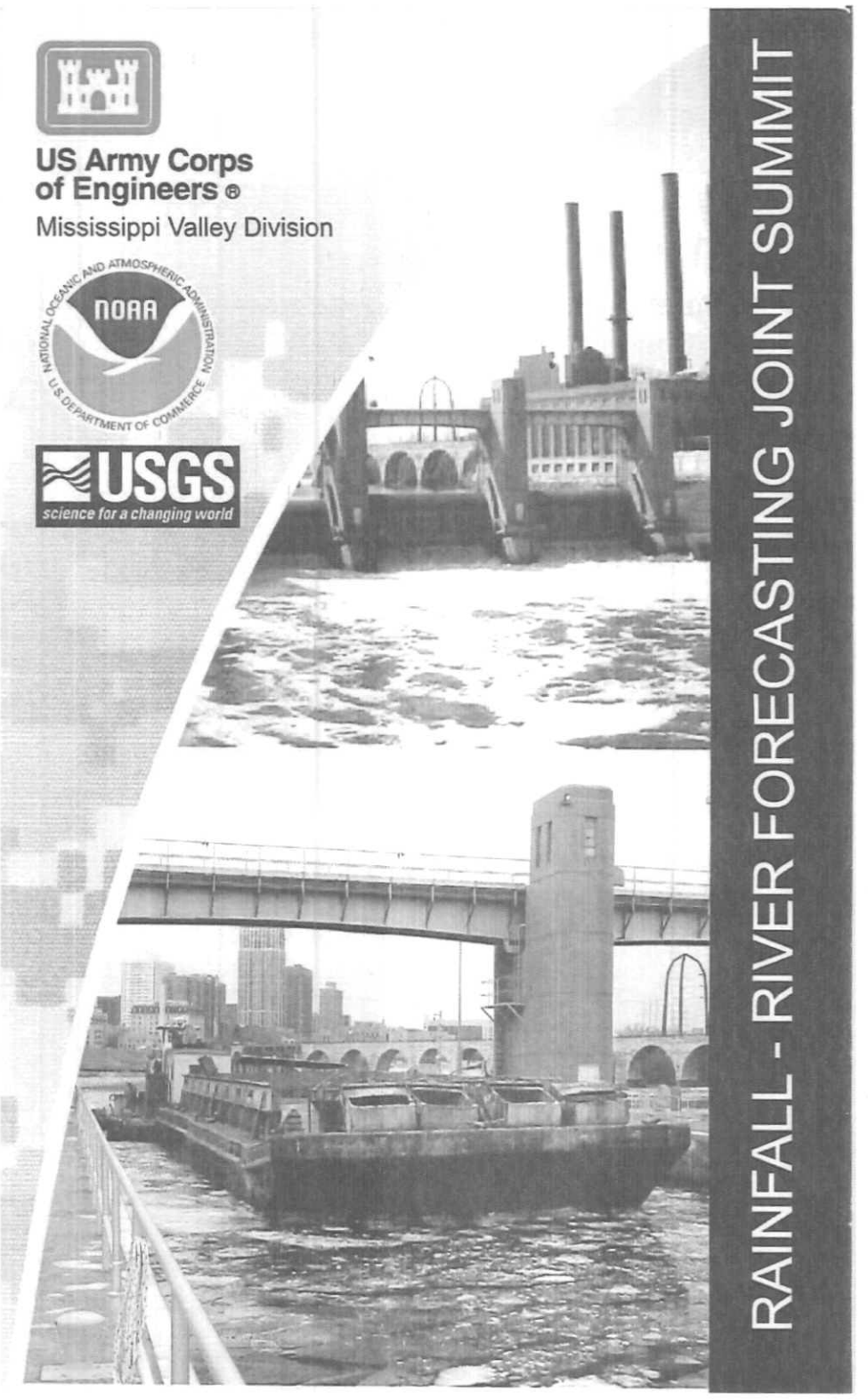

2nd Rainfall-River Forecasting Summit Report
19-20 October 2009

Rainfall-River Forecasting Summit Report

Summit Report Purpose: The purpose of this report is to provide a summary of the 2nd Rainfall-River Forecasting Summit hosted by the U.S. Army Corps of Engineers (USACE), the National Oceanic and Atmospheric Administration (NOAA), and the U.S. Geological Survey (USGS) in St. Paul, MN, on October 19-20, 2009. The summit was held to discuss what went well with forecasting during the recent 2009 flood events, as well as potential service improvements for future floods and low flow events.

