# Probabilistic Hydrologic Forecasts for Decision Support at the North Central River Forecast Center

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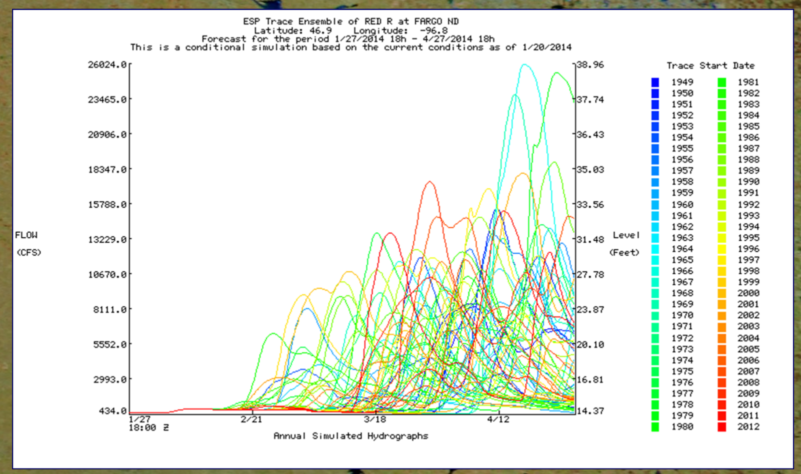
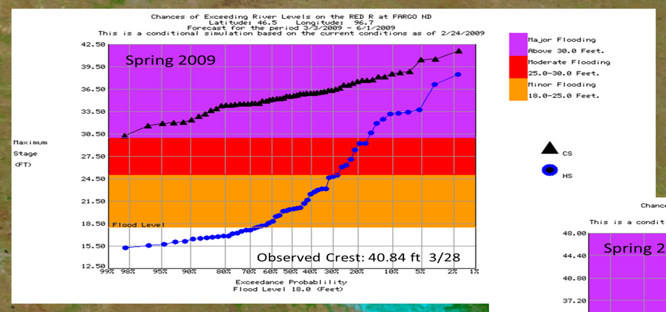
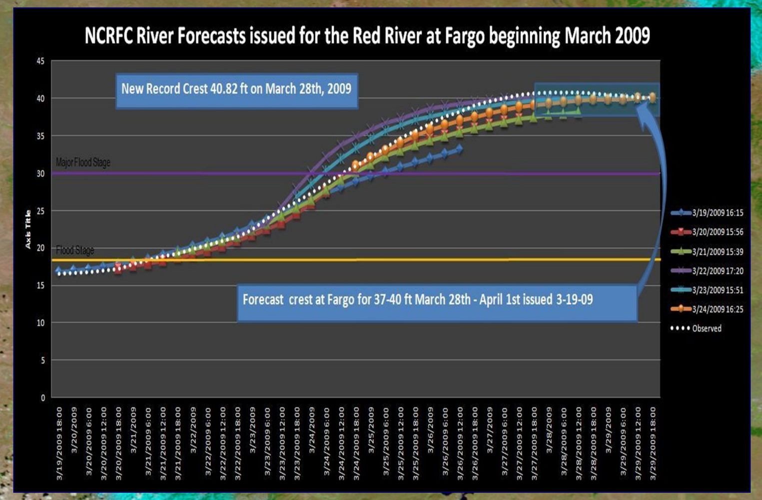
Advanced Hydrologic Prediction Service (AHPS) Ensemble Streamflow Prediction provides probabilistic forecasts with an extended window of analysis for long-range risk assessment and planning.[1] Forecasts at the NCRFC are created using 60+ years of observed temperature and precipitation as inputs to drive NWS hydrologic model simulations. Historical data and current model states are combined with forecast temperature and precipitation inputs to generate an expected range of possible streamflow, stage or volume hydrographs within a forecast window of interest (currently 90 days).

