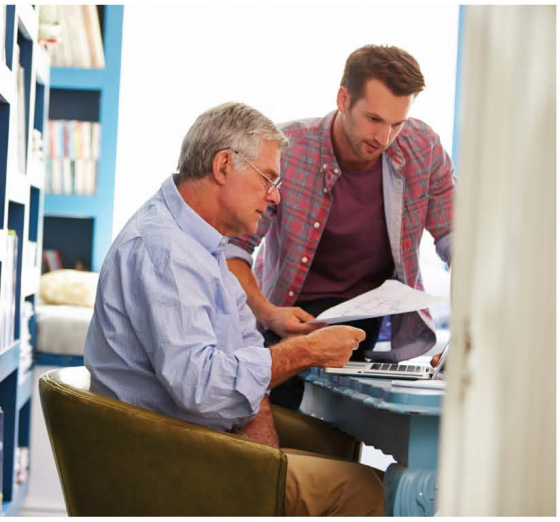
Major Risks, Uncertain Outcomes:
Making Ensemble Forecasts Work for Multiple Audiences



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Executive Summary

When extreme river levels are possible in a community, effective communication of weather and hydrologic forecasts is critical to protect life and property. Residents, emergency personnel, and water resource managers need to make timely decisions about how and when to prepare. Uncertainty in forecasting is a critical component of this decision-making, but often poses a confounding factor for public and professional understanding of forecast products.

In 2016 and 2017, building on previous research about the use of uncertainty forecast products, and with funding from NOAA's CSTAR program, East Carolina University and Nurture Nature Center (a non-profit organization with a focus on flooding issues, based in Easton, Pennsylvania) conducted a research project to understand how various audiences use and interpret ensemble forecasts showing a range of hydrologic forecast possibilities. These audiences include community residents, emergency managers and water resource managers.

The research team held focus groups in Jefferson County, WV and Frederick County, MD, to test a new suite of products from the National Weather Service's Hydrologic Ensemble Forecast System (HEFS), which provides short and long-range forecasts, ranging from 6 hours to 1 year, showing uncertainty in hydrologic forecasts. The goal of the study was to assess the utility of the newly developed HEFS products, identify any barriers to proper understanding of the products, and suggest modifications to product design that could improve the understandability and accessibility for a range of users.

The research team worked with the Sterling, VA Weather Forecast Office (WFO) and the Middle Atlantic River Forecast Center (MARFC) to develop a weather scenario as the basis of the focus group discussions, which also included pre and post session surveys. Additionally, the research study included two webinar focus groups with water resource managers, and a final online survey open to all focus group participants.

Findings from the study suggest that the tested hydrologic ensemble forecasts are useful to emergency managers, including in some instances at the longer timeframe tested (up to 15 days), and that refinements in product design and display can improve the understanding and usefulness of the products for both emergency managers and residential audiences. Residential users, overall, did not find ensemble forecasts useful and easily understandable, preferring products with a shorter forecast timeframe. Modifications to the products, including changes to legend, title and colors improved understanding by both audiences, though increased understanding did not translate into increased preference for the products among residential audiences. The addition of forecaster's note to the products was a favored product element, which should be studied further to understand the ways in which such an addition adds understanding and user trust in the product. Longer-term forecasts, including 90-day exceedance products, were useful only to water resource managers, who requested interactive capability on the data products, so they could find more detailed information at point-specific locations.

All user groups indicated that hydrologic ensemble forecasts would be used as one of several tools for decision-making, but most users had little or no experience with using the ensemble products, which have not been fully deployed regionally or nationally by NWS. Future studies could explore whether users in different geographic regions have different requirements for hydrologic ensemble forecast products, and how users incorporate the ensembles into their decision-making once the products are routinely and widely disseminated and used.

Introduction

When extreme river levels are possible in a community, effective communication of weather and hydrologic forecasts is critical to protect life and property. Residents, emergency personnel, and water resource managers need to make timely decisions about how and when to prepare. Uncertainty in forecasting is a critical component of this decision-making, but often poses a confounding factor for public and professional understanding of forecast products.

In 2016 and 2017, building on previous research about the use of uncertainty forecast products, and with funding from NOAA's CSTAR program, East Carolina University and Nurture Nature Center (a non-profit organization with a focus on flooding issues, based in Easton, Pennsylvania) conducted a research project to understand how various audiences use and interpret ensemble forecasts showing a range of hydrologic forecast possibilities. These audiences include community residents, emergency managers and water resource managers.

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The research team worked with the Sterling, VA Weather Forecast Office (WFO) and the Middle Atlantic River Forecast Center (MARFC) to develop a weather scenario as the basis of the focus group discussions, which also included pre and post session surveys. This document reports on the findings from those focus group discussions and the participant surveys, including recommendations for revisions to HEFS products to improve accessibility of the forecast tools for various audiences.

Literature Review

Meteorologists have substantial information about forecast uncertainty—both in general and in specific situations — much of which is not easily available to the public (Morss et al. 2008). In theory, uncertainty information is very useful to both weather forecasters and to the public. However, with the exception of the probability of precipitation, forecast uncertainty is not usually communicated to the public (Joslyn et al. 2007). In fact, most forecasters remain deterministic in their forecasting, in part because it is unclear whether or not people can successfully make use of uncertainty information (Joslyn et al. 2007). Individuals in the meteorological community often discourage probability forecasts for significant weather events because the public often misinterprets them, but there can be many potential benefits to using such forecasts (Murphy et al. 1980). Indeed, providing uncertainty information to the public in an accessible format may help people decide how much confidence to place in a given forecast (Morss et al. 2008).

Most practitioners view uncertainty as an unavoidable factor. Because all information about the future is uncertain, they must make decisions under uncertainty every day, in a complex and ever evolving environment (Morss et al. 2005). The decision-making process is best served when uncertainty is communicated as precisely as possible, but no more precisely than warranted (Wallsten et al.1993). The consequence of conveying only single-value, deterministic information to practitioners is that poorer decisions may be made because they do not have the benefit of knowing and accounting for the forecast uncertainties and risks on which their decisions are based (Hirschberg et al. 2011).

Previous research has suggested that communicating information about data uncertainty has the potential to increase trust in results and to support decision-making that uses that data (Kinkeldey et al. 2014). Decisions by users at all levels, but most critically those individuals associated with the protection of life and property, are often being made without the benefit of knowing uncertainties of the forecasts on which they rely (National Research Council 2006).

Yet, important questions remain regarding how uncertainty should be represented to decision makers (Finger and Bisantz 2002).

In one study, respondents were given forecasts of the percentage chance of exceeding a specific threshold. More respondents took protective action as that percentage increased, which suggest that the respondents understood the tested probabilistic forecasts well enough to make decisions (Murphy et al. 2010). In another study, the vast majority of respondents was willing to receive forecast uncertainty information, while 45 percent of respondents preferred a weather forecast that expressed uncertainty (Morss et al. 2008). This provides some evidence that probabilities may be applicable for conveying uncertainty in weather forecasts to the public (Murphy et al. 2010).

In contrast, forecasters have expressed concerns with uncertainty information, as indicated by an interviewee in a study in Europe who said that "this is too much information that the public can't use to make decisions" (Demeritt et al. 2010). Most forecasters remain deterministic in their forecasting. In part, this is because of questions as to whether people can successfully make use of uncertainty information and thereby improve deterministic forecasts (Joslyn et al. 2007). Additionally, a shift from deterministic to probabilistic forecasts also entails shifting onto forecast recipients more of the responsibility for dealing with uncertainty (Demeritt et al. 2010).

Like meteorological models, hydrological models are uncertain, and hydrologists are very conscious about the uncertainty associated with these models. Hydrologists want to see and digest as much uncertainty information as possible to help inform the production of their own forecasts (Demeritt et al. 2010). However, too much uncertainty information is not necessarily useful. The presentation of uncertainty to practitioners should be "as precise as warranted by the available information" (Finger and Bisantz 2002). Sophisticated estimates of scientific uncertainty may only complicate practitioners' already difficult jobs, without benefitting the people they serve (Morss et al. 2005).

Communicating forecast uncertainty is important because it avoids falsely portraying certainty in forecasts and may help forecast users make more informed decisions (Morss et al. 2008). Uncertainty forecasts can also be used to improve deterministic forecasts (Joslyn et al. 2007). Yet, meteorologists often find it difficult to communicate uncertainty information in a way that users understand.

One significant problem in the cognition of uncertainty involves the need to address how uncertainty information can be communicated so it can be understood and used most effectively (Ruginski et al. 2016). Current key knowledge gaps include understanding how people interpret weather forecast uncertainty and how to communicate uncertainty more effectively in real-world situations. (Morss et al. 2008). It is sometimes argued that meteorologists provide deterministic forecasts because a single number is what members of the public want, but others argue that providing uncertainty information will increase the value of weather forecasts to users (Morss et al. 2008).

Communicating forecasts effectively requires understanding how intended audiences interpret and use forecast information presented in different ways (Murphy et al. 2010). Sophisticated forecast products are of little value if they are misunderstood, used inappropriately, or simply ignored by their recipients (Demeritt et al. 2010), and other research has shown that considerations about the design and presentation of uncertainty information can strongly influence how various audiences understand and respond to that information (Hogan Carr et al. 2016a and b). Ensemble flood forecasts in particular are new and sophisticated. There are not yet any universally agreed upon methods to communicating these uncertainty forecasts (Demeritt et al. 2010). Additional social science research is needed to understand how users will likely interpret and act upon probabilistic warning forecasts. (Morss et al. 2008).

Methodology

This study is centered on answering several research questions related to NWS flood forecast improvements, the utility of HEFS products, barriers to understanding and accessing HEFS products, and modifications to product design to improve understandability (Figure 1). The HEFS products were tested through three methods and with three different audiences. In-person focus groups, online surveys and webinars were conducted with residents, emergency managers, and water resource managers in West Virginia and Maryland. Specifically, two rounds of in-person focus groups were conducted in Jefferson County, WV and Frederick County, MD. The first round was held in October 2016, with a resident session and an emergency manager session in each county for a total of four sessions. The second round of focus groups was held in April 2017 with a resident session in each county and one emergency manager session in Frederick County for a total of three sessions. A third round of focus groups was held via webinar with two different groups of water resource managers in June 2017. Following these focus groups, an online survey was administered to all previous participants.

During the first round of focus groups, the participants (14 residents and 13 emergency managers total for both counties) were led through a four-day tropical storm scenario which showed flood forecast products, including HEFS, each day leading up to the storm. Each scenario was tailored to the specific community. Only the 15-day Probabilistic Guidance HEFS product (Figure 2) was shown to the residential group, while the 15-day HEFS, 90-day Exceedance Plot for Discharge (Figure 3) and 90-day Exceedance Plot for Cumulative Volume (Figure 4) were shown to emergency managers and water resource professionals. Questions posed to the groups included how they understood the products, what actions they were motivated to make, and how they accessed information on forecasts and preparation. Focus group participants completed pre-and post-session surveys (see Appendix A for survey questions) and this information, along with focus group notes and transcripts, were used for data and NVivo analysis.

In response to what was learned in the first round of focus groups, graphical and design revisions were made to the 15-day HEFS products (Figure 5). Revisions included changes to the color scheme, design, legends, and title, as well as removing the percentage labels and simplifying the categorizations of likelihood. The 90-day products were not modified because there was no interest in using this product among the groups tested, and as such, no meaningful input into product design. Instead, the 90-day products were tested later with water resource managers who have more utility for those products and timeframe.

The second round of focus groups was conducted with new participants (22 residents and 4 emergency managers[1] total

Figure 1. Research Questions

- *What improvements to NWS flood forecast products would better motivate people to take flood preparedness and response actions?*
- *How do residential, emergency managers, and water resource managers identify the utility of HEFS products?*
- *What barriers do each of these audiences identify in understanding and accessing the HEFS products?*
- *What modifications to the product design will help improve the utility, understandability and accessibiity of the products?*

[1]Note that the small number of emergency managers was due to most emergency managers in the counties already participating in the first round of focus groups. For evaluation purposes, the participants in the second round of focus groups could not be the same as the first round.

for both counties) led through the same four-day storm scenario as the first round with the exception that the 15-day HEFS graphics were the revised versions. Participants were presented with the same questions as in the first round and the same pre- and post- session survey data was collected and analyzed. Transcripts were analyzed with NVivo.

Following the analysis of the second round of focus groups, the 15-day HEFS graphics were revised a second time (Figure 6) and an online survey (see Appendix B) was developed and a link sent to all previous focus group participants. Revisions included adding percentages back as a second legend at the bottom. Additional components, including text boxes and forecaster's note (Figure 7), were also tested with the online survey.

To assess the utility of the 90-day HEFS products, two online focus groups were held with water resource managers including Sterling Virginia Weather Forecast Office partners, and the Middle Atlantic River Forecast Center's (MARFC) customer advisory board. The participants were shown some examples of HEFS, including modified versions of the 15-day HEFS and unmodified versions of the 90-day discharge and cumulative graphs. Questions asked included: Have you seen or used this before? Would this be useful to you? How might it help your decision-making? What do you like about the graphics? What don't you like? Does this timeframe work for you? How does uncertainty information help you/ how do you use uncertainty information generally?