History: The first Rainfall-Runoff Forecasting Summit was held 7-8 October 2008 in St. Louis, Missouri. That summit focused on 2008 flood events in the Midwest, including the Cedar River. Various stakeholders raised concerns or issues about the rainfall and river forecasts. The summit provided a much needed forum for the federal agencies to openly discuss the accuracy of current, and methods for improving future, river forecasts. The first summit also provided an opportunity for members of the public to express their concerns to these federal agencies in regards to the importance of accurate and timely forecasts. A report on the first Summit can be found at: http://mvs-wc.mvs.usace.army.mil/fusion/fusion.htm.

As a result of the first summit, the agencies created a "Fusion Team" comprised of members from NWS, USGS, and COE to develop a course of action to determine what improvements to the accuracy of forecasts can be made with the current science, human resources, and level of funding. The NWS also committed to meeting with members of the river industry to work on the critical areas of concern where the industry stated the official river forecasts were not accurate enough for their needs. The Fusion Team adopted the following Mission Statement which was coordinated with the NWS, USGS, and COE.

The Fusion Team mission is to collaboratively develop a process for improving the accuracy and utility of rainfall and river forecasts within the Mississippi River Basin employing the expertise and experience of the team's member agencies.

The Fusion Team is comprised of representatives from NOAA's NWS, USGS and USACE. The Fusion Team will develop a plan for improvements respective of the current science, human resources, and level of funding. The ultimate goal of the Fusion Team is to optimize the accuracy and utility of the forecasts provided to the Public in accordance with all applicable regulations.

2nd Summit Results: The discussion below provides the information gained from the Federal, State, and local government participants, as well as private stakeholders who participated in the 2nd Summit. From those discussions, the NWS, USGS, and COE agencies agreed on the following summit results:

What Went Well:

- **Coordination** – Between Agencies, Divisions, Districts, State & Local Government, Industry, Public. The State Emergency Operations Center (EOC) staff stated that early pre-flood planning meetings were very beneficial. The daily conference calls conducted by the NWS helped keep all agencies on same page and provided crucial preparedness information for emergency responders. NWS Chat software use, although somewhat limited among the agencies, proved to be an efficient means of immediate communication.
- **Information Dissemination** – Data dissemination (observations and forecasts) were generally timely and highly useful to emergency response operations, however, several issues were noted (ref. next section). The following means of data dissemination were utilized: Rivergages.com, MVP-WC (COE-St. Paul District Water Control) website, NWS websites, USGS websites.
- **Precipitation Forecasts** – Rainfall and snowfall forecasts were quite good and helped to increase lead time for responders to take action. The NWS was able to use a 6-day rainfall forecast to aid in predicting the first Fargo crest, over a week in advance, to within one foot and two days.
- **River Forecasts – 1st crest at Fargo;** the first crest forecast at Fargo provided a 12-day lead time and was within one foot of the actual crest height observed. **Lead Time** - The mayor of Breckenridge, MN, stated the forecasts provided ample lead time for the city to be proactive in preparations. Preliminary flood outlooks and a webinar provided a long lead heads-up for the event.
- **Flood Warnings** – Overall, flood warnings were timely and effective; a media representative said the forecasts were "*successful in keeping people safe.*" However, several issues were cited and noted in the next section.
- **Products and Information** – Expanded use of NWS Ensemble river forecasts, the USGS Rating Curve Depot, satellite imagery, LIDAR-based water depth information, and unmanned aerial surveillance (UAS) video for the assessment of floodwater extent and the identification of ice cover and jams.
- **Instrumentation** – USGS Rapid deployment of temporary gages enhanced data resolution to improve forecasts.
- **Personnel** – Cross training of personnel, deployment of personnel between agencies, co-location of agencies significantly enhanced coordination. Technical agencies being in the state EOC were "priceless" and noted as critical to flood support by emergency responders.
- **Resources** – Resources were utilized efficiently by ensuring available personnel, equipment, and material were deployed when and where they were needed.

