National Weather Service Expansion of Hydrologic Services in Mississippi

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ABSTRACT

The National Weather Service is expanding and modernizing hydrologic services in the state of Mississippi. The NWS is developing a modeling system for the coastal areas that links our current hydrologic models with hydraulic and oceans models to provide better forecasts. Flood inundation maps will be developed to provide emergency managers information on areas that will be flooded at specific river levels. Enhanced modeling procedures will be tested at selected locations within the state.

As a pilot project on the Pascagoula River, the NWS is developing a hydrodynamic model simulating the water levels in the Gulf of Mexico and a 2-dimensional hydraulic model for the Pascagola River drainage below Merrill, MS. These models will be linked to the NWS hydrologic model resulting in model simulations for this area that incorporate the effects of riverine flooding and the effects of tides and storm surge from hurricanes. This system should allow the NWS to provide more accurate forecast at existing sites and easily implement forecasts at additional sites.

For selected locations in Mississippi, flood inundation maps will be prepared. At one-foot intervals from flood stage to the flood of record, a hydraulic model will be run to determine the water surface elevations for a steady state flow condition. From these elevations using geographic information systems (GIS) technologies, maps depicting flood inundation areas will be developed. These maps will be provided to local and state emergency managers for use in determining evacuation areas.

As a test, the NWS will implement additional enhanced hydrologic modeling procedures. For small watersheds, the Sacramento Soil Moisture Accounting Model will be tested on an hourly time step. A distributed hydrologic model will be calibrated and tested on a small watershed in Mississippi. In addition to model development, the NWS will conduct outreach and training with local emergency managers and officials on these new and improved techniques.

Keywords: Floods, Hydrology, Models

Introduction

The National Weather Service is responsible for preparing and issuing river and flood forecasts and warnings to mitigate the loss of life and property. NWS hydrologic forecasts and services are used by decision makers such as emergency managers and water resources managers. Those decisions range from evacuations to save lives and property to optimizing water usage for power and water supply. The NWS is modernizing the science used in their forecasting and as a result new products are being developed for the state of Mississippi.

To provide enhanced forecasts for the Pascagoula River, the NWS is developing a 2-dimensional hydraulic model of that river and linking it to an ocean model which simulates the changes in water elevation due to winds, tides, and storm surge. To provide emergency managers more information on flood evacuations, flood inundation maps are being developed for several locations throughout the state. A distributed

hydrologic model using digital elevation data and gridded inputs will be tested at selected locations in Mississippi.

Current Hydrologic Services in Mississippi

Currently, the NWS provides river and flood forecasts for 70 locations in Mississippi as shown in Figure 1. At these locations, the NWS provides forecasted river levels for the next 5 days in 6-hour increments. These forecasts are disseminated daily and are based on the rain that has already fallen plus the expected or forecasted rainfall for up to the next 24 hours. These forecasts are prepared by the Lower Mississippi River Forecast Center (LMRFC) and Southeast River Forecast Center (SERFC) as indicated in Figure 1. To prepare these forecasts, the RFCs model the soil moisture and estimate runoff using the Sacramento Soil Moisture Accounting Model (SACSMA). Unit hydrographs are utilized to convert the runoff depth to flow at the basin outlet, and Variable Lag and K routing is used to route the water downstream. Rating curves from the USGS are used to conver stages to flows. For the Mississippi River, the FLDWAV hydraulic model is run to simulate the complex hydraulic conditions on the river. Inputs into the FLDWAV model include observed and forecasted flows from the Ohio River at Smithland Lock and Dam, IL, and the Mississippi River at Chester, IL.

River Forecast Centers serve as regional centers by providing hydrologic modeling expertise. The forecasts prepared by the LMRFC and SERFC are provided to the Weather Forecast Offices (WFO). The WFOs coordinate the effects of these forecasts with local government officials and the media and issue products on NOAA Weather Radio. WFO responsibilities in Mississippi are delineated in Figure 1.