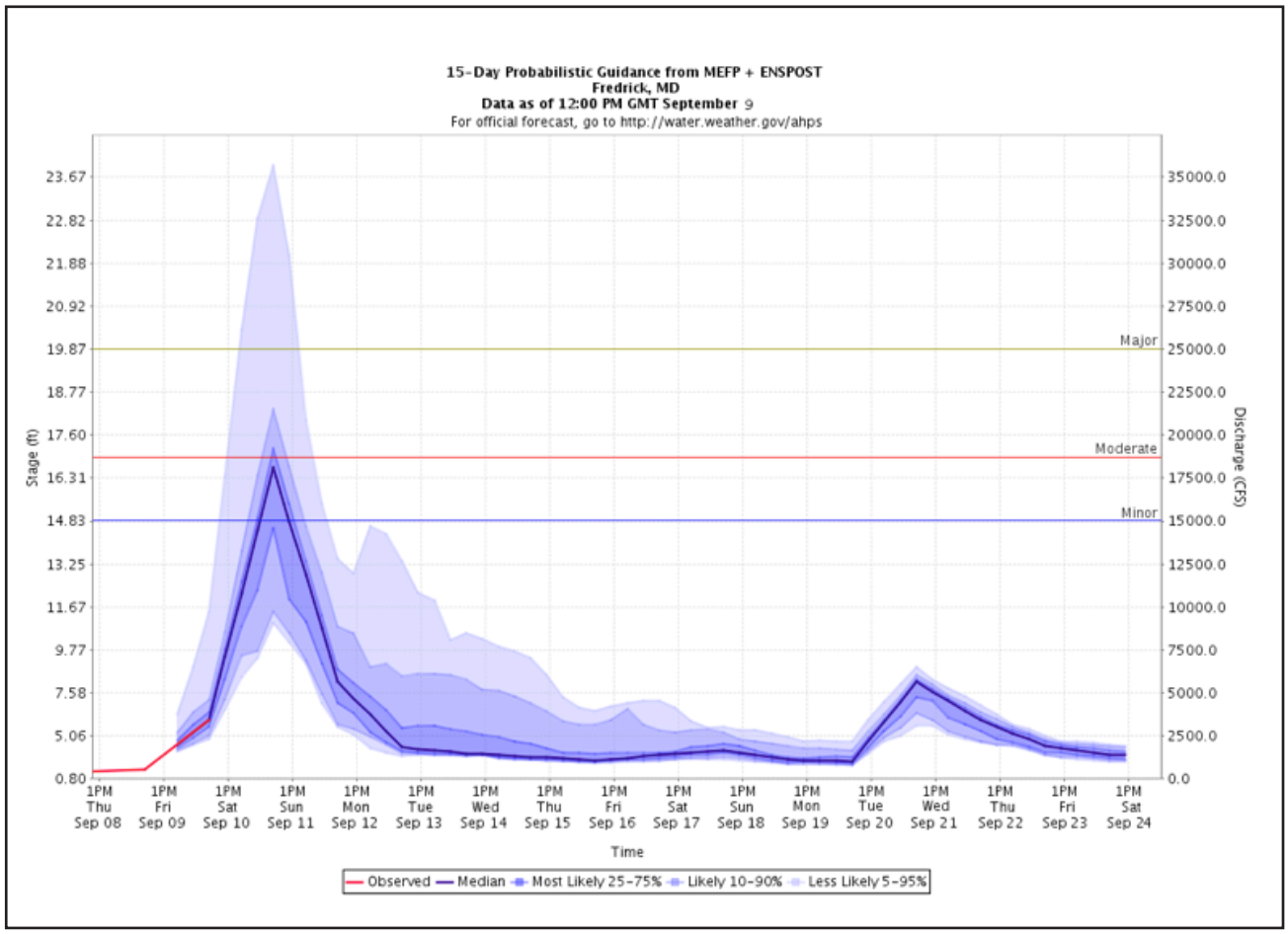


Figure 2. The 15-day Probabilistic Guidance HEFS product shown in the first round of focus groups with residents and emergency managers for Frederick, MD.

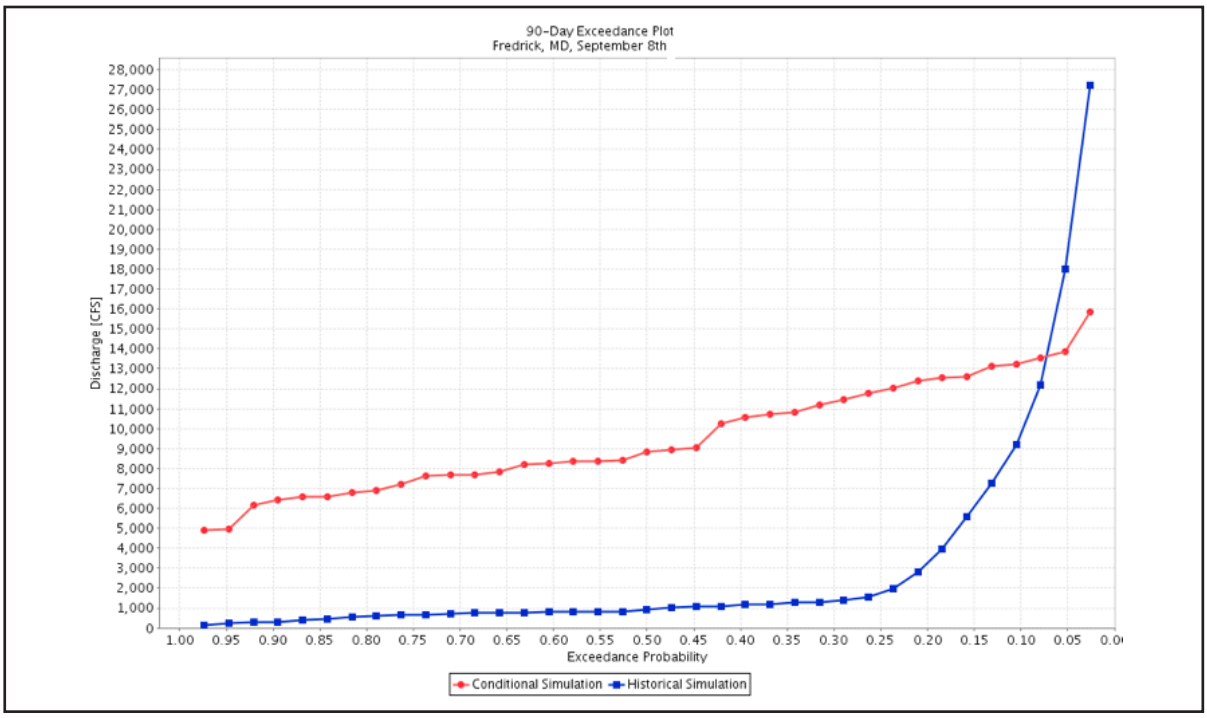


Figure 3. The 90-Day Discharge Exceedance Plot shown to emergency managers and water resource professionals. Conditional simulation above the historical simulation line indicates conditions are wetter/more flow than normal.

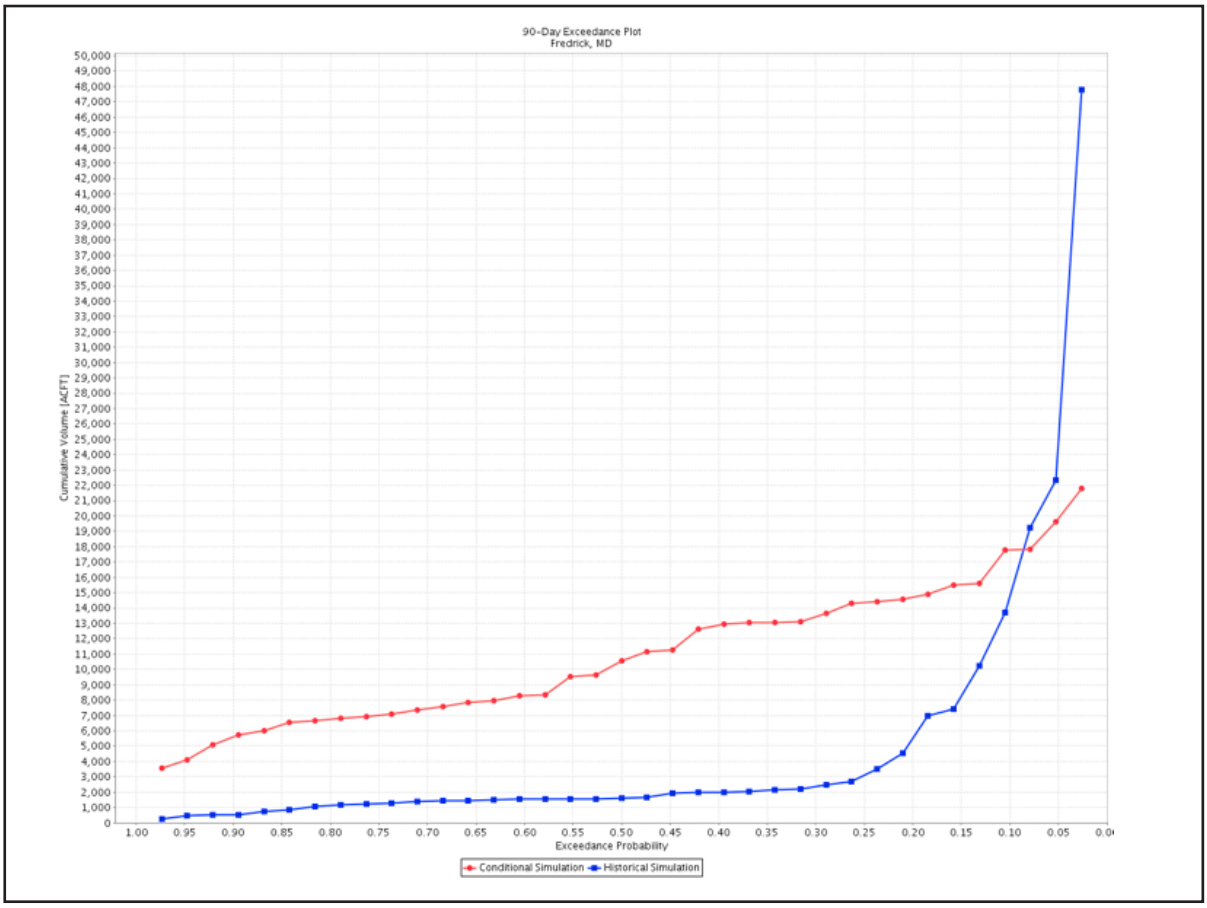


Figure 4. The 90-Day Cumulative Volume Exceedance Plot shown to emergency managers and water resource professionals. Conditional simulation above the historical simulation line indicates conditions are wetter/more flow than normal.

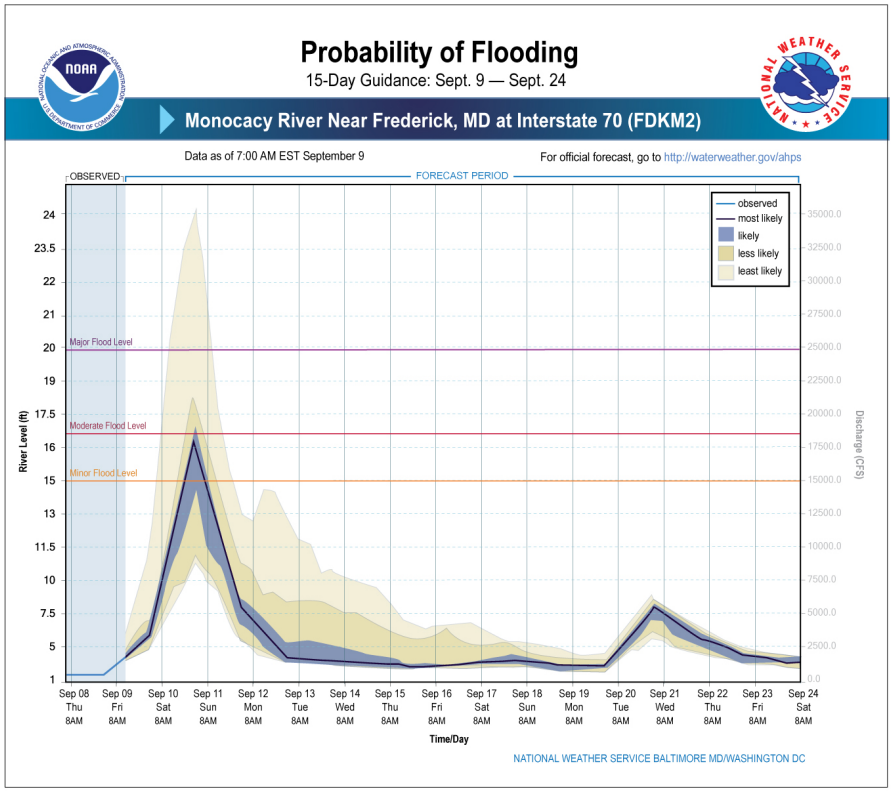


Figure 5. The 15-day HEFS graphic revisions after the first round of focus group analysis.

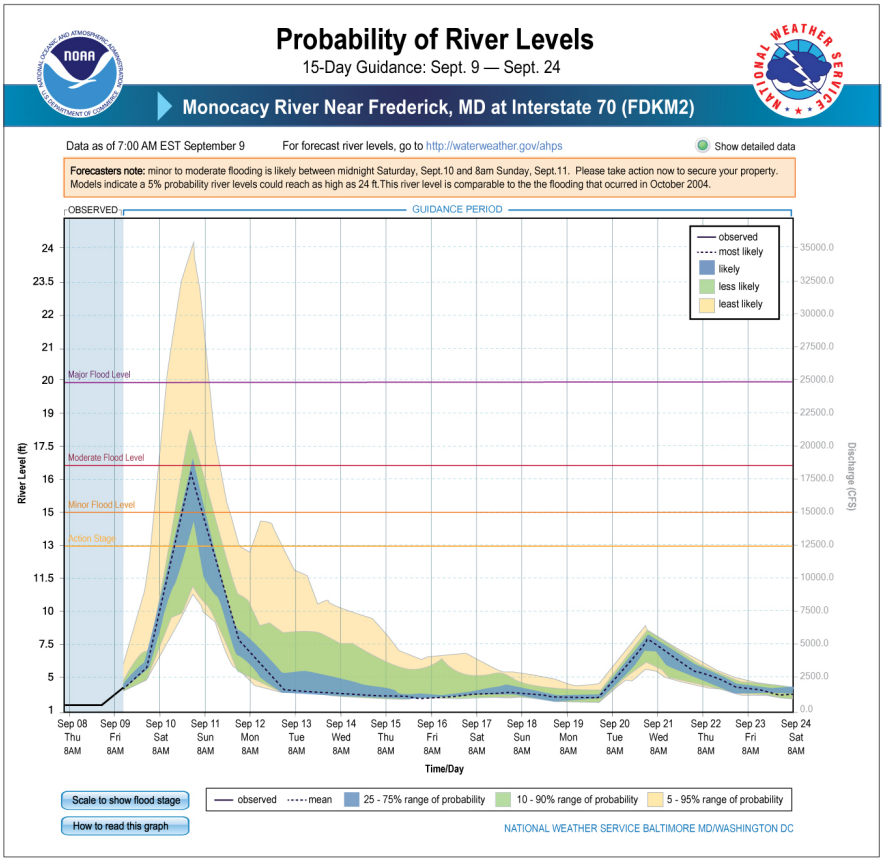


Figure 6. The 15-day HEFS graphic revisions after the second round of focus group analysis.