What Did Not Go Well:

- **Information Dissemination** – NWS messages were not always conveyed effectively; i.e., on occasion, too many acronyms were used during briefings and found on web pages. One size does not fit all for information sharing. A need exists for distributing critical information through different avenues that are accessible to all flood response personnel with and without personal computers. Computer graphics information was not always in synch with the corresponding text product information. Searching through multiple web sites posed a problem; one common data portal is needed.
- **River Forecasts** – Public expectations are increasing at a rate faster than science and technology can support. Need to better manage customer expectations by more effectively communicating the limits of the forecast. Different customers want different forms of answers (forecasts) - some want one number, some want a range. Deterministic vs. probabilistic creates problems with correct usage. Changing from probabilistic forecasts to deterministic for the first crest and then back to probabilistic for the second crest was confusing for some users. Media members had trouble understanding probabilistic numbers, focusing on the 50% probabilistic forecast. While that is the statistically "most likely" value, feedback stated it should have been relayed with the associated probability (e.g., 50% chance of reaching or exceeding X feet). Without the probability information, it was confused with a deterministic value. While the accuracy of the first crest forecast was quite good, the second crest forecast was too high. Scientific review of the model and data suggested the error was due to the frozen ground model not capturing the complicated changing soil conditions.
- **Flood Warnings** – Flood warnings need to remain in effect as long as the river is flooding, but some members of the community became desensitized to the warning due to the extremely long duration. The warning upgrades (e.g. from moderate to major flood levels) caused problems with the Fargo cable television system in that the Emergency Alert System (EAS) was activated fairly often and the system would interrupt the broadcast to announce the flood warning. This would sometimes interrupt news coverage on the flood causing viewers to miss important information. Some members of the public thought the EAS alert on the flood warning was for something more serious like a levee breach.
- **Instrumentation** – Need more USGS stream gages and snowfall reports
- **Data** – The numbers the NWS includes in their forecasts are carried out to the tenths place which some users assert relays a false sense of accuracy or precision in these numbers.

What Improvements Can Be Made By The Agencies For Future Events:

- **Coordination** – Expand use of instant messaging with NWS Chat and/or Web EOC to relay critical information, such as levee overtopping/breaching as soon as identified. Develop a protocol for phone conferences to allow info to be received in a timely and efficient manner; try to consolidate or minimize the number of calls, if possible. Make use of graphics through webinars.
- **River Forecasts** – More accuracy in predictions through science and technology improvements and enhanced communication of forecast certainty; expand use of Ensemble River Forecasts and contingency forecasting. Consider human component and provide clear explanations of predictions when they are made public to avoid public misunderstanding or interpretation. Need to better communicate, on web sites and in public, limits of the forecast through use of information such as confidence levels and expected error. Need to show how and why the forecast has been updated, especially crest forecasts. Where possible, crest forecasts should remain consistent from one forecast to the next.
- **Instrumentation** – High flow only sites may cost less than full range streamgages and should be considered as a means of supplementing and extending the regular streamgage network, perhaps on a seasonal basis. NWS equations should be calibrated with recent observed flow measurements or indirect flow measurements where possible, or used with caution. In the rare circumstance where a flow measurement may not be possible, cross sections should be surveyed in advance and used with flood profiles surveyed during flood conditions to more accurately estimate flows.
- **Flood Warning** – The NWS needs to issue warnings, but need to re-evaluate the frequency of requesting EAS activation.
- **Information Dissemination** - Need to educate people on how to get stage information. Need for more user-friendly information. Too many websites to find various information; need one agency-neutral web portal for water-related issues. Need to ensure small communities receive information, not just concentrate on the larger communities. Need to find ways for emergency responders in the field, without computers, to get needed information; perhaps through expanded use of cell phone technology.
- **Data** – River forecasts should be issued with the appropriate precision (e.g. tenths, half-foot increments).