Forecasting river stages is a collaborative effort between the NWS and other federal, state and local agencies. The NWS relies heavily on the US Geological Survey (USGS) for real-time data collection and rating curves to convert stages to flows. The US Army Corps of Engineers (COE) operates flood control structures needed by RFCs to provide forecasts downstream. RFCs coordinate closely with reservoir operators to factor observed and planned flows into downstream forecasts. Some state agencies operate reservoirs and the RFCs must work closely with them on reservoir operations.

New Products and Services

The NWS is in the middle of a multi-year project called Advanced Hydrologic Prediction Services (AHPS) to modernize and expand their products and services. As a result of Hurricane Katrina, increased emphasis has been placed on forecasting of water/river levels in the Gulf Coast states. As a result, a significant amount of effort will be placed on developing procedures to improve and expand hydrologic forecast services. Once those procedures have been proven their effectiveness, they will be used as a guide to improve services at additional locations as time and money permits.

Advanced Hydrologic Prediction Services (AHPS) – In AHPS, the NWS is working to improve and modernize hydrologic services through several major initiatives. These initiatives are focused on improving the current science used, taking advantage of new web technology and dissemination methods, developing new science and techniques, and implementing probabilistic forecasts.

To improve the existing science used in our models, RFCs are recalibrating the Sacramento Soil Moisture Accounting Model (SACSMA) for all of their current forecast system. This work is a combination of RFC staff time and efforts of contractors. This major effort was started in the LMRFC area in 2002 and is expected to last through about 2013. The precise date for the completion of all the recalibrations is uncertain because it is tied to available budget.

Concurrent with recalibrating the hydrologic models, the NWS has implemented a standard web portal to make forecasts available to our customers much easier. All NWS hydrologic forecasts are available at http://www.weather.gov/ahps/. Efforts are underway to make our websites more reliable with redundant servers at three locations and load balancing to point users to the server with the least workload.

The NWS is investing in the development of new science. Current RFCs run the SACSMA lumped hydrologic model on a 6-hour timestep. Basin sizes range from 50-800 square miles. Basin average rainfall for a 6-hour period is the primary input into these models. To compute 6-hour mean areal precipitation used in the SACSMA, hourly gridded estimates