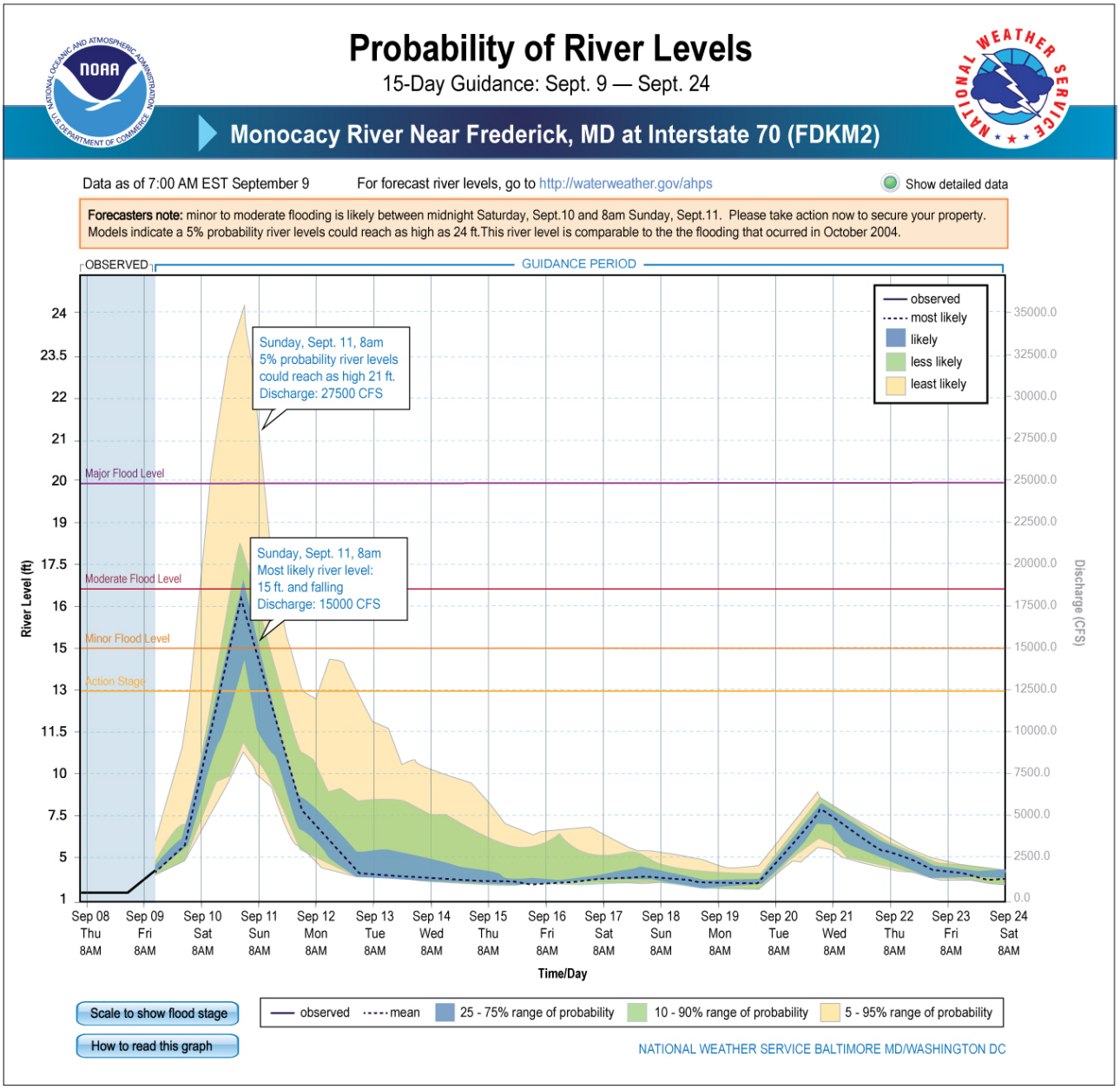


Figure 7. The 15-Day HEFS revised graphic with text box and forecaster's note additions.

Results

Demographics and Experiences of Focus Group Participants

The demographics of all groups for both rounds of focus groups are shown in Table 1 and Figure 8. Males dominated the first round of focus groups, but this changed in the second round. There was a larger percentage of college graduates among residents in Round 1 than in Round 2, though for the emergency managers, the percentages are similar. Round 2 participants were generally older than those in Round 1 and fully 90% in Round 2 have lived in their county for more than eight years, compared to 57% in Round 2.

Table 1. Demographics

	Residents 1 N=14	Residents 2 N=22	EM 1 N=13	EM 2 N=4
GENDER				
MALE	57%	36%	77%	50%
FEMALE	43%	64%	23%	50%
EDUCATION				
HS	29%	27%	23%	0%
AA	0%	27%	15%	50%
BA	21%	14%	31%	25%
Post grad	50%	32%	23%	25%
NR	0%	0%	8%	0%

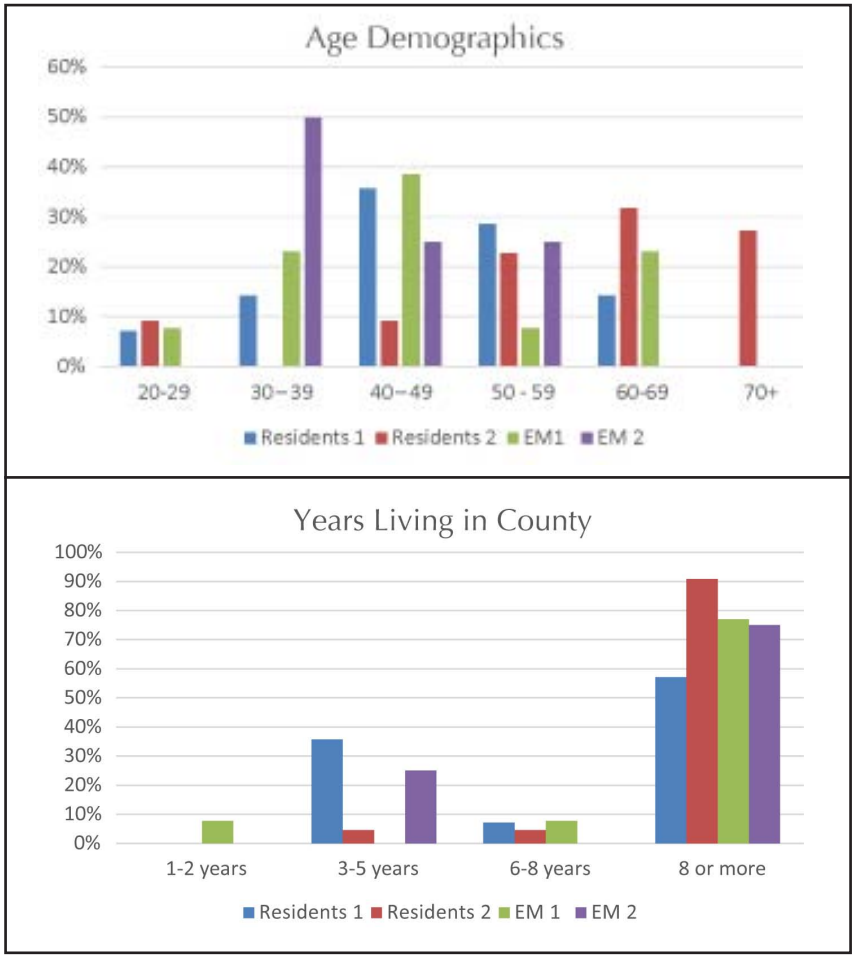


Figure 8. Age and years living in the County for focus group participants.

Table 2. Flood information needs and responses.

	Residents 1 N=14	Residents 2 N=22	EM 1 N=13	EM 2 N=4
How much advance notice?				
<1 day	7%	32%	15%	0%
1 day	29%	27%	15%	25%
2 days	14%	27%	15%	25%
3 days	36%	0%	15%	0%
ASAP	0%	0%	23%	0%
depends	0%	0%	15%	50%
NA	14%	14%	0%	0%
Have you prepared?				
Yes	50%	59%	85%	50%
No	50%	41%	15%	50%

More than half (57%) of Round 1 residents had experienced a flood compared to 50% in Round 2, while most (85%) emergency managers who participated in Round 1 had experienced a flood, 38% of which had been in the last two years (Figure 9). This contrasts with the emergency managers in Round 2, 75% of whom had not experienced a flood.

All Round 1 residents and 68% of Round 2 residents perceived their flood risk as very little to none, while 32% of Round 2 residents saw their risk as somewhat or extremely high. In Round 1, 38% of emergency managers saw their risk as somewhat high, while almost all Round 2 emergency managers perceived their risk as very little (Figure 9). In Round 1, a third of residents (36%) wanted advance notice 3 days before the storm landfall and 43% wanted notice 1-2 days prior (Table 2). In Round 2, 32% of residents wanted notice on the order of hours (< 1 day), 27% wanted 1 day notice and 27% wanted 2 days' notice. Most emergency managers stated they are constantly monitoring the situation and wanted information as soon as possible. Not surprisingly, the emergency managers are more likely to have responded to warnings than the residents, irrespective of rounds.

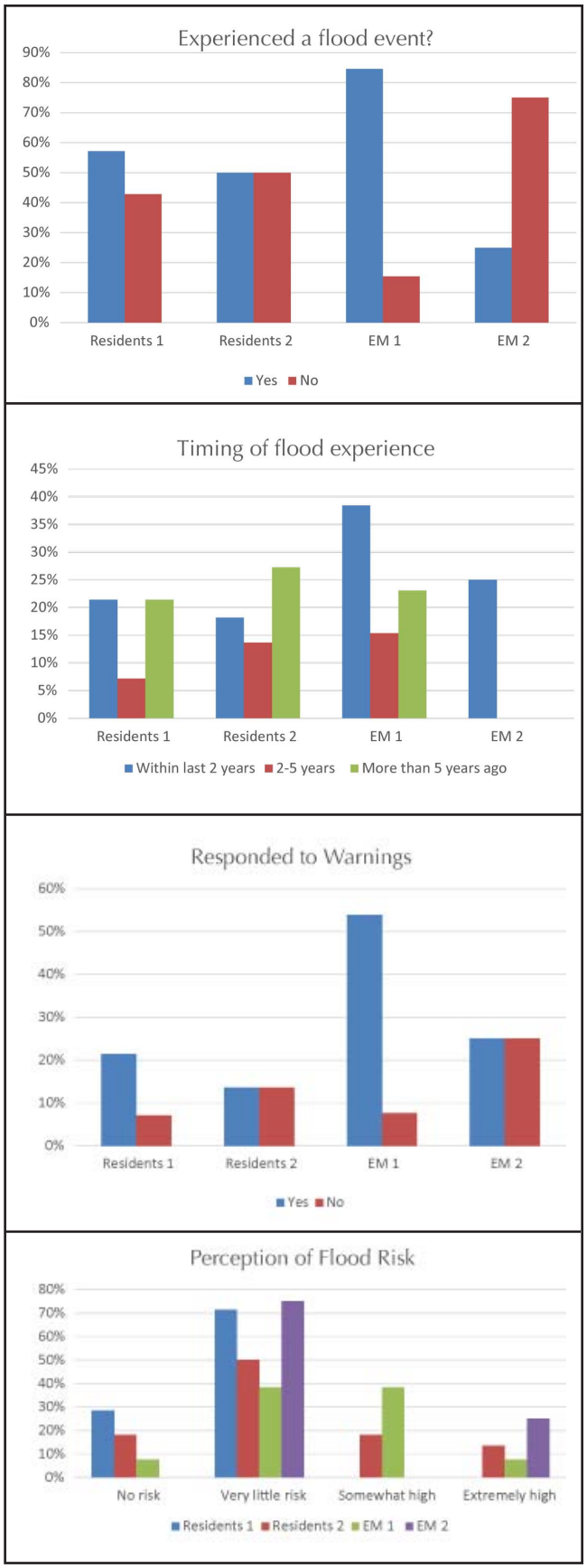


Figure 9. Flood experience characteristics of focus group participants.

Most participants looked for weather information on TV and the internet with Round 2 residents also relying on radio and smartphones (Table 3). Most residents discussed weather hazards with family and friends and sought out more information. Almost all residents and emergency managers preferred a combination of text and graphics (Table 3). Facebook and weather apps were the social media outlets preferred for information, while Twitter was hardly mentioned. Smartphones and laptops were the devices used most for accessing weather information.

Table 3. Information delivery and access preferences.

	Residents 1 N=14	Residents 2 N=22	EM 1 N=13	EM 2 N=4
Where to get information?				
TV	71%	95%	85%	75%
Radio	43%	82%	38%	25%
Smartphone	43%	73%	46%	50%
Internet	79%	68%	77%	75%
Twitter	14%	14%	15%	0%
Facebook	36%	32%	31%	25%
Other	0%	14%	69%	25%
What do you do with weather info?				
Discuss with family/friends	86%	77%	54%	25%
Seek further information	79%	82%	54%	100%
Contact local officials	14%	0%	23%	25%
Other	0%	32%	62%	25%
Digital platform for accessing NWS				
Smartphone	64%	68%	67%	75%
Tablet	14%	9%	8%	50%
Laptop	79%	36%	58 %	25%
Desktop	7%	5%	50%	25%

	Residents 1 N=14	Residents 2 N=22	EM 1 N=13	EM 2 N=4
Do you prefer text based or graphics?				
Text	7%	5%	0%	0%
Graphics	7%	5%	25%	0%
Combined	86%	82%	67%	100%
NA	0%	9%	8%	0%
Social media for information on risk?				
Facebook	57%	36%	67%	50%
Twitter	21%	9%	25%	0%
Weather App	64%	64%	58%	25%
Other	57%	32%	33%	0%
Social media for information on preparation?				
Facebook	21%	41%	58%	50%
Twitter	7%	9%	17%	0%
Weather App	50%	55%	58%	25%
Other	50%	27%	42%	0%

Focus Group Analysis: Round 1

As detailed above, focus groups were held with emergency managers, broadly defined, and with members of the public using the HEFS provided by MARFC in a scenario leading participants through an impending event. Although several NWS products were included in the scenario, the emphasis was on the HEFS. As a result, the discussion that centered on the HEFS in each focus group is presented.

