CFI Group
Claes Fornell International

Date: May 5, 2006

To: Mary Mullusky

From: Sheri Teodoru

Subject: Probability Focus Groups – Final report

cc: Frank Richards

Background

In early 2005, National Weather Service (NWS) conducted focus groups among user-professionals from various relevant fields to evaluate the AHPS web site and graphics.[1] The use of and level of understanding of probabilistic forecasts was discussed as part of these groups. It was clear from these focus groups that web site visitors made limited use of the probabilistic streamflow forecast graphics provided to them on the web site. They did not understand the graphics themselves, and did not understand how the information conveyed could be used to make decisions. This is consistent with the quantitative results from the Hydrology Customer Satisfaction Study conducted in 2004, where the probabilistic streamflow forecast graphics received poor marks relative to other graphics.

Based on these two research studies, NWS decided that it needed to better understand the need for and usage of probabilistic streamflow forecast graphics. The NWS Hydrologic Services Program contracted with CFI to conduct four focus groups. The following groups were included:

(1) Water Resources Managers participated during the American Water Resources Association (AWRA) 2005 Annual Conference in Seattle, WA on November 9, 2005

(2) Emergency Managers participated during the International Association of Emergency Managers (IAEM) 53rd Annual Conference in Phoenix, AZ on November 13, 2005

(3) Broadcast media participated on January 31, 2006 during the American Meteorological Society (AMS) meeting

(4) Private-sector value-added partners participated on February 1, 2006 during the American Meteorological Society (AMS) meeting

[1] See *Advanced Hydrologic Prediction Service – Central Region 2005 Focus Group Analysis* by Dr. Jayant Deo, Cooperative Institute for Research in the Atmosphere, Colorado State University

Executive Summary

Use of and need for probabilistic forecasts varied widely across the various customer groups that were included in this study. The participants from the Broadcast Media who represented National markets (e.g., Accuweather or Weather Channel), Water Resources Managers and Private Sector/Industrial Meteorologists focus groups typically used a combination of USGS streamflow observations, NWS observations, and NWS forecast models together with other sources of information to create their own forecasts using techniques they had developed.

The focus group participants from the Emergency Managers and Broadcast Media from smaller markets relied more heavily on NWS forecasts to make decisions and communicate to viewers. The smaller market Broadcast Media and Emergency Managers had a different set of issues to solve – "Do I tell people to change their behavior? Should the city cancel its parade? Should people evacuate? Should they avoid a particular street because it's likely to flood?" The focus group participants of Emergency Managers and smaller market Media look to NWS to help them decide what to communicate. In general, these customers conceptually understood probabilistic forecasts, but did not necessarily use these forecasts on a day-to-day basis, and preferred simpler communications that they could quickly understand and communicate.

What does this mean for NWS? Given the vastly different knowledge base and needs of NWS's customers, **new probabilistic products and services need to be developed with the targeted end-user in mind. A product developed to please everyone is likely to please no one.** The hurricane cone of uncertainty is an example of a product developed for a specific audience – the general public. While this visual depiction is useful for the general public, back-up data would be required if it were a product for a more sophisticated user group.

There were some common themes across the groups. These themes and possible next steps NWS might consider (in bold) follow:

- Participants were primarily interested in short-term probabilistic products. The exception was Water Resources Managers, who were also interested in seasonal to long term probabilistic forecast products in addition to the short term forecasts.
    - **As new probabilistic forecast products are developed, the time horizon requirements of the customers need to be considered.**
- NWS needs to document the quality of probabilistic forecasts – if NWS says there's a 30% chance of X happening, historically has X actually happened 30% of the time in similar conditions?

- **Consider putting a program in place to validate probabilistic forecasts**

- The more local the probabilistic forecast, the better.
  - Groups independently mentioned wanting the ability to get detailed local hydrologic forecasts by being able to 'point and click' on a map
  - **Explore costs/feasibility of this; evaluate quantitatively with more customers to get a better understanding of who would use it and how they would use it.**
- The ability to customize probabilistic forecasts to a particular geography or time frame was appealing to customers, as was the ability to look at scenario-based probabilistic forecasts that incorporate events like el Niño or la Niña.
  - CNRFC's Interactive ESP Product Generator is clearly on the right track. **As with more localized probabilistic forecasting, the costs/benefits of this should be explored, and the target user identified prior to further development.**
- Participants want the best of all worlds: easy-to-understand probabilistic forecast graphics backed up with observation and forecast data and a forecast discussion.
  - For less sophisticated users, simple probabilistic forecast graphics are appreciated and are often enough information
  - For the more sophisticated users, simple probabilistic forecast graphics are still appreciated, as long as they are backed up with the observation and forecast data that went into generating the probabilistic forecast graphics and a discussion of how the probabilistic forecast was developed
- Communication with customers is important; two-way communication is particularly critical for Emergency Managers (EMs).
  - Emergency Managers rely on local Warning Coordination Meteorologists (WCMs) to help them understand/interpret forecast and uncertainty information.
    - **NWS needs to better understand the role of the WCMs and the extent to which they are relied upon**
    - The EMs who participated in the focus group clearly counted on WCMs to help them make costly/critical decisions, it's important to understand whether this is representative of the entire EM community
    - Is this an area where more resources should be devoted?
  - For Media, those participating don't currently rely on interaction with NWS staff to interpret probabilistic forecast products, though having a point of contact might be appreciated.

- For the most sophisticated users, Water Resources Managers and Private Sector/Industrial Meteorologists, forecast discussions play an important role in helping them interpret the probabilistic forecast data being provided.

- NWS isn't viewed as a collection of individual groups responsible for weather, water and climate. Rather, NWS is viewed as an entity that works together (or at least should work together).
  - **Better coordination of probabilistic forecasts within NWS would be appreciated by respondents**
  - Similar 'look and feel' of probabilistic forecasts would help respondents understand and assimilate probabilistic forecast information more quickly
    - **NWS should explore the feasibility of adopting consistency of colors within hydrology and across NWS probabilistic forecast graphics – e.g., red is danger**
  - **Better communication about what probabilistic forecast products and information is available would also increase use of some products**
  - **USGS was mentioned as a 'gold standard' for observed streamflow data delivery. NWS should strive to deliver probabilistic forecast data in a similar way**

- Across all four focus groups all participants liked the idea of communicating probabilistic forecasts in a visual way. Most participants liked the ABRFC probabilistic hydrograph, and many claimed they would use it if it were available. While most claimed to understand it, they also expressed a desire for training on how to use the graphic. Of all the products evaluated, this graphic seems the closest to being ready for introduction, though some modifications should be explored and the graphic shown to customers again.
  - **Change color scheme**
  - **Make Median line more bold**
  - **Review legend: should it be words or numbers (or both); should the upper and lower bounds of "least likely" be the same color?**
  - **Present to target audience before releasing to ensure that it meets their needs and that they understand it**

- Other graphics received more mixed reactions
  - The idea of the inundation maps was good – but the actual execution was confusing. Respondents had different ideas of what this should be – should it be a probabilistic forecast that changes over time? A static map of inundation areas? Should it depict flood levels? **Before moving forward, we would**

recommend that NWS evaluate the audience for which this product is being developed, and then develop the graphics and details accordingly.

- Desire to have flood levels included on the graphic somehow.
- Point-and-click drill down within the map would be an enhancement.

- The "Chance of Exceeding Levels" graphic was not well understood by those who looked at it.
- The River Flood Outlook was also confusing to those who looked at it.

- There was some misinterpretation of the experimental products and currently available probabilistic forecast graphics shown to the focus group; respondents across the board expressed a desire for details about how to interpret the probabilistic graphics.
  - **NWS should consider developing materials to help customers use the probabilistic forecast graphics properly – anything from multimedia training modules to user guides to notations on the graphics themselves would be beneficial.**
  - More specifics about where the data comes from would be beneficial to more sophisticated users.
- **Outreach materials should accompany any new probabilistic forecast product (e.g., email notification, inclusion in newsletters, etc.).** Customers need to know the probabilistic forecast products are available and know how to use them properly.