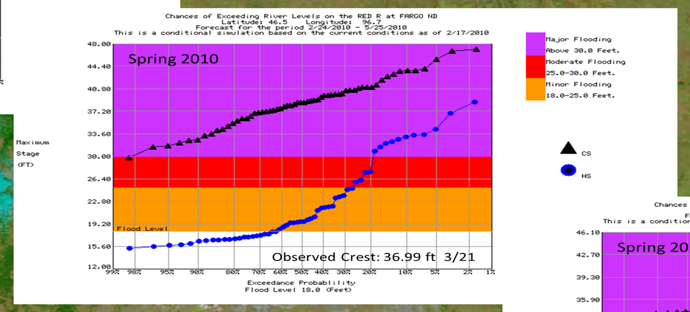
## Assessing Flood Risk

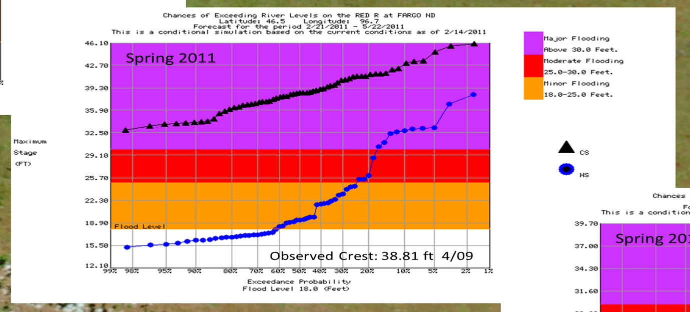
Across the Midwest, risk analysis for spring flooding is a combination of antecedent conditions (snowpack, soil moisture, and frozen ground, for example) and expected future conditions of temperature and precipitation. Antecedent conditions are tracked with continuous simulation snow and soil moisture accounting models. The expected future conditions can be simulated from a meteorological model and historical climate observations. The current application of the Advanced Hydrologic Prediction System utilizes more than 60 years of historic temperature and precipitation observations as input scenarios for future expected conditions. Future enhancements to AHPS will integrate ensembles of meteorological model forecasts to account for short-range uncertainty. This enhancement is part of the Hydrologic Ensemble Forecasting System (HEFS).

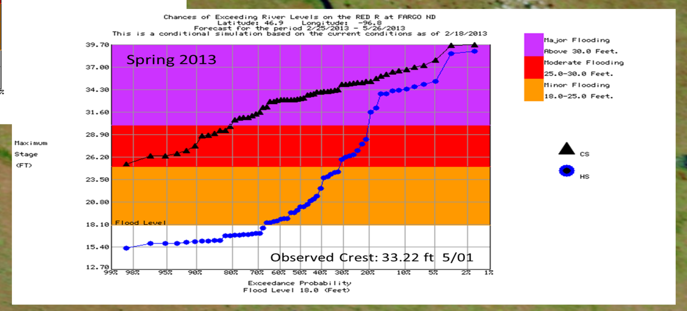


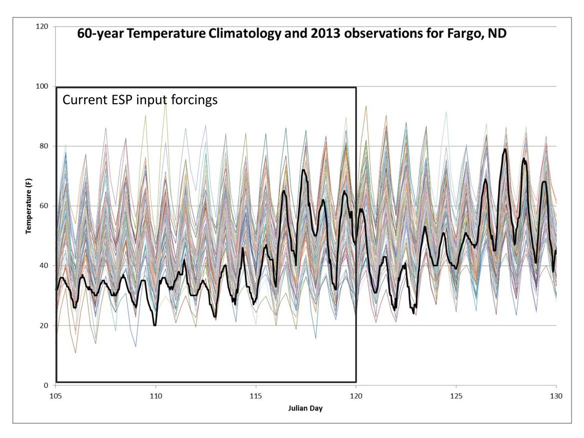



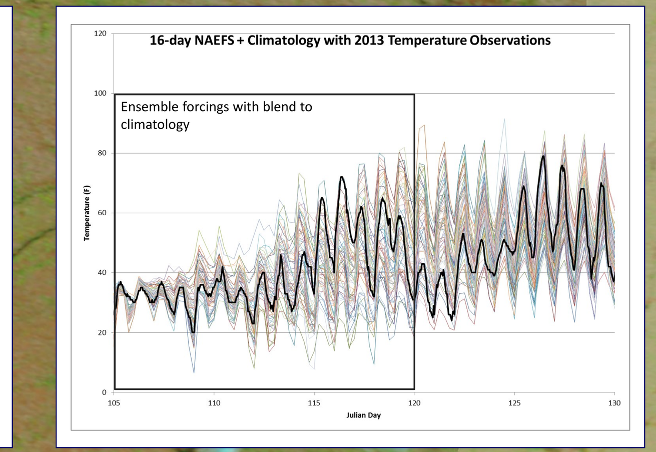




## Bridging Probabilistic and Deterministic Forecast Horizons

NOAA's National Weather Service (NWS) is implementing a short- to long-range Hydrologic Ensemble Forecast Service (HEFS). The HEFS addresses the need to quantify uncertainty in hydrologic forecasts for flood risk management, water supply management, streamflow regulation, recreation planning, and ecosystem management, among other applications. The HEFS extends the existing hydrologic ensemble services to include short-range forecasts, incorporate additional weather and climate information, and better-quantify the major uncertainties in hydrologic forecasting. It provides, at forecast horizons ranging from 6-hr to about a year, ensemble forecasts and verification products that can be tailored to users' needs.[2] Note in the example to the right that the observed temperatures for Fargo, ND starting at Day 105 were near historic lows for the period of record. With meteorological ensemble forecast input as shown in the NAEFS + Climatology graphic, a considerable amount of climatological bias is removed, as the ensembles show the possibility of even lower temperatures than were actually observed. This will allow for increased confidence in a shorter-term outlook, prior to initiating deterministic forecasts.