Emergency Managers

The participants in these focus groups were presented with both the 15-day and, following the scenario, the 90-day HEFS. With respect to the 15-day HEFS, the overall reaction was mostly positive, with comments such as "this would be very helpful" and "that's what we want to see." Interest was expressed in looking at it for monitoring the situation with one categorizing the information as "more useful and actionable," with another stating that, given the situation shown, it is "not enough to excite me at this point." Participants recognized both the complexity and the uncertainty associated with the products, with one EM noting "I find this extremely helpful as an emergency manager because I can see the worst-case scenario." On the other hand, because of those same characteristics, several mentioned the need for training if people are going to be using it so that they understand it. Indeed, one EM admitted, "I may or may not interpret these kinds of graphs correctly, so I'm going to lean on the professionals for that." Some questioned how much it could or would be used, and all agreed they would not send it out to the general public. Despite these concerns, participants see it as one of several products they would use, and one EM said he could use it to "tell stories to the public." They had few suggestions on revisions, though most said that the discharge is irrelevant to their needs; it is the stage of the river that is critical to their responsibilities.

Participants found the 90-day HEFS to be of little value to them, though some recognized its potential utility for water managers. Many of the statements echoed the sentiment shared by one EM who said, "For emergency management purposes, I don't see the value."

The Public

In contrast to the emergency managers, reaction by the public to the 15-day HEFS was largely negative. Comments centered on how complicated it is and therefore how difficult it is to understand. One representative comment is, "Yeah the more I'm looking at this, the more I think I'm confusing myself." In addition, many remarked that they did not understand it or did not care about the information provided, with some wondering about the intended audience.

Features of the product, besides the overall topic, that created confusion included the use of color which made it difficult to figure out what to "take seriously" and the use of discharge along with flood stage. Some had difficulty understanding the title and what the lines mean, particularly when trying to sort through the percentages.

This input, along with that from the emergency management focus groups, led to the revisions that were presented in a second round in which the same scenario was used but with different participants. Suggested changes included providing better visual clarity on confidence including differentiating colors. River location and title simplification were suggested as well as a vertical legend instead of a horizontal one. For residents, reducing the extra information they did not need, which included the percentages and discharge information, was critical to facilitating understanding and use.

Focus Group Analysis: Round 2

Emergency Managers

Once again, the response among the participants on the now revised 15-day HEFS was mostly positive, with emphasis on internal and partner use of the product rather than sending it out to the public. There was a distinct preference for probabilistic ranges because they are more useful to them than deterministic forecasts. At the same time, there was a preference for "having more quantitative information and not just less likely and least likely." While there was an understanding that NWS is trying to make the product suitable for everyone, some questioned why this is the case, given the difficulty they see in getting people to understand uncertainty. There was also discussion as to whether the product needs to be accessible to everyone, relating specifically to the use of both river levels and discharge.

The Public

Reaction to the revised 15-day HEFS was similar to the original, with most saying that it remains too complicated and therefore useful for only "some" people. While one participant stated that "It gives you a good visual feel of what could happen," others said, "That is actually kind of confusing" and "Yeah it just makes no sense." Further, some questioned the utility of a 15-day product. Although participants in the first round seemed to have problems with percentages, in this round, participants asked for definitions of less likely, least likely and likely, suggesting "something just a little more quantitative." Overall discussion about the product indicated continued misunderstanding of what was conveyed.

Post-Session Survey Results: Rounds 1 and 2

Participants were asked for feedback on the specific forecast products they saw during the focus group scenario. The average ranking from residents in Round 1 and Round 2 in order of their preference of use is shown in Table 4. The 15-day HEFS consistently ranked last and the National Hurricane Cone product consistently ranked first. Most products maintained their same relative order ranking from Round 1 to Round 2 with the exception of the AHPS hydrograph and the Hazardous Weather Outlook which both decreased in preference.

Emergency Managers rated the products based on the likelihood they would use the product. Almost all products increased in their ratings of usefulness from Round 1 to Round 2 (Figure 10). One exception was the 90-day HEFS which decreased in usefulness. Notably, after revisions to the 15-day HEFS product, usefulness ratings increased significantly for the EMs, while residents continued to rank the product as the least useful.

It is apparent that the 15-day HEFS has little utility for most residential audiences. Emergency managers see value in the product, especially after presented with the revised version. Emergency managers had little to no use for the 90-day HEFS, noting the time period was not applicable to the time scales needed for emergency response. The 90-day graph was seen to be more suited for water resource managers.

Water Managers

As mentioned above, a webinar was held with water managers, using both the Round 1 and Round 2 versions of the 15-day HEFS and the original 90-day HEFS. Participants had either not seen or used the 15-day HEFS and all thought it would be useful, whether for drought monitoring or for those dealing with floods. The timeframe is helpful for their decisions, and most use discharge rather than river stage. The participants were positive about the revised product, though they need the probabilities in the legend because of their importance to the decisions they must make. One

Table 4. Average ranking of preference of use for products shown to resident focus group participants in Round 1 and Round 2 with rank 1 being most preferred and 8 being least preferred.

Average Rank 1	Average Rank 2	Product
1.2	2	National Hurricane Cone
2	4.8	AHPS hydrograph
2.8	4.4	Hazardous Weather Outlook
3.4	3.5	WFO Rainfall Forecast
4.2	5	WFO River Flood Watch
4.4	4	WFO Flash Flood Watch
5	4.8	WFO River Flood Warning
6.6	7.4	15 day HEFS

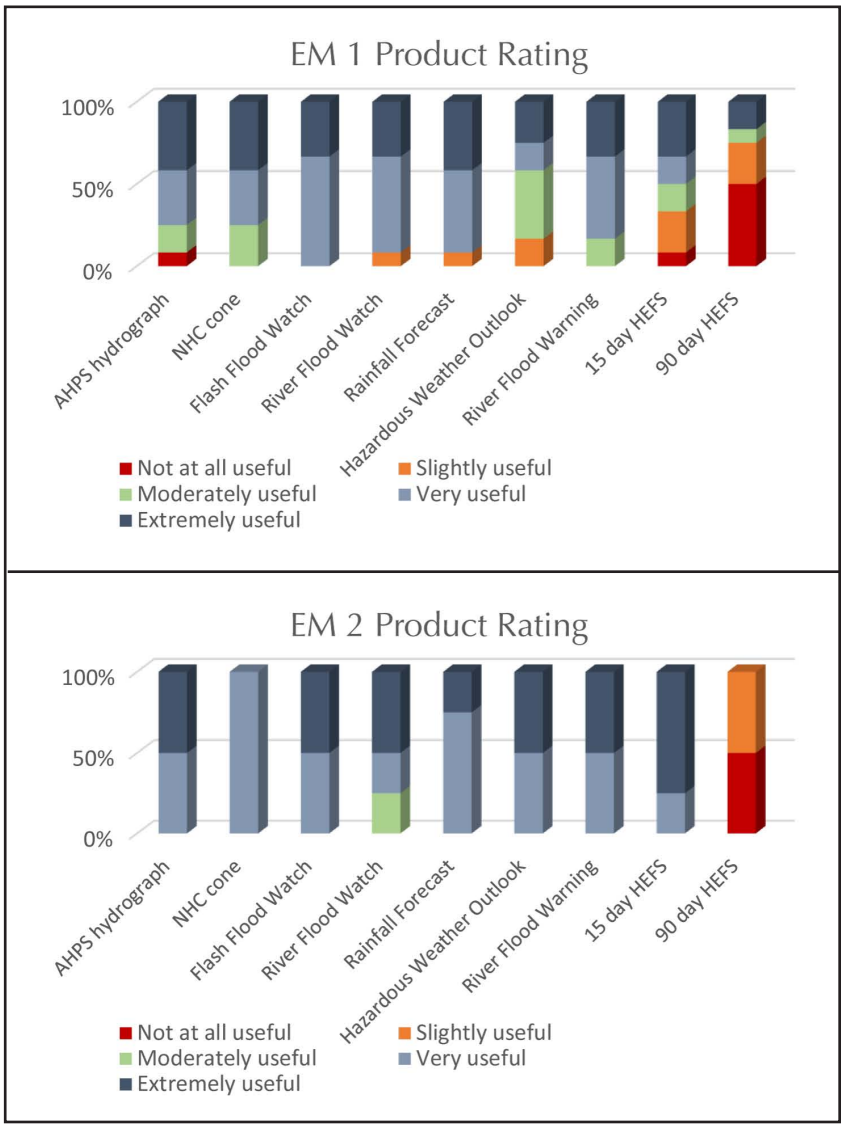


Figure 10. Emergency manager product usefulness rating for Round 1 (top) and Round 2 (bottom).

item that was mentioned as missing for their purposes was the minimum value of the ensemble, particularly for those dealing with droughts.

In their view, the 90-day exceedance plot would be a good piece of information, especially if there was a probability of low-flow conditions, which would support decisions to conserve the water in reservoirs, among others. It provides a quick idea of conditions that are likely to be wetter or drier than normal which can be used to corroborate other data, guide other model output interpretations, used as a QC check, and for ground-truthing models. One participant puts out a water supply outlook publication which includes a model about past water flow and thought the 90-day exceedance plot would be useful to include as well. Suggested improvements included adding more text if used by the public, and the ability to hover over a point to get flow information.

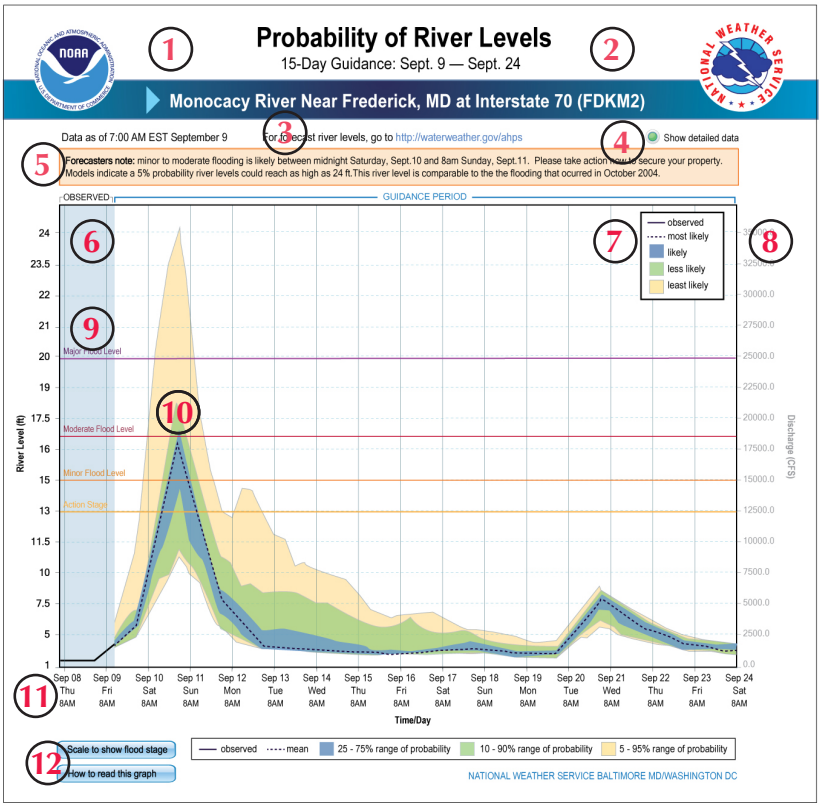
None of the participants had previously seen the Cumulative Volume for 90-day Exceedance Plot, and they thought it would be useful for monitoring both drought and flooding. None use acre feet, preferring millions of gallons, but they acknowledged the conversion was simple enough. Again, interactivity with the ability to hover over points to see values was seen as particularly useful to them and their stakeholders.

Summary of Focus Group Discussion and Session Survey Results

After Round 2, emergency managers and residents suggested adding back in the detailed probability levels, adding floods of record as a flood line on the graph, and using deeper color variations on the charts. It is important to note that in the first round of focus groups, the percentages were confusing to residents so the decision to simplify the legend with 'likely' classifications and removing the percentages was made. However, in the second round of focus groups this percentage information was missed, especially by emergency managers and water resource professionals, so the decision was made to keep the simplified legend for public audiences and add a second legend at the bottom with the percentage information for more technical users (Figure 11). These were then used in the online survey.

Online Survey

The online survey administered to all focus group participants as a third round of testing showed two graphics – a high flow and low flow scenario and asked about new, additional features including a forecaster's note and text box. A total of 23 participants completed the survey but not everyone answered all questions. The small sample size limits robustness of the findings but the results from the online survey provide important insights meriting further investigation. The group consisted of both members of the public (about 50%) and emergency and water resource managers. Jefferson and Frederick counties were about equally represented. About two-thirds (67%) of respondents were definitely interested in products that provide guidance on river levels, while only 5% were not interested.



1. Key information on top and up front
2. Simplified title and river location
3. Quick link to the AHPS hydrograph
4. Ability to activate data point text boxes on hover
5. Optional forecaster's note box
6. Differentiation between "observed" and "guidance periods"
7. Streamlined vertical legend up top for lay audiences; detailed legend with range of probabilies along bottom for professionals.
8. Discharge info de-emphasized
9. Key river level colors changed to align with hydrograph colors
10. More variation between colors (tested for color-blindness)
11. Reordering of day/time to day on top
12. Buttons that offer quick, additional information: "Scale to Flood Stage" and "How to Read this Graph"

Figure 11. Summary of Revisions

A majority of respondents correctly interpreted the information being conveyed in both graphics and were able to gauge the level of risk. Some 65% viewed their flood risk as high or somewhat high after interpreting the high flow graphic, and 71% viewed their flood risk as very low based on the low flow graphic. These findings are encouraging and supportive of the fact that the graphics are understandable and effectively convey an accurate message. However, there was a small number of respondents who saw the graphics as "confusing and not clear at all" or who could not read them. Interestingly, even though the majority assessed a high risk of flooding upon viewing the high flow graphic, only about half (55%) said they would take any actions as a result. Those actions included about a third keeping an eye on the river, 27% seeking out more information, and only 6% having an emergency preparedness kit. Lack of action was not due to the information conveyed in the product, but rather a lack of concern about flooding and its impact on daily operations.