Details

The first half of this report covers findings from the first two groups (originally issued December 2005); the second half covers findings from the second two groups, which took place at the AMS conference.

How to use Focus Group Information

Focus groups results are qualitative in nature and not projectable to a broader sample of the population. For example, if five of the ten Water Manager participants has a particular data need, it cannot be said that 50% of all Water Managers has that particular need. A more comprehensive quantitative study is required in order to make these types of statements.

Findings from focus groups should be used to understand customer needs, to identify issues, and to understand better the type of probability and uncertainty information that needs to be communicated by the NWS Hydrologic Services Program. Prior to making any revisions to the existing products and services, changes should be quantitatively examined to make sure they meet users' needs.

Objectives

The purpose of these groups is to understand the underlying need for probabilistic forecast information among various user groups.

- How do respondents deal with uncertainty in their forecasts?
- Where do they get information about uncertainty now?
- What are shortfalls of current uncertainty data?
- What type of uncertainty information would be most useful?
- Gather feedback about probabilistic forecasts graphics that are currently available.

Participants

A total of four focus groups were conducted.

1. On November 9, 2005, a group of Water Resources Managers was convened at the AWRA conference in Seattle, Washington. The group was recruited in advance, and additional participants were recruited from the conference itself. A total of eleven participants attended, in addition to Mary Mullusky from NWS. Mary was present in order to answer any specific questions about the products and services.

2. On November 13, 2005 a group of Emergency Managers was convened at the IAEM conference in Phoenix, Arizona. Participants were recruited in advance. A total of thirteen participants attended, with one latecomer joining for the second half of the discussion. In addition, Mary Mullusky and Kevin Lynott from NWS were observers and answered technical questions as they arose.

3. Members of the broadcast media attended a focus group held January 31, 2006 during the American Meteorological Society (AMS) meeting in Atlanta, Georgia. A total of six media personnel attended, across a variety of national and local broadcasters. There were representatives from two national media outlets, one broadcaster from a major metropolitan area, and two small city broadcasters. Mary Mullusky from NWS attended as an observer and answered technical questions as they arose. Attendees were pre-recruited.

4. A focus group of private sector/industrial meteorologists was held on February 1, 2006, also at the AMS conference. A total of eight private sector/industrial meteorologists were in attendance. As in the other groups, Mary Mullusky from NWS attended as an observer to answered technical questions.

Results

The commentary regarding Water Resources Managers and Emergency Managers is directly from the original report issued in December 20, 2005.

Water Resources Managers Group

The participants at the AWRA conference were primarily Water Resources Managers from various local, state and federal government agencies, but there was also one academic (who consults with NOAA), and one participant from the private sector.

The participants' responsibilities included water supply management, flood control, power, long term reservoir planning, and drought forecasting.

In general, this was a very sophisticated group that understood probability. For the most part, this group generated their own forecasts using their own models. Much of the input data used by this group were probabilistic forecasts of rainfall and snowmelt runoff (where applicable). Other types of input data needed for their forecast models included humidity, wind speed and direction, streamflow data, precipitation, temperature and snow pack.

Probabilistic Forecast Quality

In general, there were several comments – not probability related – about the accuracy and availability of historical and 'raw' data used in probabilistic forecasting. These comments covered a wide variety of observation and forecast data needs, and did not distinguish between that provided by NWS, the National Climate Data Center (NCDC), or the U.S. Geological Survey (USGS). NOAA may wish to conduct research to better understand customer data quality issues.

Respondents were concerned about the accuracy of the probability forecasts. Some respondents felt that the numbers were conservative, and erred on the side of predicting more flooding than had actually occurred historically. Respondents wondered how often the 90% probability of exceedence actually was exceeded.

For one respondent, the language used created confusion among the agricultural population. For example the probabilistic streamflow forecast in cubic feet per second (CFS) vs. acre-feet – if the forecast is 60% of normal, farmers interpret this as 60% of base flows vs. 60% of CFS during a given time frame. The new AHPS web page allows for presentation of both units of measure, but this respondent was clearly not aware of that feature.

The concept of ISO certification was discussed (International Organization for Standardization[2]). One respondent wondered whether ISO certification around forecasts would be beneficial, and what ISO certification for a forecast would actually mean.

How Probabilistic Forecasts are Used

All of these respondents used NWS probabilistic forecasts. However, this group used the numerical forecasts and not necessarily the resulting probabilistic graphics. While probabilistic forecast graphics were useful for a quick glance, or to paste into documents, actual decisions were based upon their analysis of NWS probabilistic forecast data.

Respondents combined the probabilistic forecast information provided by NWS with other observations and forecast information at hand prior to making a decision whether to act. Some respondents had their own observations that were combined with NWS's, some used Canadian forecast information. Most, if not all, respondents said that they used some degree of judgment when deciding whether to take action; they did not have a strict rule-based

[2] ISO (International Organization for Standardization) is the world's largest developer of standards. Although ISO standards are voluntary, they may become a market requirement, as has happened in the case of ISO 9000 quality management systems, or of dimensions of freight containers and bankcards. ISO develops only those standards for which there is a market requirement. While there may not be an ISO standard specifically for stream forecasting, there may be ISO standards for some of the processes involved in producing the forecasts. See www.iso.org for more details.

decision making process. Elements feeding into their decision whether to take action were the risk of inaction, the confidence of the forecast (most began to consider taking action at the 50%-60% probability level, though there was considerable 'hedge' around the point at which action is taken), and the consistency of the NWS forecasts with other forecasts presented to them at the time.

Some of the respondents said they used the probabilistic forecasts to review the outcomes and required actions under different "what if" scenarios (the 90% probability occurrence, 50%, 30%, etc.).

Probabilistic Forecast Delivery

Any type of 'database' delivery was considered acceptable. ASCII was mentioned by all respondents, with tables and XML formats also acceptable. Having probabilistic forecast data available in tabular formation would be useful; this was mentioned in the context of Ensemble Streamflow Predictions (ESP).

Desire for flexibility

There was a consistent desire for having probabilistic forecasts for selected locations and time frames.

Time:

Participants wanted to be able to get probabilistic models run for different types of – el Niño vs. la Niña vs. 'normal' years, for example.

There was also the desire to have probabilistic forecasts around varying time frames – everywhere from 15-minute increments to 12-month out forecasts. There were as many time-specific needs as there were respondents. Many also talked about the desire to have probabilistic forecasts available for a 'season', whatever that may be for their area.

Spatial Coverage:

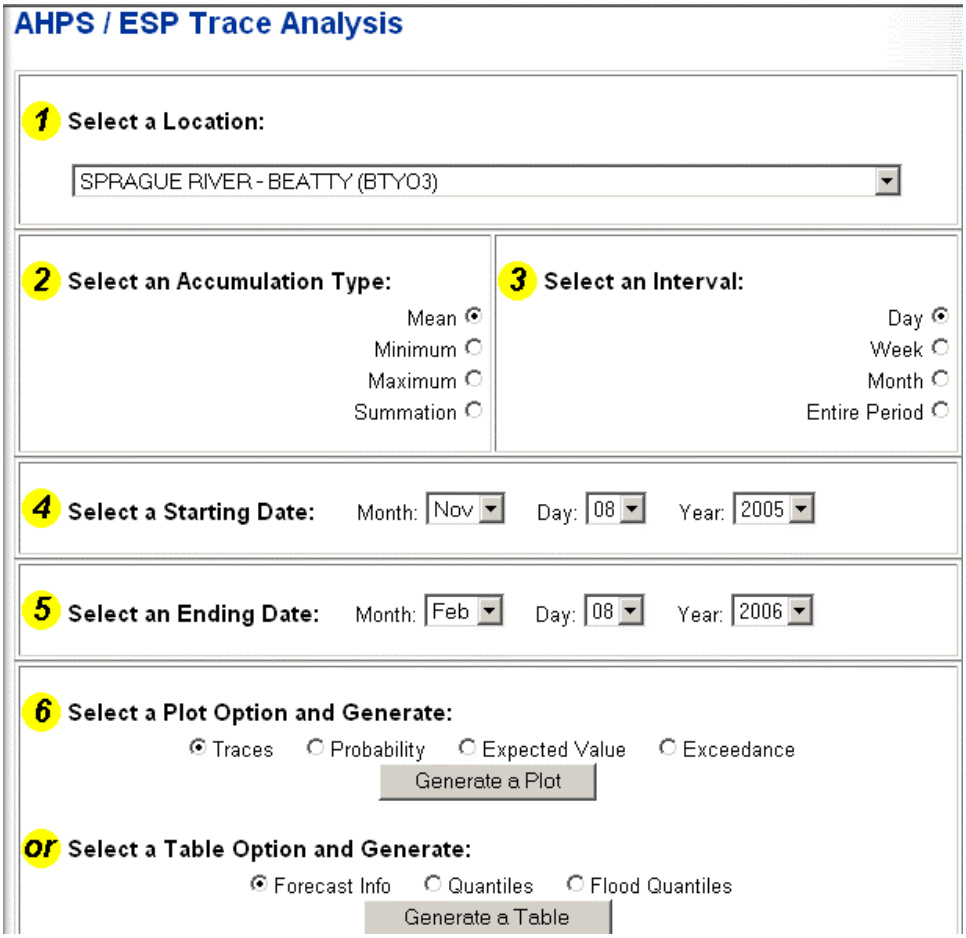
Most respondents thought that probabilistic forecasts at the watershed level was probably fine for most needs, though some had the need for more granular information, particularly if measures would be expected to vary across the watershed. Respondents wanted a process to make special requests for probabilistic forecasts for custom locations.

Ensemble streamflow forecasts were mentioned as a desirable deliverable.

While we ran out of time to show CNRFC's Interactive ESP Product Generator, this is clearly on the right track for this group.

"It would be nice if you could have a map and just click on a spot on the map that you care about and get some sort of probabilistic forecast, like the amount of precipitation you expect in, say, the next three months."

CNRFC's Interactive ESP Product Generator – Screen Shot



Awareness

It was evident from the respondents in the group that there was a basic lack of awareness of some of the available probabilistic forecast products. One respondent was lamenting the fact that a particular piece of forecast information wasn't available. The forecast information was in fact available, and another respondent stayed after the group to walk the unaware respondent through the process of getting the information s/he wanted.

Summary

Overall, this group seemed to have very disparate needs and uses for the NWS probabilistic forecasts. While having complete flexibility for probabilistic forecasts in terms of time and

location would be ideal from the water resources managers' perspective, it needs to be balanced against the costs of providing such flexibility. While probabilistic forecasts were of interest to this group, much discussion was focused on simply wanting deterministic forecast data to be more accurate, more readily available and more customizable for time and location.

Clearly probability plays a part in this groups' decision-making process, and most respondents viewed the 50-60%+ probability level as the level when they begin to consider action (e.g., spilling water from a reservoir).

Emergency Managers Group

How Probabilistic Forecasts are Used

Emergency managers were most interested in NWS forecasts for flash flood, flood, snowpack, mudslides, dam failure, erosion, tsunami warnings and surface water management. As a group, the EMs must communicate with multiple constituencies and have a variety of different roles. Decisions they have to make include evacuation decisions, road closures, water release, press releases, whether to begin sandbagging in flood-prone areas, notifying ranchers, getting personnel in, suspension of operations, asset placement, scheduling timing of repairs/maintenance in the coming days, and further out in the future. Most of their discussion focused around short-term decisions – e.g., whether or not to close a road today. While we did not guide the discussion in that direction, it was clear that short-term decisions were top of mind for most. For planning, respondents tended to use 3-day forecasts, for response they used 1-day forecasts.

We asked respondents to specifically think about decisions that were made from 72 hours through two weeks in the future. Respondents came up with a much shorter list: repairing gates on dams (need to know if it's going to be rainy), ice flow in winter, scheduling maintenance crews (vacations, training, etc.). Their focus was clearly on the more immediate term (1-3 day) forecasts.

Unlike the water resources managers, who used NWS probabilistic forecasts as an input to their own models, the EMs used NWS probabilistic forecast products 'as is', without running it through additional models. Similar to the water resources managers, the EMs also overlaid other information, as well as their own experience and judgment, onto the NWS probabilistic forecasts before taking action. Other information that was incorporated included time of day (for road closings), time it takes to execute the action, calls to other Emergency Managers (particularly for flash floods), calls to the WCM, discussions with local politicians, and the risk of not taking action.

Warning Coordination Meteorologists

The emergency managers tended to rely on personal interaction with NWS personnel before taking action based on NWS probabilistic forecasts. In particular, the Warning Coordination Meteorologist was typically consulted prior to making any key decisions.

The fact that the WCMs are local was critical to the EM group. In crisis situations the EMs rely on the WCMs to provide recommendations and advice that is relevant for their community.

> *"And that's one of the reasons we need these warning coordinating meteorologists to be local for us, because they start understanding how the differences are between my community and yours."*
>
> *"And also with the National Weather Service --- being local…they have our home phones, our pagers, our cell phones…"*
>
> *…"And we have theirs."*

Because focus group results by nature are not projectable to the population, NWS should consider follow-up quantitative research to assess the true extent to which the population of EMs consults with WCMs. Although evaluating the WCMs was not the purpose of these groups, it was clear that any reduction in WCM support would be viewed extremely negatively by the EMs included in our focus group. We did not ask what EMs would do if WCMs were unavailable, both because it wasn't the purpose of the group, and because we didn't want to raise concerns or start rumors. Today, however, WCMs are a critical resource for these EMs during crisis times.

Probabilistic Forecast Quality

Forecast quality was not a significant issue among this group. Participants realized that forecasts are sometimes wrong.

Interestingly, however, one of the respondents mentioned that they used their local television stations' weather forecasts. This respondent was from a major metropolitan area, and each of the major TV stations in the city had its own Doppler station and created its own forecasts (NBC, ABC, CBS). Other respondents tended to view NWS forecasts as the gold standard. We did not probe further about why this particular respondent used the TV station forecast information, however this may be a worthwhile item to investigate in future research.

Probabilistic Forecast Delivery

Respondents were quite varied on the type of probabilistic forecasts they liked to receive. Some preferred graphics, some use raw numbers, some use tables. Deterministic and Probabilistic forecasts were delivered in a variety of ways: phone calls and faxes from their WCM (see Appendix 4 for example), e-mail, website and weather radio were all mentioned.

> *"In my organization we have hydrologists and water engineers, they like the graphs. I've got managers who sometimes like graphs and pictures, but they also like explanations. I have others that just want the picture."*

When there is a crisis situation, EMs want direct communication via phone with the WCM. However, they want the written explanation as well so it can be sent to their customers – media, decision makers, etc.

> *"There's been more than once that I've made a decisions based on what the WCM called."*

> *"You know what I think the website is really good for, is to give as a reference for people to go and find out on their own what's really going on. For public awareness, for everyone within your community. That's a great way to inform the public without having to stop and answer a lot of questions."*

> *"If it's a real critical fast moving deal, we get the calls [from the WCM] directly whether it's the telephone, email, whatever we get the calls directly. And we can talk and ask questions. But when go to bring it to the higher ups and other people that are making decisions and media and others, having those written components, having information available that says basically the same thing on the web gives credibility to what we're saying."*

Some respondents mentioned that they receive too much information, and would prefer only to see the bad news forecasts.

> *"For me when I look at data, I don't need to know it's warm and sunny, in other words, I don't need the good news data, I just need the bad news data. And I know that sometimes the National Weather Service gives me – because of the area that I live in, like I said I know that we're not hit as hard as many of the other regions – but I get so much good news data, that I become kind of desensitized. I stop reading the data all together. But if I know that I'm going to get information because there's bad news coming your way, I'm going to perk up, I'm going to listen to it and going to respond. Am I alone on that? I don't know."*

"No I was thinking the same thing."