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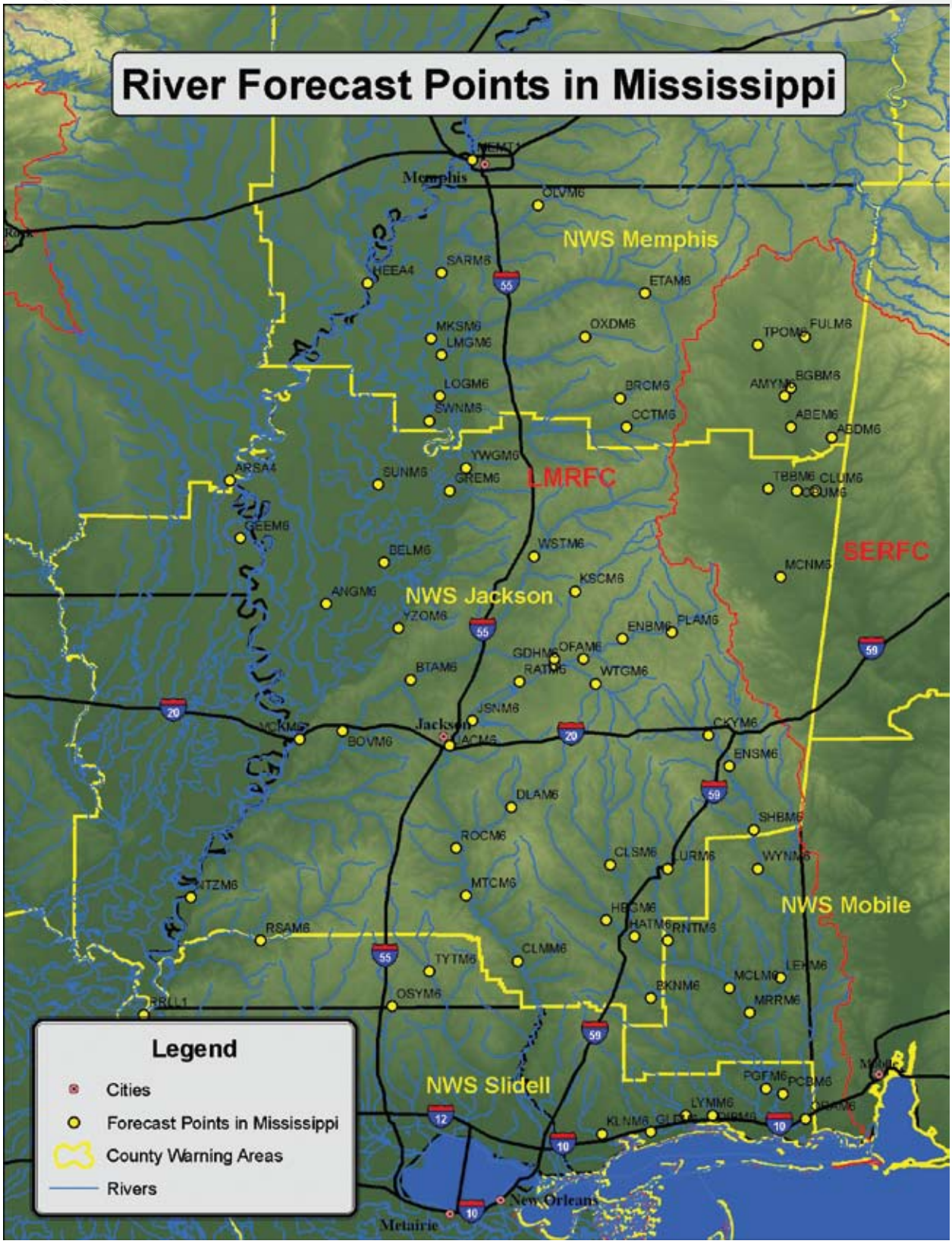

Figure 1. NWS Hydrologic Forecast Services in Mississippi.

of precipitation from the WSR-88D weather radar are averaged over the basin. These hourly basin averages are then summed to provide the necessary input into LMRFC forecast models. To make maximum use of the gridded rainfall on an hourly basis, the NWS has developed the Hydrology Laboratory Research Distributed Hydrologic Model (HL-RDHM) and is working to implement it at selected sites for evaluation and testing. Using the HRAP grid system as a basis (approximately a 4kmx4km grid), the HL-RDHM performs soil moisture accounting at each grid location using a modified SACSMA model on an hourly basis. Kinematic techniques will be used the route the water from one grid point to another until it reaches the basin outlet. The next step in development is to utilize remote-sensed data (satellite and radar) to develop a physically based distributed model.

To provide more information to our users, the NWS is implementing probabilistic forecasts. As model calibration is complete at a site, probabilistic forecasts for the next 90 days are provided. A sample of our probabilistic products is shown in Figure 2. This graph shows the likelihood of the river location reaching a specific level in the next 90 days. These probabilistic forecasts are based on current soil moisture conditions and historical precipitation data. LMRFC has implemented long-term probabilistic forecasts at several locations in northern Mississippi and expects to provide such forecasts at all locations in Mississippi by the end of 2008.

The NWS is also experimenting with short-term probability forecasts. In addition to our current deterministic forecasts, we would provide probabilities of the river reaching a specific level. A sample of how this forecast might look is shown in Figure 4. This would provide our users an indicator of the uncertainty or confidence we have in our forecasts. Two pilot projects are currently underway to develop short-term probability forecasts. Short-term probability forecasts will likely not be implemented across the country for several more years.

Pascagoula River Modeling

Historically, the NWS modeled the interface between riverine flooding and flooding from storm surge and high tides at very few locations. At this interface, subjective techniques have been employed to provide forecasts which rely heavily on RFC forecaster expertise and knowledge.