About half of the respondents felt the high flow product was very useful (Figure 12), while the low flow product was considered very to somewhat useful by 76% of respondents. Half of the respondents were extremely likely to use both the high and low flow products in the future.

Breaking the responses into two user groups, professionals (including emergency managers and water resource managers) and the public, the results show that emergency managers and other public officials see the products as very useful and they are extremely likely to use them compared to members of the public who were more mixed. Specifically, most public respondents reported finding the products somewhat useful with an even distribution of responses with respect to likelihood to use (Figure 12).

When asked about specific product components, most respondents identified the discharge on the right axis as not useful, followed by the percentages and time period (Figure 13). The 'Most likely' line and the flood levels (minor, major) were useful, as were the river level and range of probable levels. These findings echo results from the focus groups that discharge was not useful to most potential users. Revisions to the HEFS graphic to include a most likely and range of probable levels appear effective and useful to viewers.

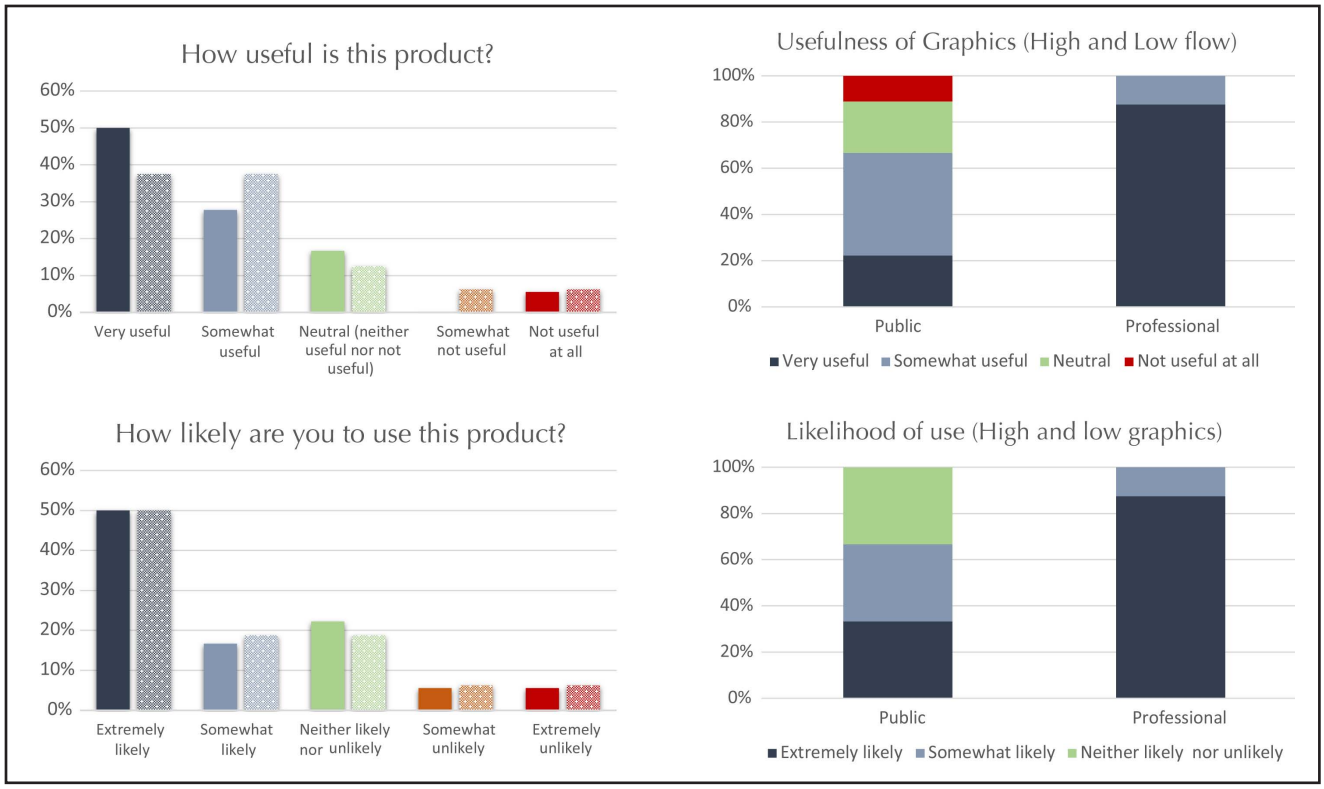


Figure 12. (Left column) Usefulness and likelihood of use of the revised high flow (solid color) and low flow (dotted color) HEFS graphics from all participants; (Right column) Usefulness and likelihood of use broken down by user group.

Some respondents provided additional explanation of why some of the graphic components were less useful. One respondent felt there were too many elements in the product. A few took issue with the time period, noting that they pay attention to a 3-5 day span and that 15 days is too far out.

Another suggested focusing on flooding, getting rid of the top right legend and calling the product "Probability of River Flooding." A few respondents were unsure how to interpret and match the percentages to the top and bottom of the color range and one suggested having simple lines for the 5% chance of exceedance, etc. with text in the legend.

Breaking the responses down by professional and public user groups, the most likely line, colors, legends, range of probable levels, and river level were favored among all groups (Figure 14). Only a very small number of professionals felt discharge was useful. Percentages and the time period were other elements not seen as useful among most groups.

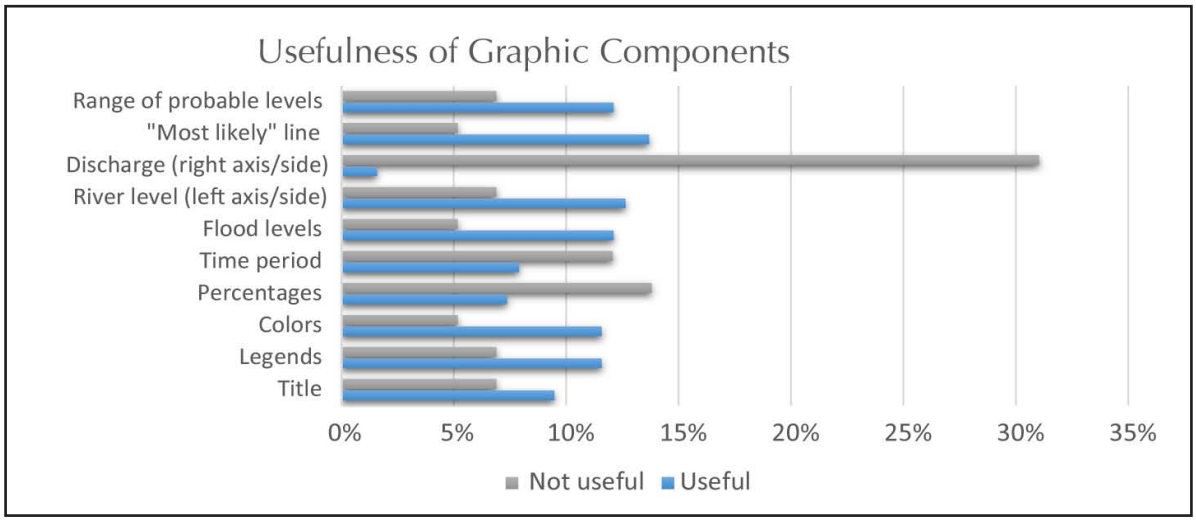


Figure 13. Usefulness of specific product components for the revised high and low flow HEFS product

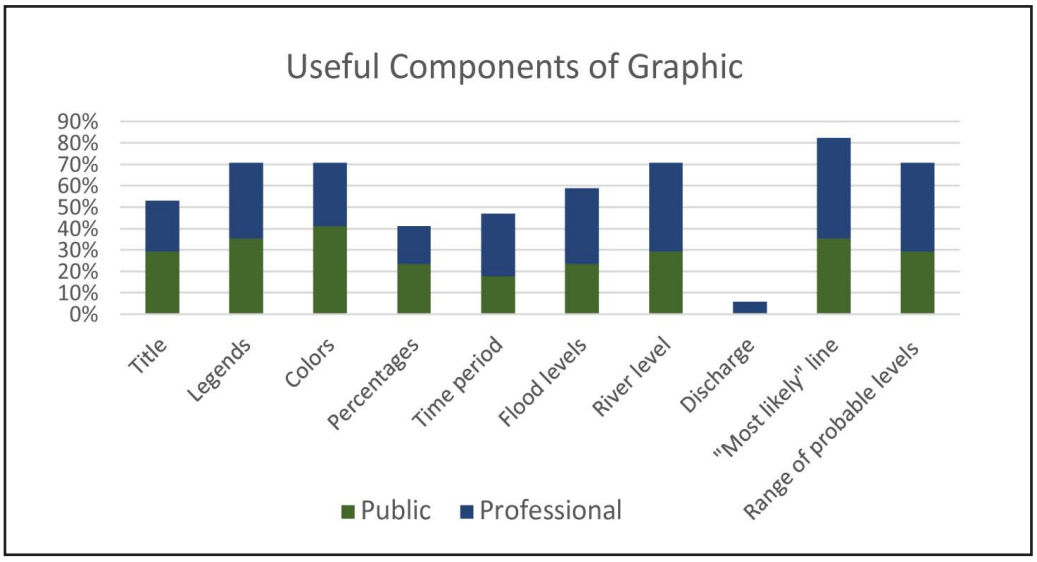


Figure 14. Useful HEFS graphic components broken down by user group.

The Utility of Additional Components: Forecaster's Note and Text Box

The online survey also asked about additional components to the graphic, specifically a forecaster's note and text box (see Figure 7 in Methodology section). The forecaster's note was rated as very useful with 88% of respondents reporting it as very or extremely useful, compared to 56% for the text box. This usefulness rating was reflected in each element's influence on decision-making (Figure 15). Forecaster's notes were expected to influence decisions to a large extent while the potential influence of text boxes was seen to be to a moderate extent. Suggestions for information that would be useful in the notes were a link to historical flooding and the type of flooding that would occur at different levels (100 or 500 year).

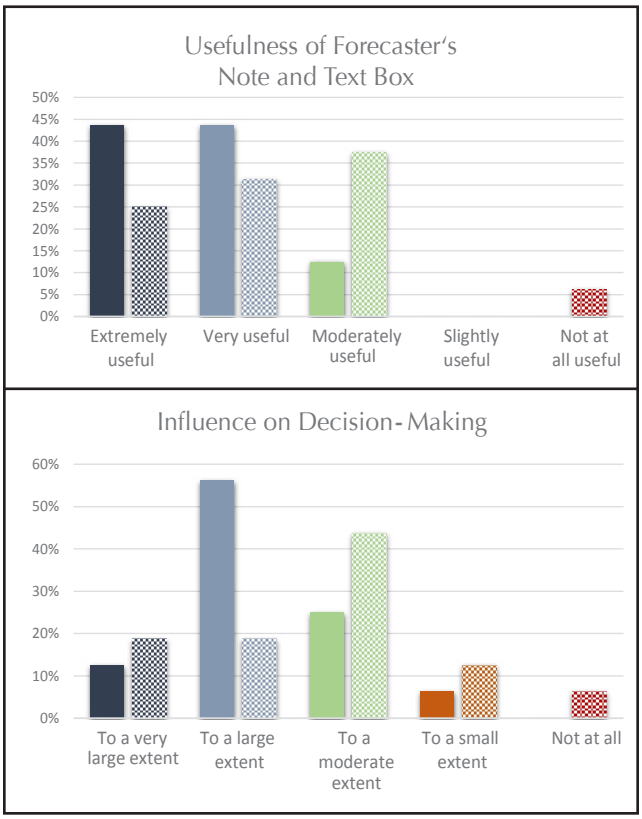


Figure 15. Usefulness and influence on decision-making of the forecaster's note (solid colors) and text box (dotted colors) graphic elements.

Assessing differences between professional and public user groups shows that professionals found the forecaster's note useful and an influence on decision-making (Figure 16). Text boxes were viewed slightly differently especially by professionals, of whom some reported the text box was not at all useful or an influence on decision making.

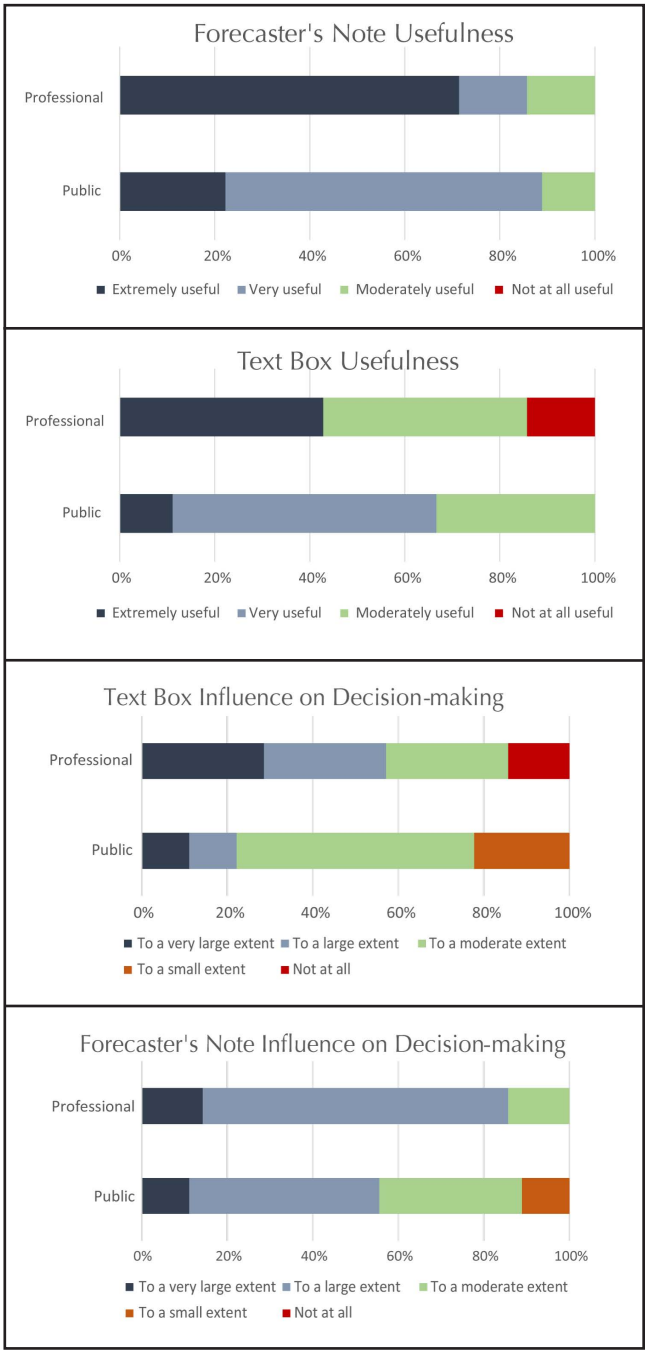


Figure 16. Usefulness and influence on decision-making for forecaster's note and text box graphic elements broken down by user group.