"Yeah."

"If there's no chance that I'm going to get a flood…then I don't have to worry about it."

"Because that's for us, that's ninety percent of the year we're not worried about anything. So you don't need to tell us ninety percent of the year you don't need to worry about anything. Just tell us when we do."

Dealing with Risk

Many actions the EMs initiate result in serious cost and inconvenience – canceling public events, evacuating cities, closing roads, moving livestock, etc. Because of this, EMs want to be fairly sure that an event will happen prior to taking action.

"Based on probabilities the Weather Service said there was a severe thunderstorm coming, so I shut [the big Renaissance Fair] down. Thank goodness it rained, sheew!"

Probabilitistic forecasts serve as a guideline for when to take action. Forecast information this group said they would find valuable is a maximum possible value (e.g., maximum flood level) as well as a 'best guess'. Additionally, respondents mentioned that there might be value in creating and defining tiers of risk – high, medium, low. Suggestions for definitions for these tiers were relatively consistent. Respondents felt that high risk was a 60-70%+ probability, medium risk would drop down to 40-50% probability, and low risk would be below that.

In general, there did not appear to be a specific probabilistic forecast threshold at which action was taken. The trigger to action varies by situation and action comes only after serious consideration and discussion.

"At what point do you make the decision? Well it's after looking at the data for quite awhile, ruminating over both what you've put on the website, what you've sent via email, what we've talked about locally, having dialogues back and forth, then we start making our decisions. There isn't anything you could put in a product – I don't think – that would provoke us to make a decision."

In addition to the probabilistic forecasts, EMs wanted a 'best guess' number from the Weather Service.

"And I think the citizens; the feedback that I'm hearing is that they want a best guess. They want a number. They don't want a probabilistic outlook. They don't want to know it's a seventy percent chance. They just want that… they need to plan for fifteen feet. That's what I'm hearing from the citizenship. So there are different needs depending upon who you're looking at. The citizen's want something basic, those of us that are in the business want more data."

Evaluation of Graphics: 'Chance of Exceeding Levels' – Figure 1

Respondents were handed an example of a 'Chance of Exceeding Levels' probabilistic forecast product and asked to comment. In general respondents seemed to understand the graphic, though it took them some time sitting down with it. A few respondents wanted to start using it. The three-month time period shown was not optimal for this group. They all suggested much shorter windows – one day, three day, seven day. They also thought that forecasts should be updated frequently; some felt daily, some felt after a rain event, some thought they should be updated every two to four hours if there is a major amount of precipitation happening.

For flash flooding, the respondents would want this information hourly, but acknowledged that this might not be feasible.

While all respondents appreciated knowing the probabilistic forecast for flood height, some respondents also mentioned wanting additional information, like duration of flooding and time of day the flood is expected to occur.

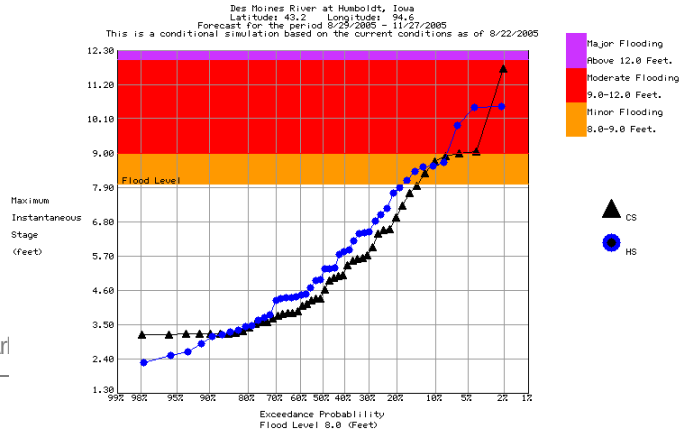
We asked respondents what changes they might make to the graphic itself. Suggestions include:

- Showing graphic with all relevant stages (minor, moderate, and major flood stages); while this is available in the web format rolled out in October, some respondents were not aware of this
- Use consistent colors that make sense – red for danger, yellow for caution
- Use a color scheme that can be printed/copied in B&W

While many respondents understood this graphic (or thought they did), some admitted to finding it confusing.

> *"…it's almost like you have to do a statistics 101 class before you could start talking about it. Even when you're used to it, you have to go back and refresh your memory as far as what it's trying to say."*

Figure 1



Evaluation of Graphics: Elk River graphic – Figure 2

In general, respondents liked this probabilistic forecast product and found it easier to understand and explain than the first graphic. Some wanted to add functionality to it. One respondent suggested that they be able to click on the graphic and an inundation map showing the impact for various scenarios would appear (similar to page two for Appendix 1).

> *"I need to see what's going to happen on the map. Because – oh wow – this is the area that's going to be impacted. And you should know that form historical records…"*

Respondents were very excited about this suggestion, and mentioned that it would be extremely useful to tie this graphic to a map for their own use as well as for communication to decision makers and citizens.

Comments on this graphic included

- Showing graphic with different stages
- Use consistent colors that make sense – red for danger, yellow for caution
- Use a color scheme that can be printed/copied in B&W
- Make the median forecast line more bold

A similar graphic with a slightly different legend was also presented (Figure 2b). Respondents found the description on the second legend confusing and suggested that it be revised if NWS decided to use it.

Figure 2a

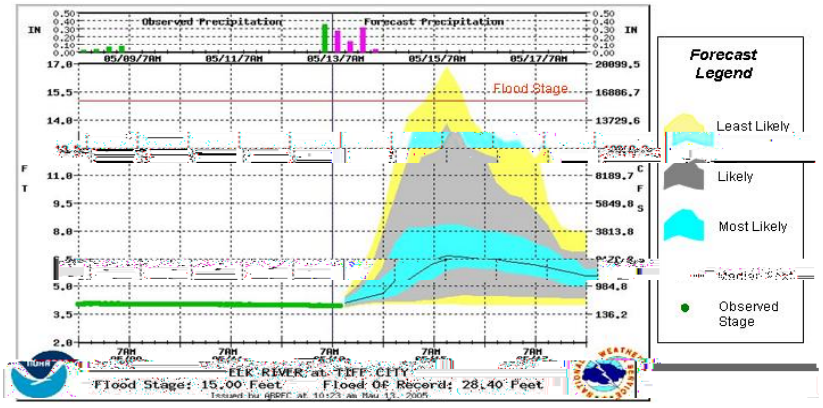
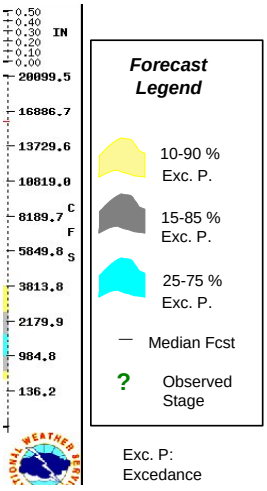