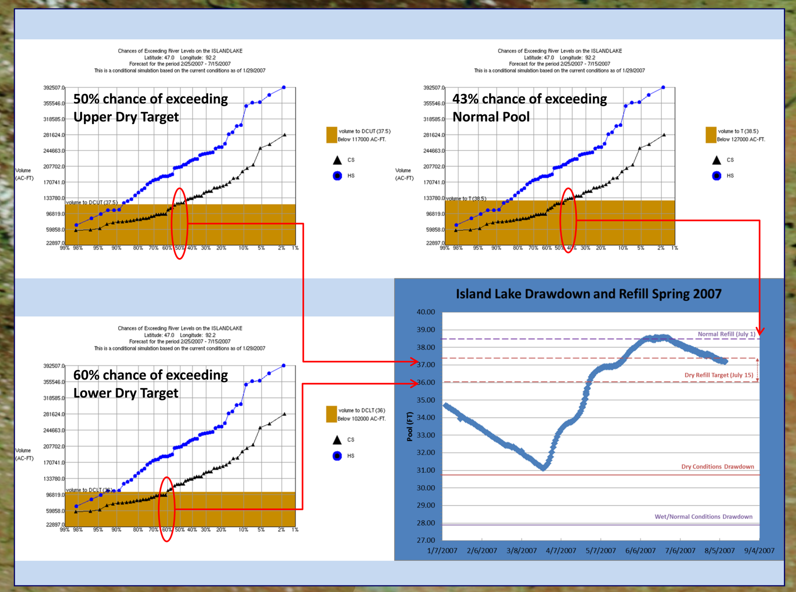



Hydropower

Recreation

Environmental Needs




## Balancing Stakeholder Interests

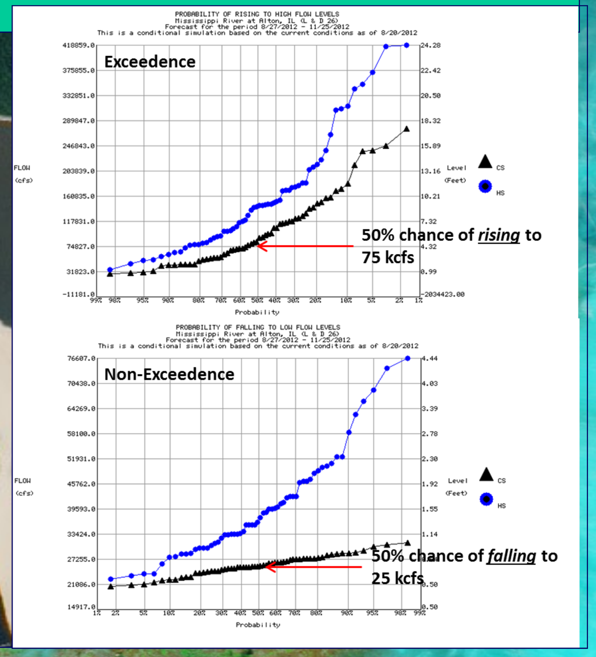
Many Upper Midwestern hydropower facilities rely on storage reservoirs to provide water for power generation during the traditionally low flow winter months. These storage reservoirs are then refilled the following spring with snowmelt runoff and rainfall. This paradigm worked well when the hydropower facilities were first constructed in the 1800s and the entire watershed had a single stakeholder interest; the electric power company. The latter part of the 20th century saw many more stakeholders emerge, as property around these reservoirs was developed for vacation homes; fisherman and boaters used the reservoirs for recreation; and, environmentalists became concerned about inconsistent water levels in the river downstream of the reservoirs. In order to balance the competing stakeholders' needs, operational decision matrices were defined. By nature, these decision matrices have temporal components that are based on real-time hydrologic conditions within the watershed. These decision points are best informed with forecasts. In the Island Lake, MN example to the left, the forecasts informed a decision to not fully drawdown, in order to mitigate the risk of not refilling to target levels in a dry year while still meeting minimal environmental flows, maximizing hydropower generation, and protecting recreational interests.

Water Supply

Navigation

### Exceedence vs. Non-exceedence for Low Flow

Lower flow conditions on the Mississippi River pose challenges to both municipal and industrial water consumers, as well as the navigation industry. In order to economically plan for low flow conditions, relative risk of future low flow conditions must be quantified, then operating scenarios can be optimized to mitigate that risk. Maintenance of a required 9-foot navigation channel and maximum barge draught are of significant importance.


**References:**

1. Day, G. (1985). "Extended Streamflow Forecasting Using NWSRFS." *J. Water Resour. Plann. Manage.*, 111(2), 157–170.

2. Demargne, J., et. al. (2014). "The Science of NOAA's Operational Hydrologic Ensemble Forecast Service." *Bulletin of the American Meteorological Society* (pending publication; January, 2014).

http://www.crh.noaa.gov/ncrfc/