As a result of Hurricane Katrina, a modeling system is being developed to link the current RFC riverine forecast models with hydrodynamic ocean models. The University of Central Florida (UCF) is developing the Advanced Circulation Model (ADCIRC), a finite element hydrodynamic model, to simulate water elevations in the Gulf of Mexico, the Caribbean, and western half of the Atlantic Ocean. UCF will then develop the ADCIRC model for the Pascagoula River below Merrill in a finer mesh. Downstream boundary conditions for the fine mesh ADCIRC model will be obtained from the larger scale model run. Upstream boundary conditions will be the locations where the LMRFC performs hydrologic model simulations as shown in Figure 4. In addition to UCF developing the ADCIRC model of the Pascagoula, LMRFC will develop the HEC-RAS model, a 1-dimensional hydraulic model. Results of the 2-dimensional ADCIRC runs and the 1-dimensional HEC-RAS runs will be compared. The NWS will have access to ADCIRC model output during landfalling tropical systems. Computer hardware requirements will be determined to run ADCIRC operationally at a River Forecast Center.

Inundation Mapping

Emergency managers have repeatedly called for inundation maps to delineate areas of flooding based on a specific river stage. Through a contractor, flood inundation maps will be developed for five (5) locations in Mississippi as a proof of concept. The contractor will utilize LIDAR data and available cross-sectional data used in developing FEMA Flood Inundation Rate Maps (FIRMs) to compute the water surface profile for water levels at 1-foot increments above flood stage. This catalog of inundation maps will be provided to emergency managers to support evacuation efforts.

The NWS is developing a website to serve up these images and data can be downloaded from the server and imported into a GIS. The NWS is evaluating the availability of data for selected sites to determine the optimum locations to develop these maps. As resources and money permits, these maps will be developed for the rest of the state. The