Figure 2b



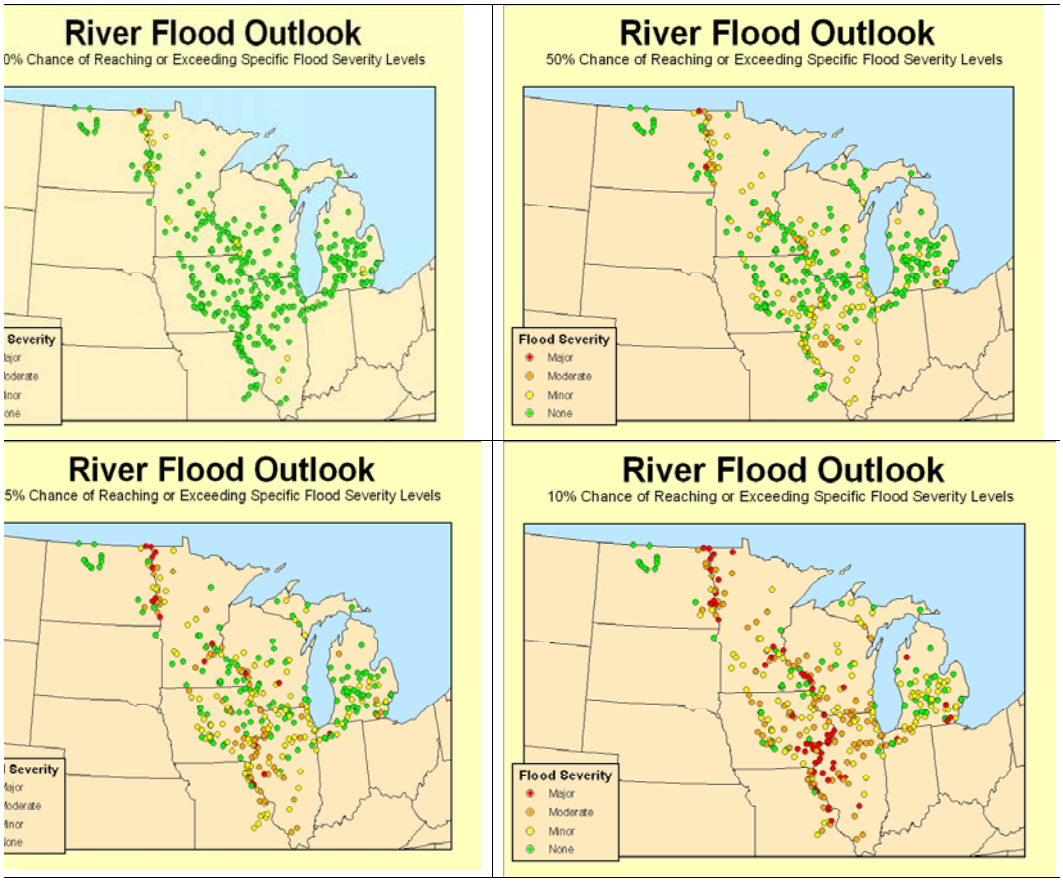
Evaluation of Graphics: River Flood Outlook (Figure 3)

In general, this probabilistic forecast product was very confusing to respondents. They noted that there was no time horizon presented with the graphic. They also wondered what the dots were – they wanted to see the dots in context of a river. There was also confusion about what the maps actually meant. Some respondents thought the 90% graphic was mislabeled and should have been 10% because all of the dots were green.

As with the other graphic, respondents wanted to be able to drill down to their state, county or river.

If this graphic continues to be used, NWS should investigate different legends and labels, and should conduct testing to determine whether it is being interpreted correctly.

Figure 3



Participants offered a myriad of suggestions on how to improve this graphic, with the gist of the commentary captured in the quote below.

> *"I think this would be great if you could pull up your state, zero in on your county, and on your river gauges, and then go to look at that. If this is the first thing I look at and I can just keep clicking and start zooming in that's great. But say this was just my county and had all these river gauges – we don't, but if we did – again I would go back and clean up the data even more and get rid of all the good news, just give me the warning points, or the potential areas."*
>
> [M: What is bad news? You said you want to be notified only when there's bad news?]
>
> *"Well I would say if something… fifty percent or greater, if there's a river gauge that is showing that there's a fifty percent or greater chance of that river starting to flood, or going into potential flood stage, then I would want to start monitoring that. But if I've got five other rivers or tributaries in the area, five other gauges that are below fifty percent, don't even list them. I don't need it."*

Evaluation of probabilistic forecast graphics – overall comments

Many of the respondents misinterpreted the graphics. During the AWRA conference, another research study was being conducted to assess whether people were interpreting Climate forecast graphics correctly. The results of this research might be useful as further graphics are developed.

In the short term, NWS should consider training classes and/or FAQs to insure that graphics are interpreted correctly. Respondents even suggested a multi-media explanation describing how to use new probabilistic forecast products (though the concept could certainly be applied to older graphics as well).

> *"And every time you guys put a new graph on there, if you could put a like a multi-media presentation explaining the graph."*
>
> *"Like have a little guy with him talking?"*

Other

One respondent was clearly confused between the definition of a watch and a warning. The opportunity for training extends beyond graphics.

"…they issued a watch, which in reality should have just probably have been a warning. When you issue a watch, that to me tells me it's on it's way, and that's a concern. … A watch to us meant it's on its way and so we have to start evacuating, and that's a major concern."

Summary for WRMs and EMs
The following summary and recommendations are based on two of the four groups we have planned. Once the entire project is complete, NWS will be able to prioritize actions across segments and projects.

Consistent with CFI's findings from the customer satisfaction studies that have been conducted, a 'one size fits all' approach to communication of probabilistic forecasts will not best meet the needs of NWS's customers.

Possible next steps to consider:

Better understand the role of the WCMs and the extent of their personal contact with Emergency Managers.

- What proportion of EMs relies on WCMs? Clearly the WCMs were vital for these respondents – is that consistent everywhere?
- How crucial is the WCM role when costly and/or life-or-death decisions are being made?
  - Will inferior decisions be made if the WCM role is reduced?
- Should more resources be devoted to this area?

NWS should conduct quantitative research to assess the true proportions of Water Resources Managers and Emergency Managers who use probabilistic forecasts from tables vs. graphics vs. raw data, and focus efforts accordingly.

- Water Resources Managers seemed to use graphics very little, but tables of ensemble forecast data would be/are useful.
  - If follow-up quantitative research suggests that Water Resources Managers do not want or need probabilistic graphics, NWS should not target this group in its development efforts.
- Some respondents were not aware what probabilistic forecasts might be available – an opportunity for communication/training for NWS.

- EMs used some probabilistic forecast graphics, but there seemed to be an awareness issue about what was available.
    - If graphics could be modified, might be more use – e.g., add inundation maps as a drill-down feature.

Use consistent graphics when communicating probabilities.

- Use similar colors for similar messages (red is danger, yellow is caution, for example).
- Make sure graphics can be copied or printed in B&W.

The idea of generating ensemble forecasts from customized historical data created a lot of excitement, and suggests an interactive ESP product generator is on the right track.

- Location (watersheds and sub-watershed level)
- Time ('season', week, 3-day, 1-day, hourly)

For Water Resources Managers, having more 'scenario-based' forecasts would be beneficial. The example cited was the desire for climate-based forecasts for 'normal' periods, v. El Niño v. La Niña.

Recognize that not one size fits all – there is need for simple and complex communication; information that is used for decision making can be different from information that is used for communication to the general public

- Probabilistic forecast data (graphics and tables) is needed for decision making – Do I spill water from the reservoir? Do I close this road? Do I cancel this event?
- But these participants (primarily emergency managers) also want a one-number "best guess" forecast from NWS to communicate to citizens

Part Two: Focus Groups with Broadcast Media and Private Sector/Industrial Meteorologists

For Broadcast Media and Private Sector/Industrial Meteorologists we talked in broader terms about probabilistic forecasts in addition to hydrologic-specific discussion. The discussion flow followed the flow of information: how probabilistic forecast and information was received by respondents, what they did with it once it was received, and then how they turned around and communicated this information to their customers.

Broadcast Media Group
Forecasts received

Forecasts are gathered from many sources: including their own internal resources (in the case of the large national media), NWS, weather.com, Accuweather, local rain gauges, USGS.

One respondent commented on the timing. The media wants to get forecasts to customers before or during 'drive time'. If information comes in after that, it is more difficult to get it to their audience. This respondent requested that watch information be issued at 4:00 or 4:30am rather than at 6:30am as it is now.

Broadcasters have a limited amount of time in which to process the information before they present it to their audience. While some wanted significant amounts of detailed information (national and major metro), others wanted summary information as well.

> *"As a broadcaster, I've got limited time. I'm going to school. I'm going to meetings. I don't have an hour to sit here and figure [things] out."*

Most of the broadcasters did not deal with hydrologic information on a regular basis; flooding was not a frequent occurrence for them. Probabilistic hydrologic forecasts were even less used (if at all).