Overall Summary

Overall, the findings from the focus group discussions and survey responses suggest that HEFS has limited utility for public audiences but is valuable information to professional users. Graphic revisions and additional components will enhance understandability and likelihood of use by both groups. Such revisions may foster decision-making relating to preparedness for extreme weather events and may encourage use of uncertainty forecasts. This is reflected in the responses from focus group participants when asked what actions they were likely to undertake after attending the focus group session and seeing the HEFS information (Figures 17 and 18). A higher percentage of emergency managers in Round 2 compared to Round 1 was very likely to use uncertainty forecasts in decision-making, seek NWS information about extreme weather risks, and share what they learned with others (Figure 17). A higher percentage of residents in Round 2 compared to Round 1 was very likely to better understand the uncertainty in flood forecasts and seek out NWS information about extreme weather risks, suggesting that the changes to the HEFS graphics improved the ability of residents to understand uncertainty (Figure 18). Further, these results suggest that, as users become more familiar with the products, their utility may increase, though not without guidance for interpretation.

The 15-day HEFS present problems for public users of the products, as detailed above. Beyond the findings relating to the HEFS, resident participants in the focus groups provided additional information about barriers to their use of flood forecast products which include excess verbiage in forecasts and warnings, access/loss of electricity, difficulties with understandability, finding pertinent information on NWS' website, information not being specific enough to local area, and inconsistency among different sources. Residents emphasized the desire for more localized (less than 50 miles) information, for information about past floods and on where to go if evacuation was necessary. These elements require close cooperation between the NWS and emergency management professionals.

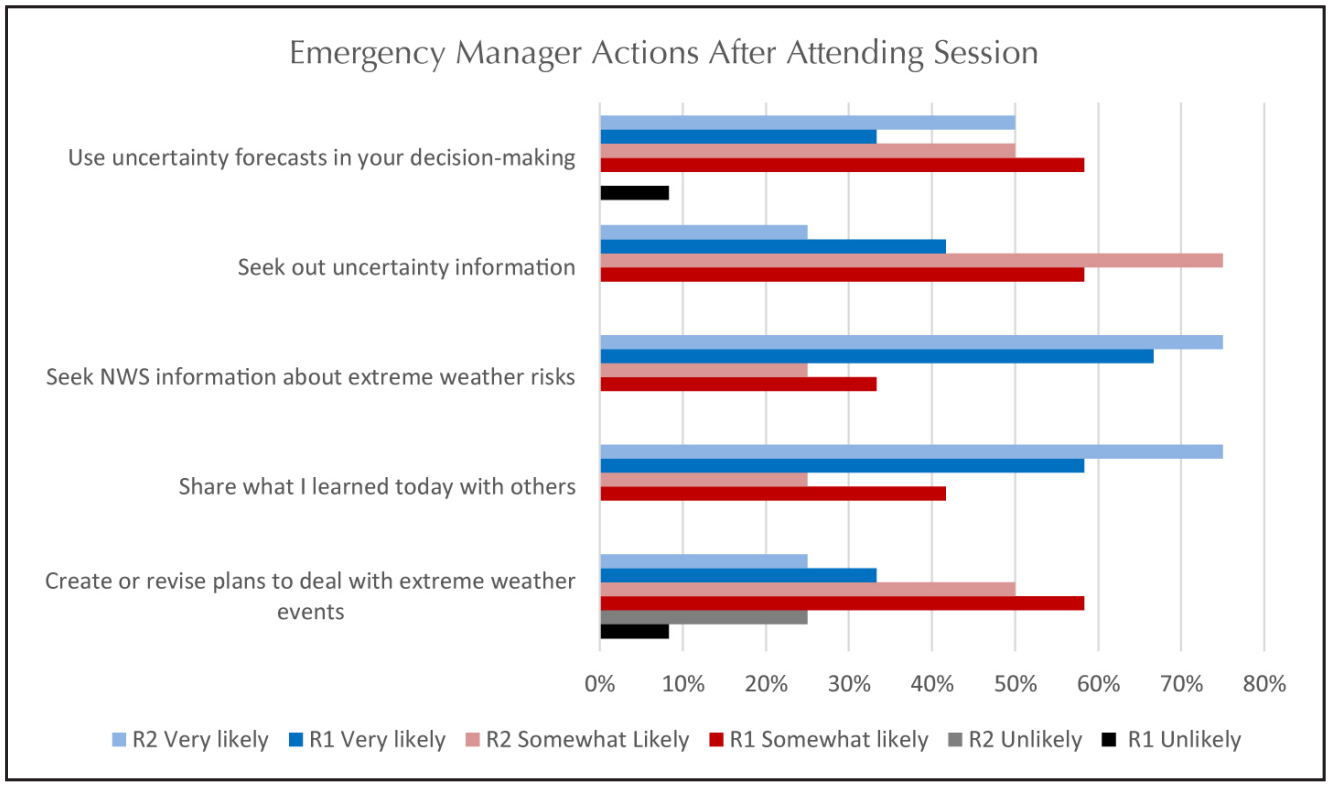


Figure 17. Emergency manager stated likelihood to take action after focus group comparison between Round 1 and Round 2.

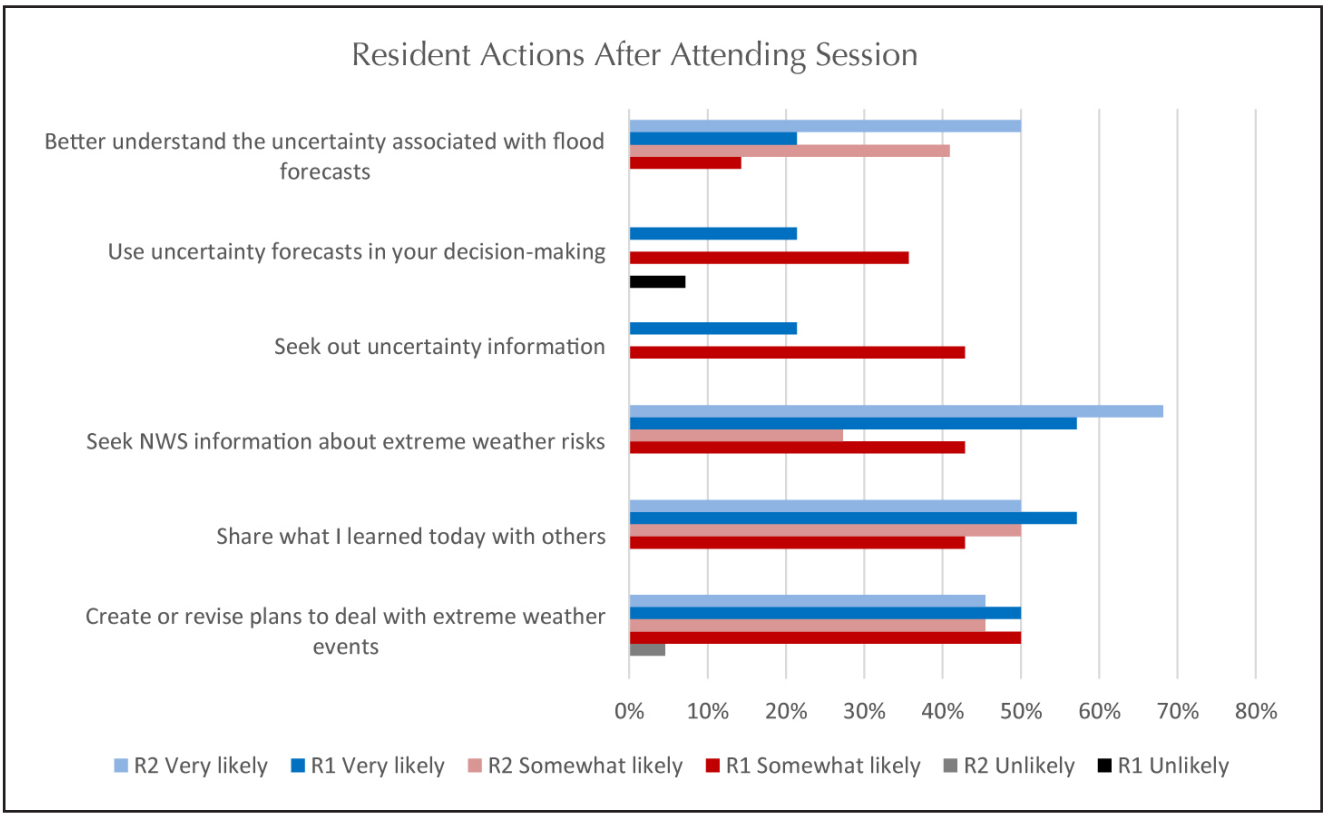


Figure 18. Resident stated likelihood to take action after focus group session comparison between Round 1 and Round 2.

Conclusions

Several sets of conclusions emanate from this project, centering on the utility of the information provided by the HEFS, whether 15- or 90-day, and the preferred format and content of the products. The variation in findings among the user groups should inform the next stage in product development.

The results of this project suggest that both the 15-and 90-day HEFS have the potential for rather widespread use by specific groups, notably emergency managers and water resource professionals for the 15-day and water resource managers for the 90-day products. This was the case with both the original and revised HEFS. It became clear during the focus groups that there is some potential for misinterpretation, yet the more familiar that users, particularly emergency managers and water resource professionals, become with the products, the more use they may derive from the product. However, even these users suggested that training and guidance will be needed. The findings are somewhat more complicated for the public.

Improvements in understanding the 15-day HEFS were evident in the second round of resident focus groups, but this did not translate into increased preference for the product. It appears, then, that it is the information and not the design of the product that is the issue. Fifteen days out may well be too long a timeframe for many users. In addition, in Round 2, residents appeared to become increasingly distrustful of the 15-day HEFS as the session progressed. This was especially evident in the second Frederick, MD focus group where initial reaction to the HEFS was more positive than in either of the Round 1 focus groups or in the other Round 2 session. However, the differences they saw in the data shown in the HEFS and the hydrograph led them to decide that both were untrustworthy. The previously mentioned change in ranking of the HEFS as well as the hydrograph ranking in Round 2 (Table 4) shows this. Although this was an observation in only one focus group, it was striking and lowered rankings, suggesting perhaps that residents using this tool as part of a suite of information will compare it to deterministic forecasts for developing situational understanding.
An important question that the issue above raises is how far apart a deterministic and a probabilistic forecast can be at one point and still be issued safely without causing confusion. This is much less a problem for professionals who deal with both deterministic and probabilistic forecasts on a daily basis, but it harkens back to the public's ability to understand probabilistic forecasts and the most appropriate means of communicating uncertainties and probabilities. Results from previous projects suggest that the hydrograph is the public's "go to" product in some places (Hogan Carr et al. 2016a), yet even then it was misinterpreted at times. This is not to suggest that the 15-day HEFS should not be issued except to specific audiences (which is very difficult if it is on a NOAA website), but rather that difficulties that it may create be recognized and perhaps detailed explanations provided.

The revisions in colors, legends and text were seen by all to improve understanding of, if not preference for, the 15-day HEFS. Attempts to meet the needs of one group, the residents, were met with some concern by the professional groups, particularly regarding the use of probabilities in the legend. Subsequent revisions tested in the online survey addressed this and received positive responses. This example illustrates the difficulties in developing one product to meet the needs of users with varied responsibilities, interests and levels of knowledge. The addition of a text box and, especially, a forecaster's note was seen to be particularly useful and potentially helpful to decision-making. The text boxes provide the ability to hover over a point for specific information, as suggested by the professionals in the focus groups. (Note that the text boxes were not dynamic in the survey and thus may have received lower rankings as a result). What is not known, however, is why these elements, and again especially the forecaster's note, generated such positive responses. Is it because it presumes a connection to the forecaster and thus a human

connection which in turn causes an increase in trust? Is it seen to provide the guidance that was suggested in the focus groups by using plain text to provide clarification? Or is it something else? Wider dissemination of the online survey and final revised products are warranted and will provide further insight into the utility of the graphics, specifically the forecaster's note and text boxes, and to the barriers to understanding.

The utility of the HEFS products to motivate preparedness actions varies with user groups, with the least potentially positive effect on residents, in large part because of the timeframes in which they make decisions. All users in this project see the products as useful for situational awareness, but not necessarily as ones on which they would take specific actions. The water resource managers seemed to see the greatest utility in the products given the types of decisions they make. Most participants in the project had some difficulty understanding what the products were showing, particularly with respect to the way in which the probabilities are depicted. Changes in design elements, including colors and legends, improved understandability, but not preference for the products, especially among the public participants. It appears that one product may not be suitable for all audiences and, instead, should be targeted to specific stakeholders and partners, while at the same time, providing sufficient guidance to avoid confusion with other products such as the hydrograph.