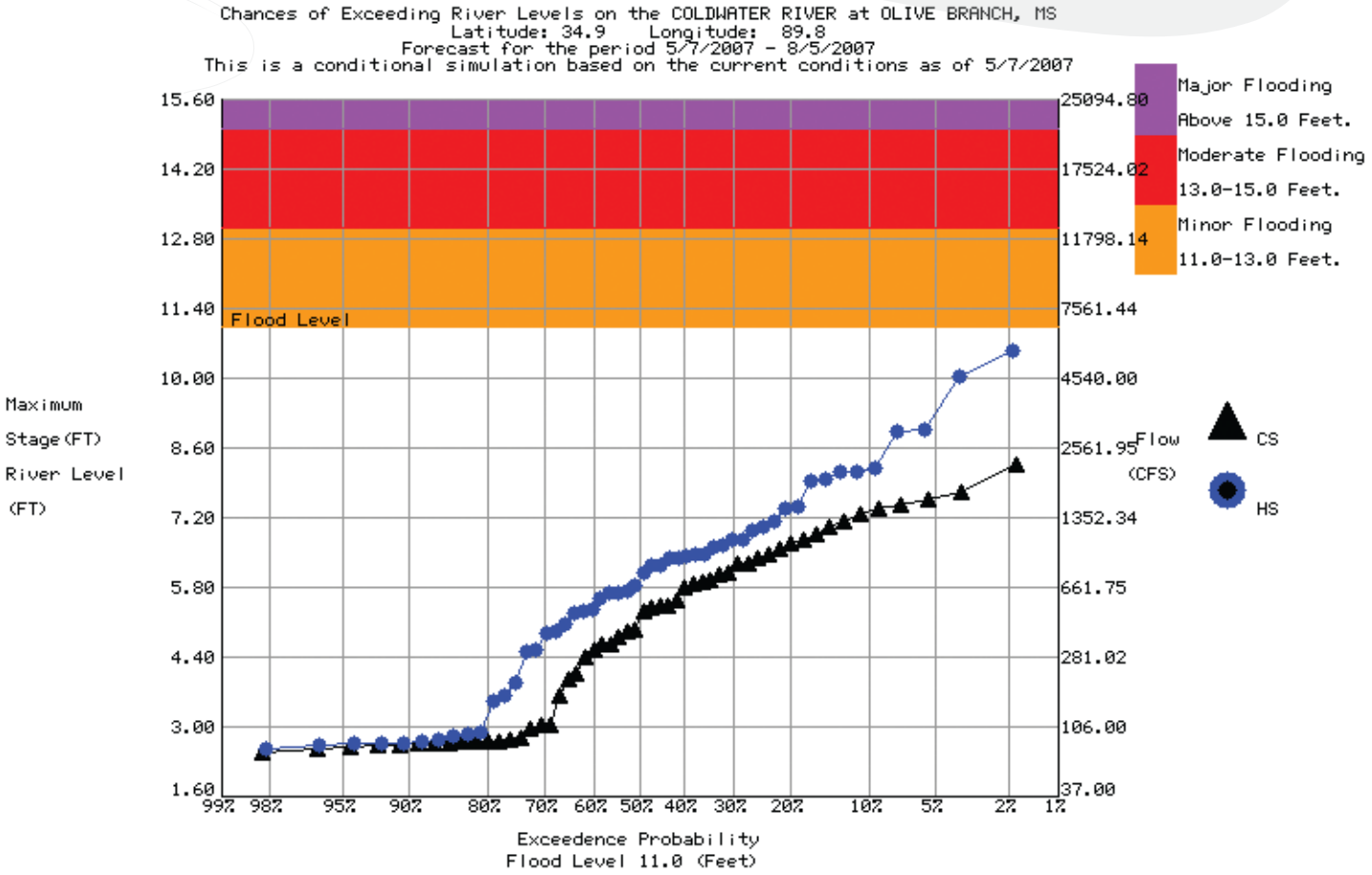

Figure 2. Sample long-term probabilistic product showing the likelihood of flooding in the next 90 days.

NWS is also working with the Federal Emergency Management Agency (FEMA) to encourage cities to develop these inundations maps during the modernization and update of FEMA Flood Insurance Rate Maps (FIRMs). These is only a small incremental increase in cost to develop inundation maps when flood studies are completed.

Distributed Hydrologic Model

Current RFC lumped hydrologic models run on a 6-hour timestep. Basin average rainfall for a 6-hour period is the primary input into these models. This modeling approach negates the utility and strengths of 4km x 4km precipitation estimates from the WSR-88D. To make maximum use of the gridded rainfall on an hourly basis, LMRFC will implement the HL-RDHM for selected basins. Using the HRAP grid system as a basis, soil moisture accounting will be performed each grid location using a modified SACSMA model. Kinematic techniques will be used the route water from one grid point to another until it reaches the basin outlet. This distributed model will help in forecasting since rainfall rarely falls uniformly in time and space across our modeled basins which may be as large as 800 square miles in size. The LMRFC will compare the output from the distributed model with the lumped parameter hydrologic model currently used