Graphical presentation of probabilistic forecasts was viewed positively, and respondents want/expect more of this in the future. However, the data also needs to be there for the more sophisticated media customers.

> *"This general concept of this, to graphically display uncertainties, [is] something that people find useful and can understand relatively easily… In fact, there's a TV station in Europe which is actually doing this sort of thing for temperature forecasts…So this seems to be the wave of the future."*

The national media participants recognized the limitations of the science in providing probabilities

> *"What we're looking at here, again, are river forecasts crests, which are relatively predictable, that can go down stream slowly even after the rain is long gone. But the kind of small-scale flash flood kind of detail does not lend itself to doing this [probabilistic forecasting] very well at this stage of the science."*
>
> *So, for example, if I have a business who could actually contemplate that if I say there is a 30% chance a quarter inch of rain tomorrow at noon, they're going to take one action, and if it's 35%, they'll take some different action. I have no basis for even giving the larger number because I can't really say that in 35 out of 100 cases there would be this.*

Ideally, respondents want forecasts they get from NWS to be as local as possible. An interactive map with point-and-click drill-down capabilities was mentioned as something that would be useful.

The Watches and Warnings issued by NWS were discussed. There was disagreement about whether probability information should be provided around Watches. While some respondents wanted probabilities around everything, including watches, others liked the 'yes/no' approach currently used – there either is a watch or there isn't.

> *It's like a watch or not. Should I go on this trip? Yes or no. Well, there's an 80% chance that you could. Well, they can't 80% go. They either go or they don't. You either issue a watch or you don't. Frankly, I think having an, I'm 80% sure of this watch, just muddies the whole issue.*
> *…*
> *You can't really be in a position where you can tell someone what to do…The best you can do, and the most valuable thing one can do as a meteorologist, is provide them with the best possible information so that they can make the wisest decision that's relevant to their particular circumstances.*
> *…*
> *But tell that to the lady that calls me up and wants me to tell her what to do.*

There was some desire to understand the rules behind issuing a watch.

"I don't know what their criteria is. They're using, I would say, a 50/50 probability. You know, if there is a 50% chance of exceeding or having some flash flooding, I would suspect, that's what they're using as their threshold. But we don't know. I don't think that they know either, themselves."

Information processing/creation of forecasts

Forecasts were created based on the data received from various sources. The large national media have staffs of people creating probabilistic forecasts, but did mention looking at NWS probabilistic forecasts prior to issuing their own to make sure there's not a significant difference in the two. Other (non-national) media use NWS forecasts and other inputs (including experience) to craft their forecast.

"Well, we'll look at, obviously, a variety of model output from a variety of things. We look at, is there consensus or is there a large spread? We also, you know, obviously, rely on our local experience for those particular situations. But I think the way we do it is that we make essentially our own forecast. We look at the Weather Service forecast last…And then if there is a significant difference, I'll say, what am I seeing that they're not seeing or visa-versa."

Communicating information to viewers/listeners

Media communicate uncertainty through a variety of means. Many of the broadcasters have a relationship with their viewers/listeners, and provide cues (body language, choice of words) that communicate uncertainty.

"He's got a unique knack for conveying his feeling of confidence, especially in a big event like a snow storm, with his body language and verbiage, that really gets the message across without having to put it on the screen or database"

What I've done in snow situations that seems to work, is I'll tell people what I'm going to do...I don't tell them what they should be doing. But again…if you watch somebody for [long enough], or my neighbors see that I park my old Bronco at the end of the driveway…

The media communicates most forecast uncertainty in a simplistic way. POP is routinely communicated, though some broadcasters report specific probability numbers only for short-term forecasts (3-day) and report more general probability information for the longer-term forecasts. Specific POP may or may not be reported in the extended forecasts.

> *"One of the interesting internal discussions we had is that if for the extended we don't include any number, even in the POP. We just put the word chance…Given the uncertainty, it should be a low POP, but one of my colleagues said, you know, since we can't even determine the number out that far, even putting a number, even though it's a low number, implies some determinism that we don't have so let's just put the word "chance". I would put a word like… cooler, hot, warm. Something that was reflective of what the general trend was. So that's a way that we still utilize the uncertainty in the day-to- day forecast, including temperature ranges."* (Interestingly, some broadcasters voiced a dislike of the words 'slight' and 'moderate'; there seemed to be less issue with the word 'chance'.)

While most forecast uncertainty information is communicated simplistically (20% chance of X), broadcasters were open to communicating uncertainty in different ways – provided the communication was simple. For example broadcasters were comfortable using a graphical cone to communicate uncertainty in a forecasted hurricane track. This visual depiction enables broadcasters to quickly communicate the likely path to their viewers. The concept of using visual information to communicate uncertainty was popular.

While temperature and precipitation forecasts were not necessarily identical to the NWS forecasts, broadcasters did not discuss deviating from the NWS forecast for floods. The Broadcasters viewed their role as interpretation of the probabilistic forecast – talking about how this street or that bridge will be impassable.

Broadcasters have a very limited time in which to communicate their forecasts, so probabilistic information must be provided in a way that can be easily digested, assimilated and communicated.

> *"And it depends on how much time you have, not only to forecast, but to broadcast… In terms of conveying the information, I might have 30 seconds to do that. So then it's up to me to decide how best to tell people what I'm seeing here."*

> *"But really, what the viewer wants to know is, what's going to happen, and how is it going to affect me, and when? That's basically all they want to know."*

If probabilistic forecast graphics were simple enough, some TV broadcasters might be able to use them on air.

Private Sector/Industrial Meteorologists

Information received

Similar to the Water Resources Managers we spoke to in November, Private Sector/Industrial Meteorologists were most interested in receiving probabilistic forecast data. Graphics were appreciated, particularly by the smaller firms, but the *data* itself was critical as it was an input into respondents' models. The ideal situation is a probabilistic forecast graphic backed up with tabular data.

Observations and forecast data was obtained from a variety of sources, including NWS, NCEP, USGS, radar, company-owned sensors or networks of observation sites, and locally owned observational data.

This group had a high need to understand where the probabilistic forecasts came from; the source of the input data, the models that were used to build the forecast, the level of human input involved.

The more forecast uncertainty information that can be provided to this group, the better. Probabilistic forecasts should be provided in ranges, as well as exceedance levels. Some respondents wanted the complete probability density function of exceedance levels so they could target probabilistic forecasts for specific customers. Their clients often have decisions that are based on a particular threshold, so the Private Sector/Industrial Meteorologists would find exceedance probabilities useful to customize forecasts.

> *"Ultimately, when we talk to the people that do business with us, they have thresholds. At 20 feet, they have to start switching pumps. So what's the probability it's going to get to 20 feet? We like to hear that and then we like to go to that client and say, okay, this is what you need to do. You want to keep somebody to switch these pumps on. Or, don't worry. You can send him home. The risk is not likely it's going to get there."*

Information processing and communication

The forecast created and the information communicated is tailored to the needs of the end customer being served.

> *"Ranges work best, probably, I think, when you're dealing with the public…and farmers…"*

> *"But then it may be different…for an energy client because we can speak to them in a different language."*

"So we actually kind of clarified [our client's] own internal procedures, and then when we did that, we then built our probability schemes based upon what their true needs were…The National Weather Service, obviously, is not going to do that on a user by user basis, or even by sector basis it's going to be hard to do because it's different even within the sector. One energy company does things different than another energy company. Agriculture companies do things different."

"That's what the hard thing is about issuing straight probabilities to an unknown audience. It's difficult."

The forecaster discussion was very important in providing context around the NWS probabilistic forecasts.

"They issue the AFDs (Area Forecast Discussion) where they essentially describe why they forecast what they forecast. And they talk about, you know, well this is what we're seeing. We don't believe this is going to be taking place even though the GFS says it's going to happen. You get a lot more feel for why they've made the forecast, and thus, you can then, as a meteorologist, you can then interpret and say, well, okay, this is what they thought, but I don't agree with it. Or, I do agree with it. I don't think they went far enough. And so you get a better sense as to how to then position the forecast because you know more about it. If there was just a 75% confidence factor or a 90% confidence factor, I have no idea what that means because I don't know what goes in behind it. I'm not saying you can't have that confidence factor too, but I think you've got to have the discussion element to it for meteorologists then to understand, okay, it's nice to know the person making the forecast thought this. Okay, now, is that what I want to communicate to my clients, your clients or their clients?"