Tested HEFS products had not been fully implemented regionally or nationally at the time of testing, so user experience with the products was minimal. An increase in familiarity with the products may enhance user interest in probabilistic forecasts and change specific user preferences over time. Future studies should explore evolving needs for probabilistic forecasts as products are deployed, including how users incorporate the ensembles into their decision-making once the products are routinely and widely disseminated. Future research should also examine whether users in different geographic regions have different requirements for hydrologic ensemble forecast products.

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Appendix A

Residential Pre-Focus Group Survey (1)

Nurture Nature Center and East Carolina University

National Weather Service Product Study

FREDERICK Pre-Session Survey

March, 2017

1. **How did you learn about this focus group?**

   _____

   _____

2. **What was your reason for attending?**

   _____

   _____

Please tell us about your experience with flood events.

3. **Have you, a family member, or close friend experienced one or more significant flood events (e.g., experienced damage, loss, evacuation)?**

   ___Yes ___No

   If yes, please indicate: ___ within the last 2 years ___2-5 years ago ___ more than 5 years ago

4. **How do you rate your own chance of being flooded at your home or business?**
   Extremely high risk **Somewhat high risk** **Very little risk** **No risk**

5. **If you have experienced a flood, did you respond to official flood warning messages?**

   ___Yes ___No ___Not applicable

6. **Have you ever prepared for an anticipated flood?** ___Yes ___No

7. **How much advance notice do you need to prepare for a flood?** _____

8. **Where do you get information about imminent extreme weather events, such as flooding and hurricanes? Please check all that apply.**

   __TV: Station(s)?_____

   __Radio: Station(s)?_____

   __Smartphone: App(s)?_____

   __Internet: Website(s)_____

   __Twitter: Follow_____

   __Facebook: Source(s)_____

   __Other:_____

9. **Where do you get information about how to prepare for extreme weather events? Please check all that apply and identify sources.**

__TV: Station(s)? _____

__Radio: Station(s)? _____

__Smartphone: App(s)? _____

__Internet: Website(s) _____

__Twitter: Follow_____

__Facebook: Source(s)_____

__Other: _____

10. **If you learn that a significant weather hazard is approaching your area, what do you typically do with that information? (Please check all that apply.)**

__Discuss with family and friends

__Seek further information

__Contact local officials

__Other _____

Please tell us about yourself.

10. **Age:** ___under 20 ___20-29 ___30-39 ___40-49 ___50-59 ___60-69 ___70+
11. **Gender:** ___Male ___Female
12. **Municipality**: _____ **County:** _____
13. **Length of time living in this municipality:**

___under 1 year ___1-2 years ___3-5 years ___6-8 years ___8 or more years

14. **Length of time living in this county:**

___under 1 year ___1-2 years ___3-5 years ___6-8 years ___8 or more years

15. **Highest level of education completed:**

___High School/GED ___Associate's degree or 2-year college degree

___Bachelor's degree or other 4-year college degree ___Post graduate work

Thank you for participating. Your feedback is valuable.

Emergency Manager Pre-Focus Group Survey (1)

Nurture Nature Center and East Carolina University

National Weather Service Product Study

Pre-Session Survey

March 2017

1. **How did you learn about this focus group?**

   _____

   _____

2. **What was your reason for attending?**

   _____

   _____

Please tell us about your experience with flood events.

3. **Have you, a family member, or close friend experienced one or more significant flood events (e.g., experienced damage, loss, evacuation)?**

   ___Yes ___No

   If yes, please indicate: ___ within the last 2 years ___2-5 years ago ___ more than 5 years ago

4. **How do you rate your own chance of being flooded at your home or business?**
   Extremely high risk **Somewhat high risk** **Very little risk** **No risk**

5. **If you have experienced a flood, did you respond to official flood warning messages?**

   ___Yes ___No ___Not applicable

6. **Have you ever prepared for an anticipated flood?** ___Yes ___No

7. **How much advance notice do you need to prepare for a flood?** _____

8. **Where do you get information about imminent extreme weather events, such as flooding and hurricanes? Please check all that apply.**

   __TV: Station(s)?_____

   __Radio: Station(s)?_____

   __Smartphone: App(s)?_____

   __Internet: Website(s)_____

   __Twitter: Follow_____

   __Facebook: Source(s)_____

   __Other:_____

9. **Where do you get information about how to prepare for extreme weather events? Please check all that apply and identify sources.**

__TV: Station(s)? _____

__Radio: Station(s)? _____

__Smartphone: App(s)? _____

__Internet: Website(s) _____

__Twitter: Follow_____

__Facebook: Source(s)_____

__Other: _____

10. **If you learn that a significant weather hazard is approaching your area, what do you typically do with that information? (Please check all that apply.)**

__Discuss with family and friends

__Seek further information

__Contact local officials

__Other _____

Please tell us about yourself.

10. **Age:** ___under 20 ___20-29 ___30-39 ___40-49 ___50-59 ___60-69 ___70+
11. **Gender:** ___Male ___Female
12. **Municipality**: _____ **County:** _____
13. **Length of time living in this municipality:**

___under 1 year ___1-2 years ___3-5 years ___6-8 years ___8 or more years

14. **Length of time living in this county:**

___under 1 year ___1-2 years ___3-5 years ___6-8 years ___8 or more years

15. **Highest level of education completed:**

___High School/GED ___Associate's degree or 2-year college degree

___Bachelor's degree or other 4-year college degree ___Post graduate work

16. **What is the title of your position?** _____

Thank you for participating. Your feedback is valuable.

Residential Post- Focus Group Survey (1)

Nurture Nature Center and East Carolina University
CSTAR Project
October 2016

Post-Session Survey

1. **Please rate your agreement with the following statements about the forum.**

Please check ONE box for each statement.

	Strongly Agree	Agree	Disagree	Strongly Disagree
The information was clearly presented.				
I felt comfortable voicing my opinion.				
I know more about the National Weather Service (NWS) resources.				
I feel I could use NWS resources to judge my risk in an extreme weather event.				

2. **What is the biggest barrier you face in possibly using NWS flood forecast and warning products?**

_____

3. **Our goal today was to gather feedback to improve NWS flood forecast and warning tools, including the HEFS. Beyond the questions asked today, what else would be important to know about how you gather information about extreme weather risks and your intended actions?**

_____

4. **After attending today's session, how likely are you to:**

Please check ONE box for each statement.

	Very Likely	Somewhat Likely	Somewhat Unlikely	Unlikely
Create or revise plans to deal with extreme weather events.				
Share what I learned today with others.				
Seek NWS information about extreme weather risks.				
Better understand the uncertainty associated with flood forecasts				

5. **Do you prefer text-based or graphical/visual products in trying to understand your level of risk from flooding?**

Text Graphics Combined text and graphics

Please explain why. _____

Residential Post- Focus Group Survey (2)

6. **Of all the weather products discussed today, which would you use in order to learn about and prepare for extreme weather events?**

Please rank in order of usefulness 1 = most useful and 9 = least.		Please explain why you ranked this product in this order.
	Advanced Hydrologic Prediction Services (AHPS) Hydrograph	
	National Hurricane Center Cone	
	WFO Flash Flood Watch	
	WFO River Flood Watch	
	WFO Rainfall Forecast	
	Hazardous Weather Outlook	
	WFO River FloodWarning	
	15-Day Probabilistic Guidance	

7. **Which social media would you use to find information about the risk of flooding near you? Please check all that apply:**

   Facebook Twitter Weather App: _____ Other:_____

8. **Which social media would you use to find information about how to prepare for a flood? Please check all that apply:**

   Facebook Twitter Weather App:_____ Other:_____

9. **Which digital platform are you most likely to use to access NWS resources?**

   Smartphone Tablet Laptop Desktop Other: _____

10. **Was anything in the session confusing?** Yes No
    If Yes, please explain:

_____

_____

11. **What improvements could be made in the format or content?**

_____

_____

12. **Additional comments:**

_____

_____

Thank you for participating!

Emergency Manager Post- Focus Group Survey (1)

Nurture Nature Center and East Carolina University
CSTAR Project
March 2017

Post-Session Survey

1. **Please rate your agreement with the following statements about the forum.**

Please check ONE box for each statement.

	Strongly Agree	Agree	Disagree	Strongly Disagree
The information was clearly presented.				
I felt comfortable voicing my opinion.				
I know more about the National Weather Service (NWS) resources.				
I feel I could use NWS resources to judge my risk in an extreme weather event.				

2. **What is the biggest barrier you face in possibly using NWS flood forecast and warning products?**

_____

_____

3. **Our goal today was to gather feedback to improve NWS flood forecast and warning tools, including the HEFS. Beyond the questions asked today, what else would be important to know about how you gather information about extreme weather risks and your intended actions?**

_____

_____

4. **After attending today's session, how likely are you to:**

Please check ONE box for each statement.

	Very Likely	Somewhat Likely	Somewhat Unlikely	Unlikely
Create or revise plans to deal with extreme weather events.				
Share what I learned today with others.				
Seek NWS information about extreme weather risks.				
Seek out uncertainty information				
Use uncertainty forecasts in your decision-making				

5. **Do you prefer text-based or graphical/visual products in trying to understand your level of risk from flooding?**

Text Graphics Combined text and graphics

Please explain why. _____

Emergency Manager Post- Focus Group Survey (2)

6. **Please rate the weather products discussed today based on their usefulness to you in assessing your flood situation.**

	Extremely useful	Very useful	Moderately useful	Slightly useful	Not at all useful
Advanced Hydrologic Prediction Services (AHPS) Hydrograph					
National Hurricane Center Cone					
WFO Flash Flood Watch					
WFO River Flood Watch					
WFO Rainfall Forecast					
Hazardous Weather Outlook					
WFO River Flood Warning					
15-Day Probabilistic Guidance (HEFS)					
90-Day Probabilistic Guidance (HEFS)					

7. **What changes might you recommend for the 15-Day Probabilistic Guidance product?**

8. **Which social media would you use to find information about the risk of flooding near you? Please check all that apply:**

   Facebook Twitter Weather App: _____ Other:_____

9. **Which social media would you use to find information about how to prepare for a flood? Please check all that apply:**

   Facebook Twitter Weather App:_____ Other:_____

10. **Which digital platform are you most likely to use to access NWS resources?**

    Smartphone Tablet Laptop Desktop Other: _____

11. **Was anything in the session confusing?** Yes No
    If Yes, please explain:

_____

_____

12. **What improvements could be made in the format or content?**

_____

_____

Thank you for participating!

Follow-up Online Survey

When did you participate in a Focus Group?

- ○ October 2016 (1)
- ○ March 2017 (2)
- ○ Not sure (3)

In what county do you live?

- ○ Jefferson (1)
- ○ Frederick (2)
- ○ Other (3)

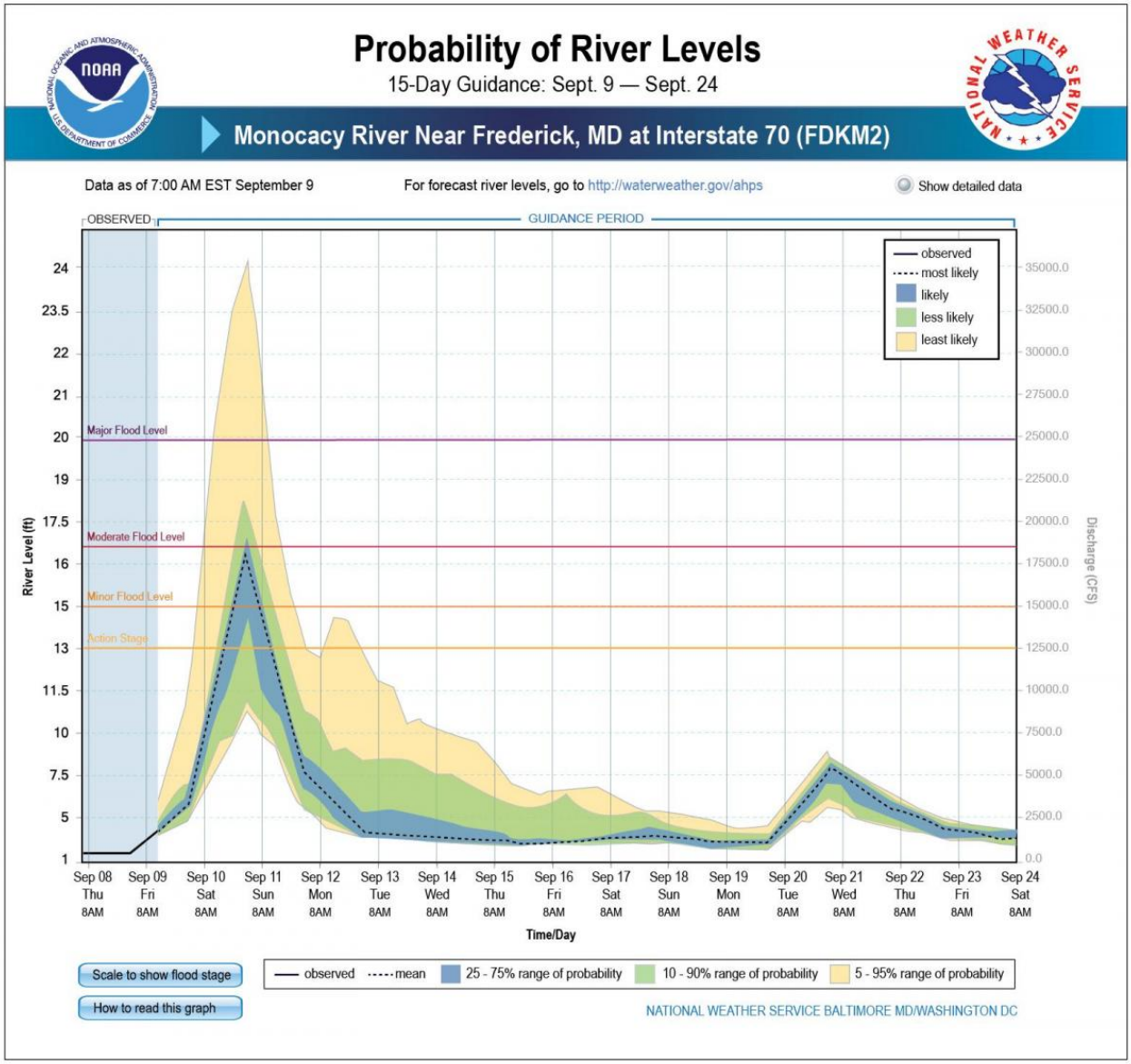
Which of these best describes you?