Public Meeting Purpose: A public open house on 19 October 2009 was conducted to hear concerns from industry and interested members of the public on rainfall-river forecasting issues. Prior to the statements from the public the following overview of each agencies roles and responsibilities were presented:

The National Weather Service Roles and responsibilities in rainfall-river forecasting: The National Weather Service provides hydrologic forecasts and warnings for the United States, its territories, and adjacent waters and ocean areas, for the protection of life and property and the enhancement of the national economy. Legal authority for the National

Weather Service to issue flood forecasts, watches and warnings to the public can be found at 15 U.S.C., Section 313 of the United States Code, available at: http://www.gpoaccess.gov/USCODE/index.html . National Weather Service data and products form a national information database and infrastructure which can be used by other governmental agencies, the private sector, the public and the global community. The River Forecast Centers provide river forecasts and hydrologic guidance to their partners, which consist of Weather Forecast Offices, other River Forecast Centers and cooperating water-related agencies. The Weather Forecast Offices disseminate river/flood forecasts and warnings which are used for the protection of life and property, and to provide water resource information to support commerce and economic decisions. To access National Weather Service river forecasts across the country: http://www.weather.gov/ahps/ . For more information contact: noreen.schwein@noaa.gov.

The United States Geological Survey Roles and responsibilities in rainfall-river forecasting: Making wise decisions to manage floods and their impacts requires information derived from data on stream behavior — both current and past. For more than 100 years, the U.S. Geological Survey has collected, managed and disseminated these data, measuring and reporting on the behavior of United States streams. The USGS currently operates and maintains a nationwide streamgaging network of about 7,500 gages in cooperation with more than 800 organizations. The annual cost of operating the national streamgage network is about $120 million. USGS provides streamflow data to numerous agencies, including the Corps of Engineers for flood control management and the National Weather Service for input to river forecast models. USGS streamflow data are used for such things as: (1) planning, designing, operating and maintaining the nation's multipurpose water management systems; (2) issuing flood warnings to protect lives and reduce property damage; (3) designing highways and bridges; and (4) mapping floodplains. Real-time streamflow data are available at: http://waterdata.usgs.gov/nwis/rt and are used by various organizations and emergency managers to better respond to floods as they occur. During major floods, the USGS enters a mode of intensive data collection. This additional information is needed to provide improved estimates of risk and impacts for better hazard response and mitigation. Information collected includes systematic field surveys of precipitation, river stage, and river discharge and water quality. In addition, temporary streamgages are deployed during floods to ensure adequate data are available for forecasting and response activities in critical locations where there are no permanent streamgages. For more information contact: jlavista@usgs.gov.

The United States Army Corps of Engineers Roles and responsibilities in rainfall-river forecasting: The U.S. Army Corps of Engineers is a significant steward of the nation's water resources and is responsible for water control activities to achieve project purposes such as flood control, water quality, water supply, irrigation, navigation, hydropower, recreation, and fish and wildlife enhancement. The Corps is responsible for "management" of these activities, which requires expert knowledge of the engineering and scientific aspect of the work and water control management policies. In carrying out water control activities, the Corps recognizes and observes the legal responsibility of the

National Weather Service, National Oceanic and Atmospheric Administration, for issuing weather forecasts and flood warnings, including river discharge and stage forecasts. The Corps of Engineers has the responsibility for developing situational forecasts for the operation and maintenance of the Corps projects and to provide timely and accurate information to the National Weather Service for their use in developing official public forecasts. The Corps is also responsible for coordinating with other agencies and providing relevant, coordinated forecasts to Corps of Engineers flood fight teams. For more information contact: robert.t.anderson@usace.army.mil.

