month to month
- No use of “future” data
  - Causes non-optimal coefficients (weights)
- Balance lower errors with good spatial distribution of stations
  - Attempt to introduce “some” hydrology
- Equations can be used in a mid-month mode
  - Estimate %normal to date and assume %normal to EOM
  - Use next month’s equation

CNRFC Operational SWS Forecasting Process

- Monitor and quality control incoming data
- Run equations and make adjustments
  - Compare with ESP information
- Coordinate forecasts with other agencies
  - NRCS in Nevada and Southern Oregon
  - Comparison with CA DWR in California
- Publish forecasts on Internet
Statistical Procedures for San Joaquin – Millerton Lake Inflow

- All forecasts are for April – July volume
- Maps of precipitation and snow course stations used in equations
- Monthly progression of SE and CV
- January 1 through May 1 equations
  - Scatter plots
  - Precipitation and Snow Courses used

Utilized Snow Courses
Utilized Precipitation Gages

Monthly Standard Errors

San Joaquin – Millerton Lake Inflow (Apr-Jul)
Monthly Coefficient of Variation
(Standard Error / Average)

San Joaquin - Millerton Lake Inflow (Apr-Jul)

- JAN 1
- FEB 1
- MAR 1
- APR 1
- MAY 1

CV

January Equation (Millerton, Apr-Jul)

- Standard Error = 636 KAF
- December Precipitation
  - Gem Lake
  - South Entrance YNP
  - Auberry
  - North Fork Ranger Station
February Equation (Millerton, Apr-Jul)

- Standard Error = 376 KAF
- Dec-Jan Precipitation
  - Auberry
  - North Fork Ranger Station
- Feb 1 SWE
  - Lake Thomas Edison
  - Rock Creek 1
  - Rock Creek 2

March Equation (Millerton, Apr-Jul)

- Standard Error = 276 KAF
- Dec-Feb Precipitation
  - Auberry
  - North Fork Ranger Station
- Mar 1 SWE
  - Gem Pass
  - Mono Pass
  - Piute Pass
April Equation (Millerton, Apr-Jul)

- Standard Error = 155 KAF
- Dec-Mar Precipitation
  - Auberry
  - North Fork Ranger Station
- Apr 1 SWE
  - Gem Pass
  - Mono Pass
  - Piute Pass
  - Cora Lakes
  - Lake Thomas Edison
  - Rock Creek 2
  - Mammoth Pass

May Equation (Millerton, Apr-Jul)

- Standard Error = 59 KAF
- Dec-Apr Precipitation
  - Auberry
  - North Fork Ranger Station
- Apr 1 SWE
  - Gem Pass
  - Mono Pass
  - Piute Pass
  - Cora Lakes
  - Lake Thomas Edison
- May 1 SWE
  - Huntington Lake
  - Kaiser Pass
  - Badger Flat
  - Beard Meadow
CNRFC Water Supply Products and Services

- CNRFC Monthly Water Supply Outlook
  - [www.cnrfc.noaa.gov/products/water_supply](http://www.cnrfc.noaa.gov/products/water_supply)

- Westwide Water Supply Outlook
  - [www.cbrfc.noaa.gov/wsup/westwide/westwide.cgi](http://www.cbrfc.noaa.gov/wsup/westwide/westwide.cgi)

- Western Water Supply Website
  - [www.nwrfc.noaa.gov/westernwater](http://www.nwrfc.noaa.gov/westernwater)

CNRFC Monthly Water Supply Outlooks

[Water Supply Outlook](#)

[Water Supply Forecasts](#)

[www.cnrfc.noaa.gov/products/water_supply](http://www.cnrfc.noaa.gov/products/water_supply)
Westwide Water Supply Forecasts

- Current and archive ('95 on) of:
  - Monthly/Seasonal Precipitation
  - Snow water
  - Snow cover (satellite)
  - Reservoir storage
  - Streamflow forecasts

www.cbrfc.noaa.gov/wsup/westwide/westwide.cgi

Western Water Supply Website

- Stat-based forecasts
  - Monthly progression
- ESP-based forecasts
  - Monthly break-downs
- Verification information
- More...
- All points in Western US
  - Expanding Nation-wide

www.nwrfc.noaa.gov/westernwater
Changes Are Coming!

- CHPS (Community Hydrologic Prediction System) to replace NWSRFS
  - Service oriented architecture
  - Delft FEWS + NWS models + custom development
  - Easier to integrate external models
  - Deployment at CNRFC underway now!
    - Massive migration effort
    - Started parallel operations in October 2009
    - Fully operational before October 2010
  - Fully operational across US by October 2011
- See website NEWSLETTER for details…
Changes Are Coming!

- Hydrologic Ensemble Forecasting System
  - PROBABLISTIC FORECASTS
    - Short (hours), Medium(days), Long(weeks/months)
  - Requires CHPS
  - Many years in prototype development
  - Partial operational deployment planned for WY11
  
  - See website NEWSLETTER for details…

Future CNRFC Hydrologic Modeling

- Short Range … … … … … … Long Range

  - CHPS
    - 1-6 hour time step
    - Single value

  - HEFS…………………….................................
    - probabilistic (ensemble-based)

  Statistical
  - simple, efficient, inflexible