"If you get a sense of what the forecaster is thinking, if they say 50% chance of rain, okay, do they think it's 50% chance that that rain is just going to get here, or are they thinking it's a 50% chance that the system might not even evolve? And is that conservative or overly optimistic or underestimated? How do they see that range? Do they think it could be a lot more, but that's our best guess? Or it could be a lot less."

Private Sector/Industrial Meteorologists are expected to tell their clients whether or not to take action, and not just to provide probabilistic forecasts.

"Well, the [client] that I work for, they needed sometimes four or five days forecasts in advance, and sometimes up to six or seven. You try to tell them this cold weather is

going to come in three days from now, four days from now, which may be worth millions of dollars to them…And they get pretty annoyed if you miss that by a day or two, which is awful easy to do. So you try to give them the probability. And they're not a bit interested. If you say probability of 70%, to hell with you."

Some customers had a strong dislike of reporting the '50% probability' of an event happening (e.g., 50% chance of rain), though others were not as opposed to it. If probabilistic information is provided to these customers, NWS may wish to provide 40% and 60% levels as well as the median.

"You don't use 50%"

"I agree with you when it comes to standard probability. I agree with you 100%. No one should ever use 50%."

"It doesn't give you any information. If you said there's a 50% chance of rain, well then, it may or may not rain. And it's equal chances. To me, that's worthless."

Other customers were not quite as critical of the concept of '50%', and recognized it as a valuable piece of information, particularly with respect to an exceedance probability, or in comparison to historical levels.

"…they may want to know, okay, if there is a 25% chance there will be eight inches of snow, and there is a 50% chance there will be five and a half inches of snow, and there's a 90% chance there will be at least one inch of snow. They want to know [the exceedance probabilities] because they want to do their own distribution..."

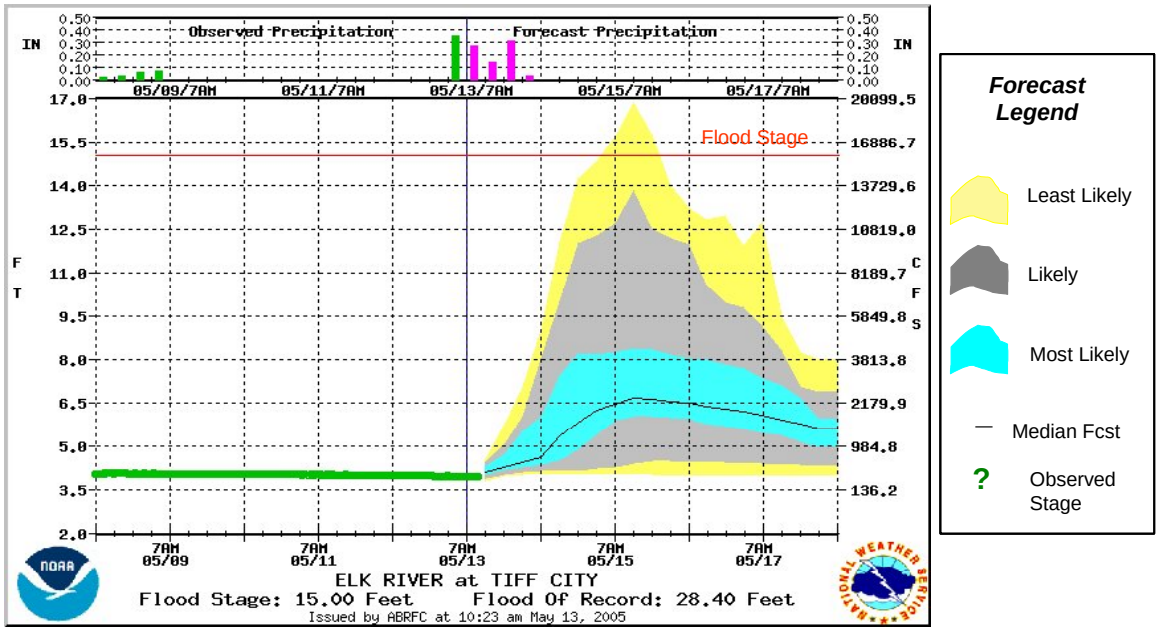
"I have to jump in because 50% means a lot if the climatology…is only 5%. That means it's 10 times more likely to happen [than has happened historically]…"

As with every group, probabilistic forecast validation is important. How much faith to place in the NWS probabilistic forecasts depends in part on how accurate those forecasts have been in the past.

Evaluation of Graphics

Each group evaluated two different forecast products: the ABRFC probabilistic hydrograph graphic and the inundation map graphic. The Private Sector/Industrial Meteorologists also commented on the Exceedance Probability graphic.

Probabilistic Hydrograph



Most respondents appeared to like this graphic and said they would use it if it were available. However, they also mentioned that they would want a NWS point-of-contact to be available to answer questions and that they would want more information describing the inputs and forecast processes used to produce this graphic.

> *"Maybe for people who are seeing this product for the first time, there is…a product guide or something."*

This group needs more than just the graphic. They want tabular forecast data and the forecast discussion in addition to the graphic.

> *"Give it to me in this format. Give it to me in a tabular, numbers driven format. Give me a discussion and my answer would be yes."*

> *"I might want to put it in my own GIS format or do something else with it."*

"This wouldn't be something that we would then pass onto our clients. It's just for our internal [use]. So then we would look at this and then create our product."

"We're not saying it's not useful...I don't think that anybody is saying that. It's just that some people would like to have more in addition to this."

Respondents mentioned that it would be useful to update this when the river forecasts are updated, every six hours.

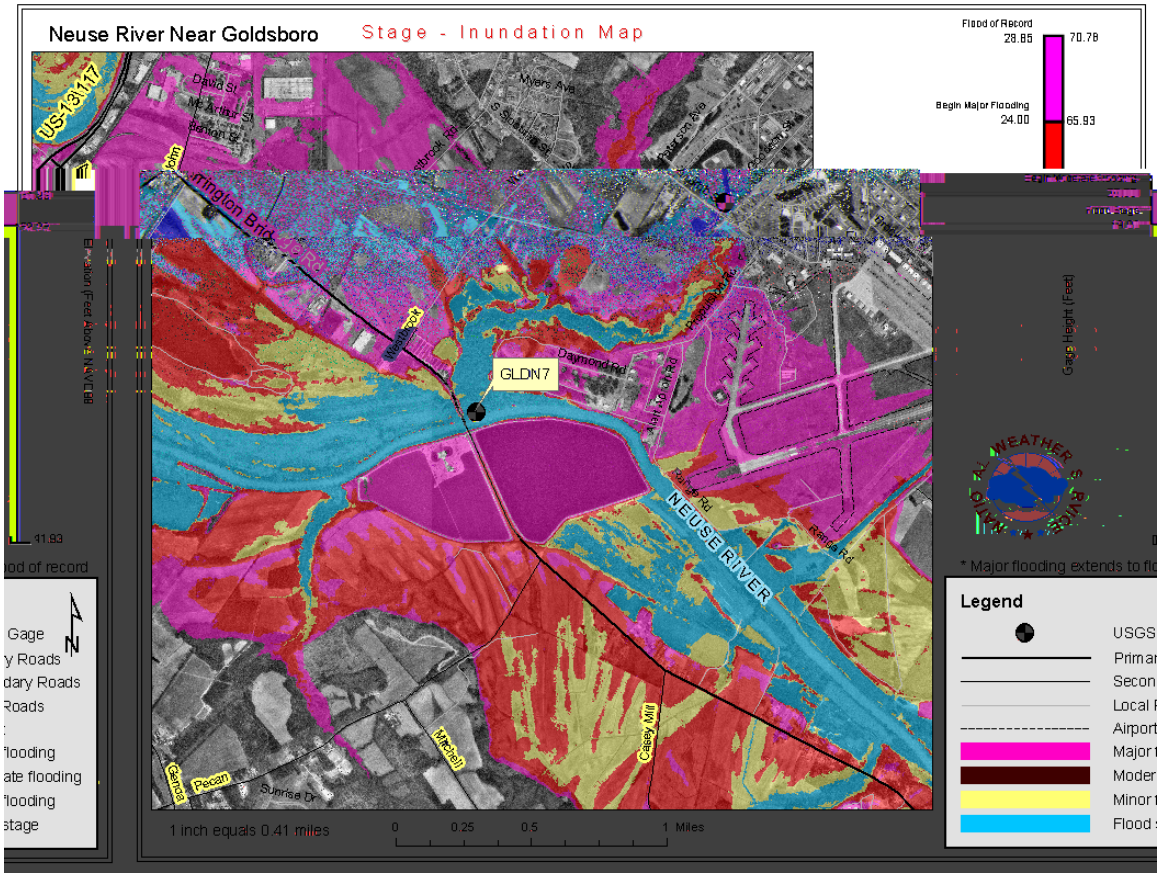
In looking at the format, there was some commentary about the color scheme chosen (should be revised). For the legend, some respondents also wanted the actual exceedance probability values in addition to the verbal descriptions (10% instead of least likely, etc.).