The public meeting featured a panel comprised of the following members:

Senior Representatives **Technical Representatives**

National Weather Service

Dr. Thomas M. Graziano
Chief, Hydrologic Services Division
Headquarters, Office of Climate, Weather and Water

Steve Buan
Service Coordination Hydrologist
North Central River Forecast Center

United States Geological Survey

Robert R. Mason, Jr.
Assistant Chief, Office of Surface Water

U.S. Army Corps of Engineers

Colonel Thatch Shepard
Deputy Commander, Mississippi Valley Division

Chuck Shadie
Watershed Management Team
Mississippi Valley Division

Stakeholder Panel

Mr. Clifford Barth
Mayor, Breckenridge, MN

Ms. Terri Smith
MN Department of Homeland Security
& Emergency Management (HSEM)

Mr. John Wheeler,
Meteorologist, WDAY-TV
Fargo, ND

Mr. Sammy Dickey
River Industry Action Committee

Stakeholder Input: The public was then asked to provide feedback to the panel on rainfall-river forecasting issues.

The Mayor of Fargo provided a letter which addressed his concerns. He was frustrated with the daily increases in the 2009 crest predictions. He would like more accuracy in the predictions along with more information about flood probabilities. He would like to ensure that the human component is taken into consideration when these predictions are made public.

The Mayor of Grand Forks also provided a written statement. He expressed similar disappointment with the short notice of increases in predictions. He would like for an improvement in the availability of long-term forecasts.

The panel members that were present agreed that there is "no easy answer", that predicting floods is hard. There was also agreement that "one-size does not fit all". Some raised concerns that information distributed via the NWS does not always give a clear explanation of the flood prediction. Media members, public, state EOC's have trouble understanding probabilistic numbers. There is a need for user friendly information via the websites. The NWS could provide a summary statement that highlights changes in the forecasts and explanation of these changes. Probabilistic forecasts are too specific and deterministic are not user friendly.

RIAC also addressed concerns of the River Industry. Their main concern is the QPF (no-rain) 14-day forecasting, river lows for boat drafts, and consistency (the morning forecasts tend to always be on the high side). RIAC asked if quality control was being conducted on the forecasts, particularly on weekends. They indicated that the 3, 5, 7-day forecasts are usable, but that the 14-day and 28-day forecasts change too much to use.

Summit Results:
The Summit provided a much needed forum for the federal agencies to openly discuss the accuracy of current river forecasts and methods for improving future forecasts. The Summit also provided an opportunity for members of the public to express their concerns to these federal agencies in regards to the importance of accurate and timely forecasts.

NWS will continue to make data easily interpretable; they recognize the need to provide narratives when forecasts are updated/changed. The perceived accuracy to the tenth is a problem that has been recognized and they will continue to develop a solution. The flood warnings must be kept in effect to keep the threat of flood aware to the public. However, the frequency at which they are re-issued needs to be evaluated.

Next Steps by Agency:
The NWS, USGS, and the COE will continue to evaluate their respective roles in the process for improving the accuracy and consistency of rainfall/river forecasts within the Mississippi River Basin. Each agency will ensure that any actions taken will be coordinated between the agencies and with the Fusion Team to minimize any potential conflicts.

Proposed Actions by Agency and Fusion Team:

Possible Action Items for National Weather Service:

The following is a non-exclusive list of possible action items the National Weather Service could evaluate, recommend or incorporate as needed and in conjunction with those items addressed by the Fusion Team.

1. Improve clarity of river forecasts and warnings by exploring ways to better communicate forecasts, especially probabilistic forecasts.
    a. Pursue method to provide forecast reasoning, especially for significant changes in crest forecasts.
    b. Ensure crest forecast trends are consistent from one forecast to the next; changes should be based on science.
    c. Expand use of ensemble river forecasts.
    d. Expand outreach or training on use of probabilistic forecasts.
    e. Provide confidence level or expected error information.
2. Avoid use of acronyms in coordination briefings and on web pages.
3. Pursue a more consolidated approach to coordination briefings.
4. Explore enhanced dissemination methods for emergency responders that do not have a personal computer on hand (e.g. RSS feeds, I-NWS).
5. Pursue more limited use of EAS activations in widespread flood events.
6. Update river forecast software to be able to output the appropriate precision (e.g. tenths, half-foot increments).
7. Pursue expansion of snow reporting network.
8. Explore science and technology improvements, particularly regarding the frozen ground model.