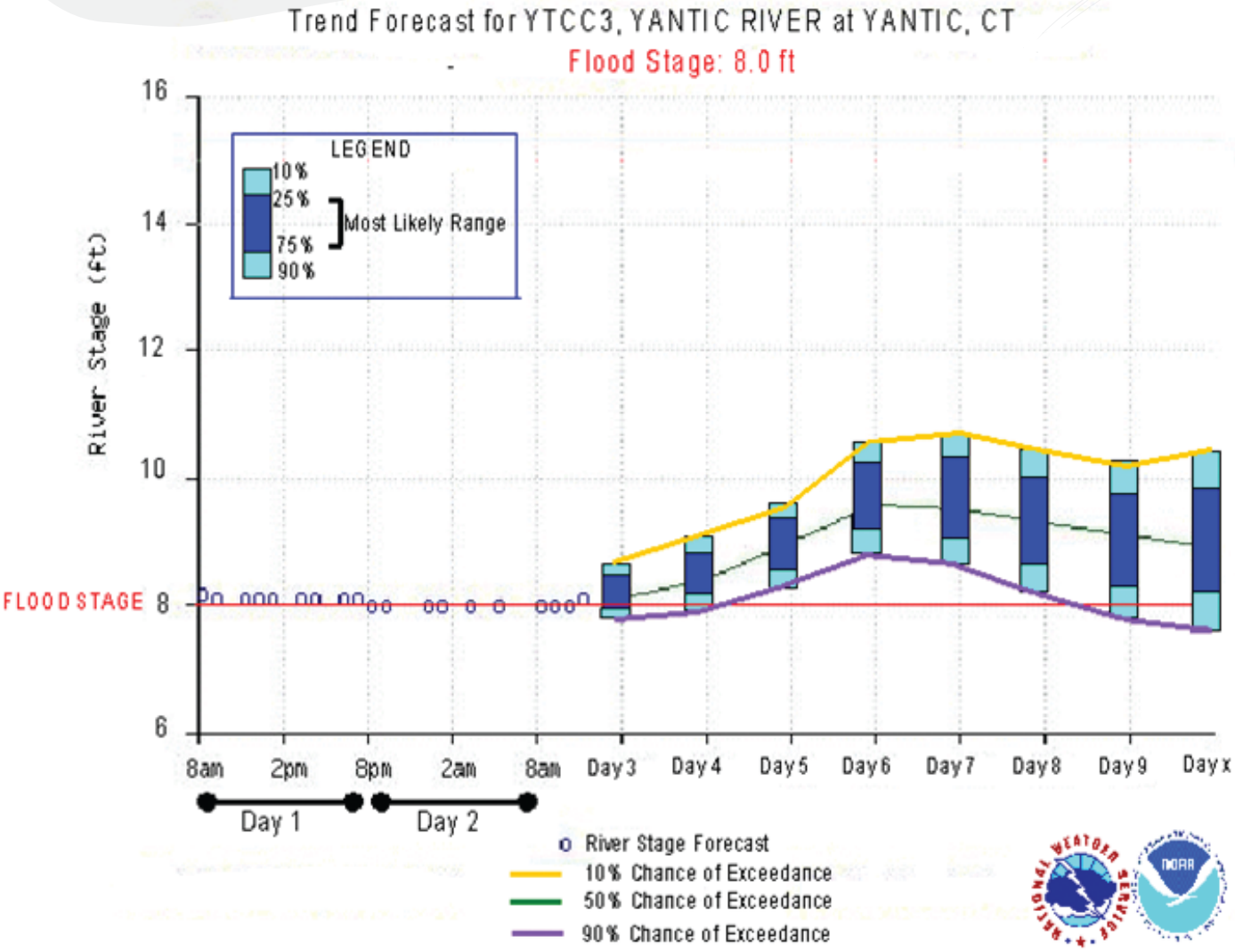

Figure 3. Sample of a short-term probabilistic river forecast.

in forecasting. Basin selection should be completed this summer and the model calibrated and implemented in late 2007 and 2008.

Expanded Outreach

These new tools and modeling techniques allow the NWS to expand the services provided to emergency managers and the public. These new tools are not perfect and the assumptions that are made in these techniques must be understood to be used effectively. The NWS will conduct extensive outreach and training with our customers to ensure they understand the limitations of these products. During these visits, user feedback will be obtained and factored into future service improvements. Training and obtaining feedback is essential to ensuring that the products are used properly and that we meet customer needs as they evolve.

Conclusions

The NWS is implementing new and enhanced technologies to provide better forecast to the citizens of Mississippi. Coupling hydrodynamic oceans models with current riverine models and a 2-dimensional model of the Pascagoula will provide enhanced forecasts for that area. Flood inundation maps will provide emergency managers with an additional

Figure 4. River gages and boundary conditions in the Pascagoula River basin.

tool to make decisions on evacuations. The hourly SACSMA Site Specific model and the Distributed Hydrologic Model will provide forecasts in a finer temporal and spatial scale. The NWS will expand its outreach to brief the cooperators on these new tools.