"You know, maybe try to give both. If you had least likely, but then maybe put in parenthesis, you know, 10% to 90%."

One respondent thought that having the 10% and 90% probabilities the same color was confusing (currently both yellow).

- NWS may want to test various ways of communicating the probabilistic forecast information prior to releasing the graphic

Inundation Map



This graphic was confusing to some, but others were excited by the possibilities it offered, particularly if it could be interactive.

> *"Yeah. I think again you could do a point and click and then if I'm here at the airport and I click there, it shows me, here's the probability of the water being four feet above the ground. Here's the probability of it being five feet above my ground level. You know, if the water is one inch above the current ground level, there is some flooding involved. But I want to know, what's the probability that… I know my basement foundation goes up one foot and I want to know, what's the probability that the water is going to be up three feet and flood my basement?"*

"Or even mouse over and see for specific lats and longs, specific latitude and longitude. You know, location, and then get a data point to pop up."

"How deep is that water at that point? Is it a [little water] or is it 10 feet?"

Some of the confusion came from the results depicted on the graphic– how could there be major flooding in one area, and no flooding at all immediately next to it?

Respondents commented that they wanted to see a time period associated with the map (they assumed it was a forecast). One person commented that the blue area on the legend should read "Below Flood Stage".

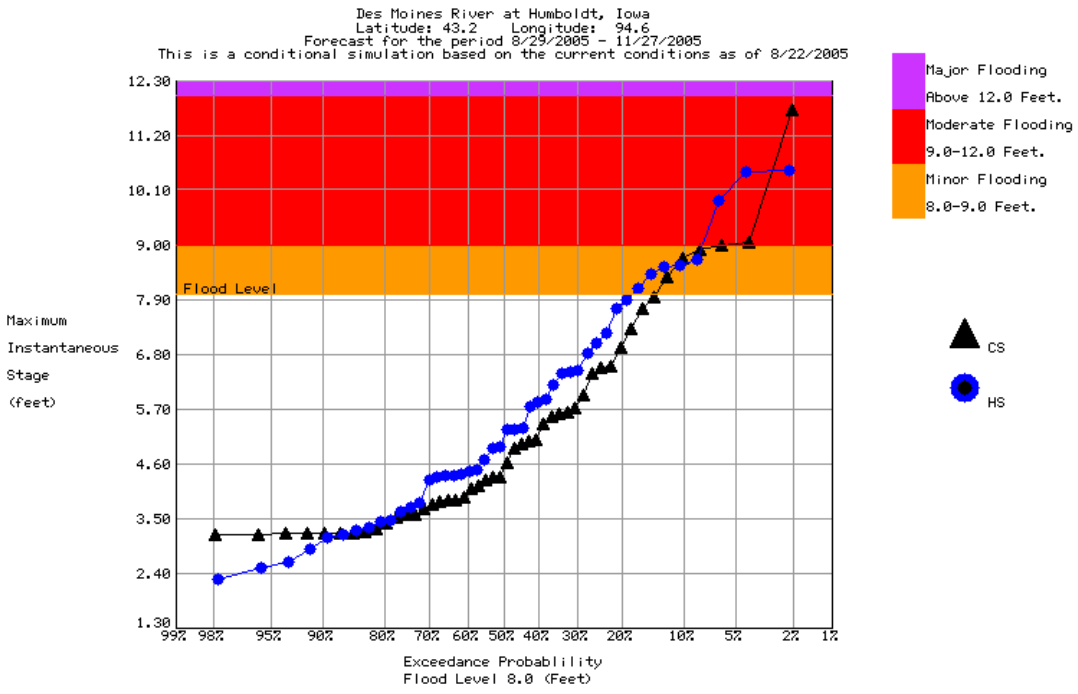
- Given the confusion surrounding this graphic among some users, training or a 'user guide' would be important if it is further developed.

Exceedance Probability Graph

Respondents wanted to understand the inputs and forecast processes that were used to create this graphic. Overall it received mixed reviews. While some thought it might be useful to have, others said that they would have no need for it because their clients would have no need for it – primarily because they were concerned about the time frame (three months) from which the forecast is being provided.

Respondents thought this might be more useful if it were produced for a different time frame: a 12-hour or 360-hour forecast rather than a 90-day forecast.

- There is little trust in the accuracy of a 90-day forecast.



Summary for Broadcast Media and Private Sector/Industrial Meteorologists
The following summarizes comments from the final two groups.

Broadcast Media were somewhat akin to the Emergency Managers in that they look to NWS to help them help their customers make decisions based on weather forecasts

- While probabilistic forecasts are important, it is an input into their final communication – ultimately there is a yes/no decision to be made. Do I recommend that viewers cancel outdoor events? Do I evacuate an area?
- The non-national Broadcast Media customers were less likely to create their own forecasts
    - Deviation from the NWS forecasts would not likely be the result of a complex model, it would more likely be made based on 'gut', experience, or by looking at forecasts created by others; this is particularly true of smaller media markets, as they do not have the resources to develop independent forecasts

Private Sector/Industrial Meteorologists were similar to Water Resources Managers in that the NWS data – probabilistic and otherwise – was an input into their own models; significantly more data processing and modeling goes on with these groups than with the Broadcast Media or the Emergency Managers

- Many of these partners create their own probabilistic forecasts based on complex models, and the resulting forecasts may be different from those issued by NWS (or be something that NWS cannot/does not issue)
- AFDs were important to these customers to help them understand how and why the forecaster arrived at the conclusion they did; this discussion helps the Private Sector/Industrial Meteorologists decide how much they agree or disagree with the NWS forecast

Forecast validation is also a concern among these participants

- NWS should consider a forecast validation program

Simple graphical representation of probabilistic forecasts is something that would be appreciated by most customers, particularly those without the resources to develop their own (smaller media, smaller value-added companies)

- While the graphics can be simple, accompanying (tabular) data is important (critical for the Private Sector/Industrial Meteorologists)
- The hurricane cone of uncertainty is a good example of a complicated concept communicated via a simple graphic

The idea of interactive graphics was exciting to respondents

- Both groups (unprompted) immediately asked whether the inundation map is/could be interactive; could they point and click on the map to get more information?

The ABRFC Probabilistic Hydrograph was generally liked

- The idea of knowing 'when' and 'how much' was appealing
- NWS needs to decide who the target for this graphic is, and design the legend to best suit the target customers' needs and level of understanding]
- For Private Sector/Industrial Meteorologists, having the tabular data to back up the table is important
- Respondents would not likely share this graphic with their viewers/clients, but use it as an input into their own forecasts