Possible Action Items for U.S. Geological Survey:

The following is a non-exclusive list of possible action items the U.S. Geological Survey could evaluate, recommend or incorporate as needed and in conjunction with those items addressed by the Fusion Team.

1. Utilize NWS CHAT to better communicate new USGS ratings changes and stage–corrections data and the plans for and results of data-collection activities such as flow measurements and streamgage repairs.
2. Work with the NWS, COE, and other Federal, state, and local agencies to identify where forecasts indicate an urgent need to extend existing ratings.
3. Continue efforts to replace low rate satellite radios with new, high-rate radios so that stage data are transmitted at least hourly.
4. On a request basis, detail to NWS river forecast centers USGS personnel who can help with the development and implementation of rating extensions.

Possible Action Items for U.S. Army Corps of Engineers

The following is a non-exclusive list of possible action items the U.S. Army Corps of Engineers could evaluate, recommend or incorporate as needed and in conjunction with those items addressed by the Fusion Team.

1. Continue to support the Fusion Team Focus Areas.
2. Communicate improvements in forecasting, methodology, and results COE-wide.
3. Expand COE use of NWS Chat to ensure better communication during events.
4. Work with NWS to improve how levee overtoppings/breaches are reported and modeled.

Action Items for Fusion Team:

The following is a non-exclusive list of action items the Fusion Team has or could evaluate, recommend or incorporate. Many of the items have been addressed in the past year. Other action items could be added once identified. The items are divided into the focus areas of the Fusion Team.

A. Cross-Training and Operations

1. Cross-training
2. Joint-exercises
3. Playbook

B. Enhance Communication and Coordination

4. Forecasters Communication
    a. Chat rooms
    b. Phone
    c. Web
    d. Conference calls
    e. Webinar/GoTo meetings
5. Forecast Communication
    a. Best method to communicate to public
    b. How many different web sites do we really need?
6. Sharing employees during events
    a. Co-located?
    b. Remote?
    c. 24x7 contact information

C. Accurate Data Available Concurrently to All Agencies

7. Rating tables
    a. Extending key locations before floods.
    b. Having "full" rating available.
8. Discharge Measurements
    a. Who decides where to put resources?

b. How do we communicate to everyone that needs this data?
c. Techniques
d. Payment

D. Technical Forecast and River Forecast Improvements

9. Technical forecast issues
    a. HEC-RAS ?
    b. Recession curves
10. Ensembles Forecast
    a. Model run or contingency type?
11. 7-day forecast
12. No rain Forecast
13. Levees – Overtoppings/Breaches
    a. How does field data get transferred to forecast offices
    b. Volume behind levee
    c. Size of breach (if any)

In addition, the Fusion Team will evaluate forming work teams to address remaining or new individual action items. These teams will be made up predominately of non-fusion team members from each of the three agencies. At least one member of the Fusion team (normally a technical member) will be on each working team. These teams would develop a scope of work, team members and execute the work. They would report back to the Fusion Team as a whole.

Possible Teams that could be formed include:

1. Lower River Forecasts – Mississippi River below Cairo, IL
2. Upper River Forecast – Mississippi River above Cairo, IL
3. Ohio River Forecast

Recommendation:
All three agencies agree that continued coordination, evaluation and cooperation are vital to the process of improving the accuracy and consistency of rainfall/river forecasts. These accurate and consistent forecasts are of the utmost importance to each Federal, State, Municipal and Private Stakeholders for their respective needs and uses. It is recommended that each agency and the Fusion Team continue to identify and evaluate those areas of the forecasting process that can be improved and to better communicate those actions/improvements to the stakeholders.

Michael J. Walsh
Brigadier General(P), U.S. Army
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Date: 4 MAR 10

Gary M. Carter
Director, NOAA/NWS Office
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Date: 3/15/10

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Chief, Office of
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Geological Survey
Date: 4-15-2010

Appendix A