- ○ General public (1)
- ○ Emergency management (2)
- ○ Water resource manager (3)
- ○ Other (please specify) (4) _____

Are you interested in products that provide guidance on river levels?

- ○ Yes, definitely (1)
- ○ Somewhat (2)
- ○ Not really (3)
- ○ Definitely not (4)

Below are the revised graphics with a series of questions that follows each.


Probability of River Levels
15-Day Guidance: Sept. 9 — Sept. 24
Monocacy River Near Frederick, MD at Interstate 70 (FDKM2)
Data as of 7:00 AM EST September 9
For forecast river levels, go to http://waterweather.gov/ahps
Show detailed data
OBSERVED
GUIDANCE PERIOD
observed
most likely
likely
less likely
least likely
Major Flood Level
Moderate Flood Level
Minor Flood Level
Action Stage
River Level (ft)
Discharge (CFS)
Time/Day
Scale to show flood stage
How to read this graph
observed
mean
25 - 75% range of probability
10 - 90% range of probability
5 - 95% range of probability
NATIONAL WEATHER SERVICE BALTIMORE MD/WASHINGTON DC

What is this graphic telling you? (Select all that apply)

- ☐ There will be moderate flooding (16 feet) on the Monocacy River around September 10th and 11th (1)
- ☐ There is a low probability of moderate flooding on September 11th (2)
- ☐ There is high confidence that there will be low river levels a week from September 9th (3)
- ☐ There is a possibility of major flooding on September 11th but there is a low chance of it happening (4)
- ☐ Other (please specify) (5) _____

After looking at this graphic, how do you view the risk of flooding in the time period from September 10-11th ?

- ○ Very high (1)
- ○ Somewhat high (2)
- ○ Neither high nor low (3)
- ○ Somewhat low (4)
- ○ Very low (5)

Would you take any actions as a result of this product?

- ○ Yes (1)
- ○ No (2)

What actions would you take as a result of this product? (check all that apply)

- ☐ Seek out more information (1)
- ☐ Talk to friends, family and neighbors (2)
- ☐ Take action to secure outdoor property and reduce property loss from flooding (3)
- ☐ Make sure to have an emergency preparedness kit/stock up on food, water, and batteries (4)
- ☐ Keep an eye on the river (5)

Why would you not take any action? (check all that apply)

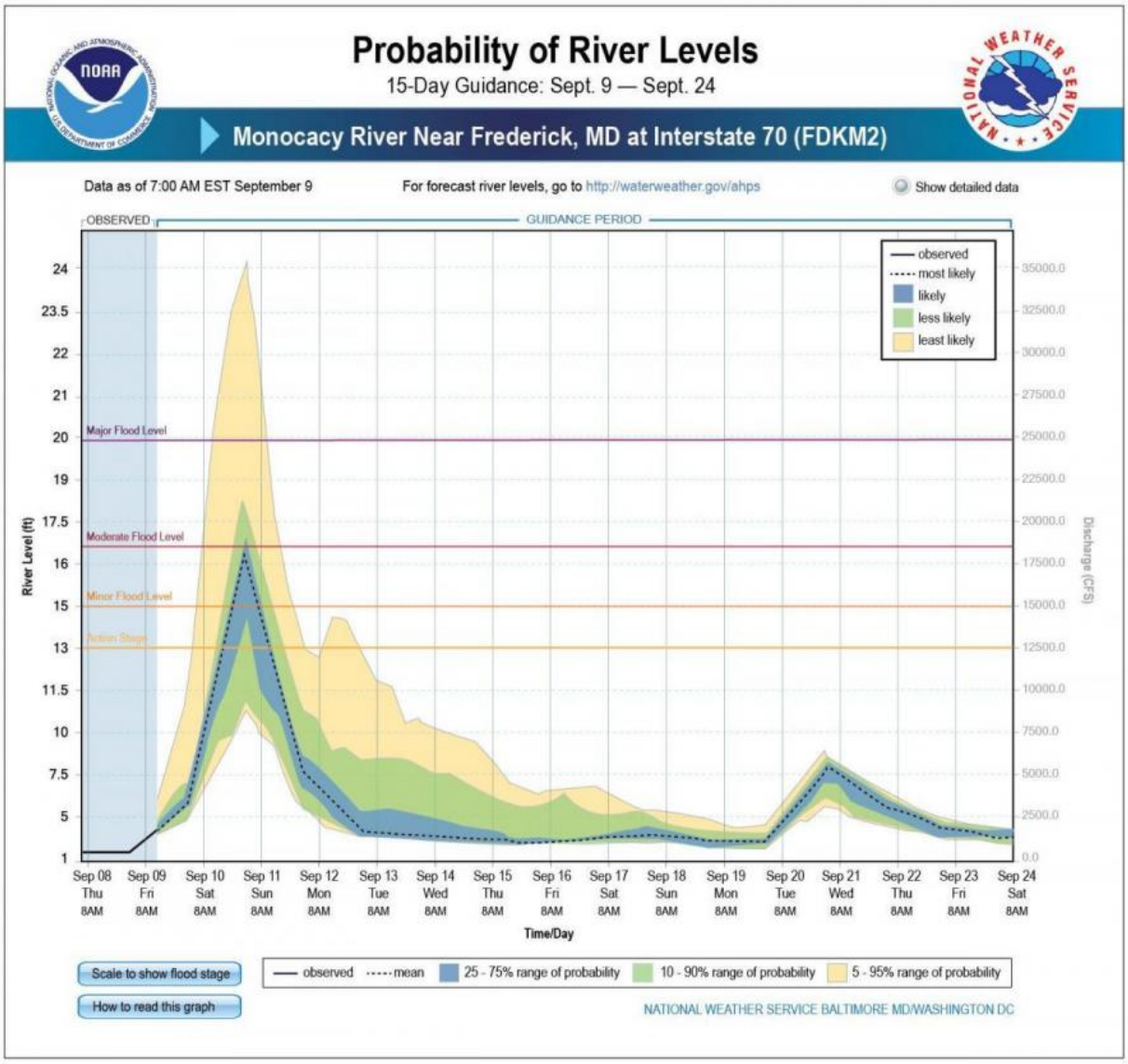
- ☐ I'm not concerned about flooding risk (1)
- ☐ The information in this product doesn't tell me enough (2)
- ☐ I don't believe the data shown (3)
- ☐ I don't know what actions to take (4)
- ☐ Other (please specify) (5) _____

How useful is this product?

- ○ Very useful (1)
- ○ Somewhat useful (2)
- ○ Neutral (neither useful nor not useful) (3)
- ○ Somewhat not useful (4)
- ○ Not useful at all (5)

How likely are you to use this product in the future?

- ○ Extremely likely (1)
- ○ Somewhat likely (2)
- ○ Neither likely nor unlikely (3)
- ○ Somewhat unlikely (4)
- ○ Extremely unlikely (5)



What elements of this product are most useful in understanding the situation? (check all that apply)

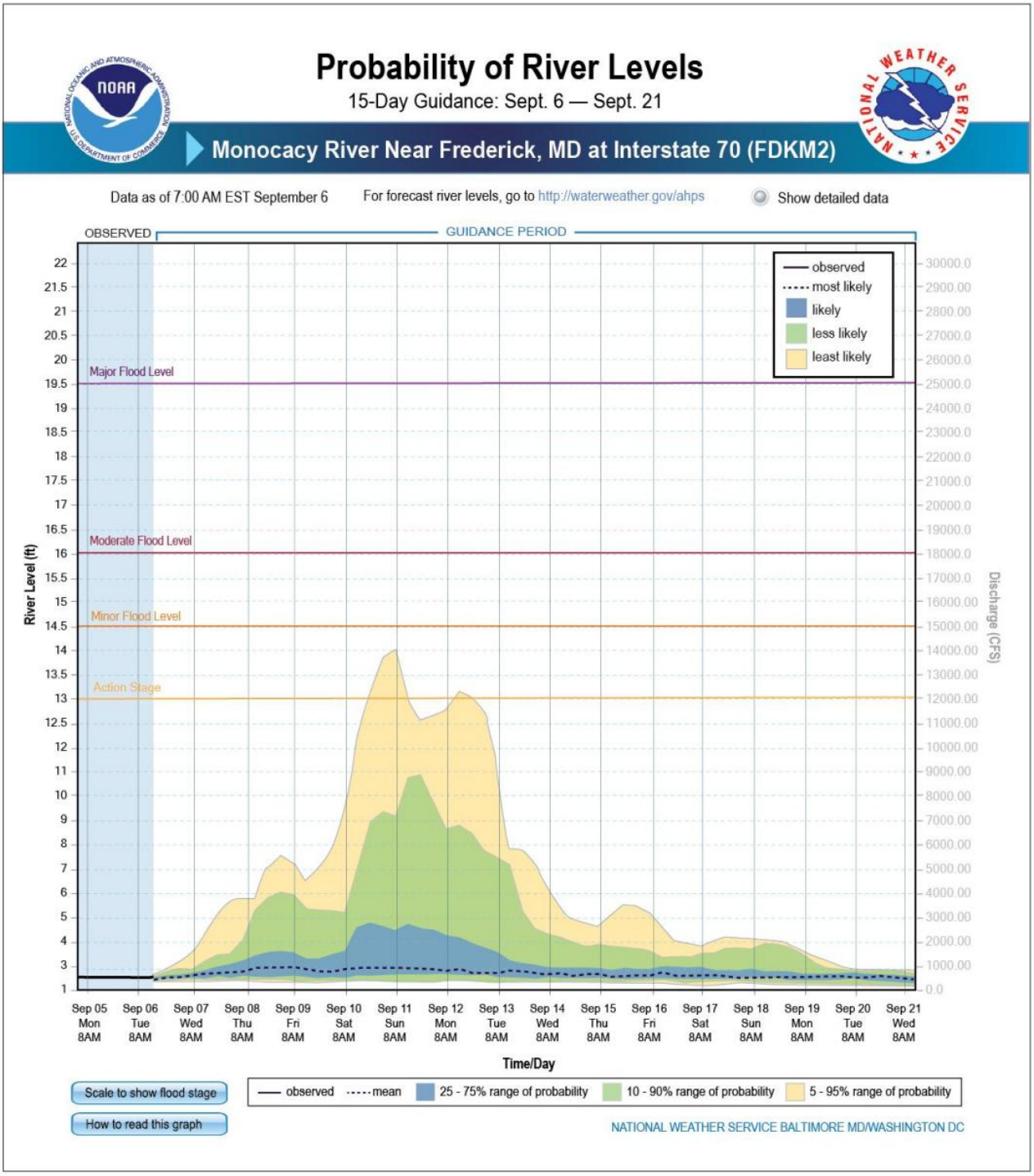
- ☐ Title (1)
- ☐ Legends (2)
- ☐ Colors (3)
- ☐ Percentages (4)
- ☐ Time period (15 day outlook) (5)
- ☐ Flood levels (minor, moderate, major) (6)
- ☐ River level (left axis/side) (7)
- ☐ Discharge (right axis/side) (8)
- ☐ "Most likely" line (9)
- ☐ Range of probable levels (different shades/colors) (10)

What elements of this product are not useful or are confusing to you in understanding the situation? (check all that apply)

- ☐ Title (1)
- ☐ Legends (2)
- ☐ Colors (3)
- ☐ Percentages (4)
- ☐ Time period (15 day outlook) (5)
- ☐ Flood levels (minor, moderate, major) (6)
- ☐ River level (left axis/side) (7)
- ☐ Discharge (right axis/side) (8)
- ☐ "Most likely" line (9)
- ☐ Range of probable levels (different shades/colors) (10)

Why are these elements a problem?

_____


Probability of River Levels
15-Day Guidance: Sept. 6 — Sept. 21
Monocacy River Near Frederick, MD at Interstate 70 (FDKM2)
Data as of 7:00 AM EST September 6
For forecast river levels, go to http://waterweather.gov/ahps
Show detailed data
OBSERVED
GUIDANCE PERIOD
observed
most likely
likely
less likely
least likely
Major Flood Level
Moderate Flood Level
Minor Flood Level
Action Stage
River Level (ft)
Discharge (CFS)
Sep 05 Mon 8AM
Sep 06 Tue 8AM
Sep 07 Wed 8AM
Sep 08 Thu 8AM
Sep 09 Fri 8AM
Sep 10 Sat 8AM
Sep 11 Sun 8AM
Sep 12 Mon 8AM
Sep 13 Tue 8AM
Sep 14 Wed 8AM
Sep 15 Thu 8AM
Sep 16 Fri 8AM
Sep 17 Sat 8AM
Sep 18 Sun 8AM
Sep 19 Mon 8AM
Sep 20 Tue 8AM
Sep 21 Wed 8AM
Time/Day
Scale to show flood stage
How to read this graph
observed
mean
25 - 75% range of probability
10 - 90% range of probability
5 - 95% range of probability
NATIONAL WEATHER SERVICE BALTIMORE MD/WASHINGTON DC

What is this product telling you? (select all that apply)

- ☐ The river level will be between 1 and 3 feet for 2 weeks starting on September 6th (1)
- ☐ There is a high probability of moderate flooding on September 11th (2)
- ☐ There is high confidence that there will be low river levels September 10-12th (3)
- ☐ There is a possibility of minor flooding on September 11th but there is a low chance of it happening (4)
- ☐ Other (please specify) (5) _____

After looking at this graphic, how do you view the risk of flooding in the time period from September 10-11th?

- ○ Very high (1)
- ○ Somewhat high (2)
- ○ Neither high nor low (3)
- ○ Somewhat low (4)
- ○ Very low (5)

Would you take any actions as a result of this product?

- ○ Yes (1)
- ○ No (2)

Why would you not take any action? (check all that apply)

- ☐ I'm not concerned about flooding risk (1)
- ☐ The information in this product doesn't tell me enough (2)
- ☐ I don't believe the data shown (3)
- ☐ I don't know what actions to take (4)
- ☐ Other (5) _____

What actions would you take as a result of this product? (check all that apply)

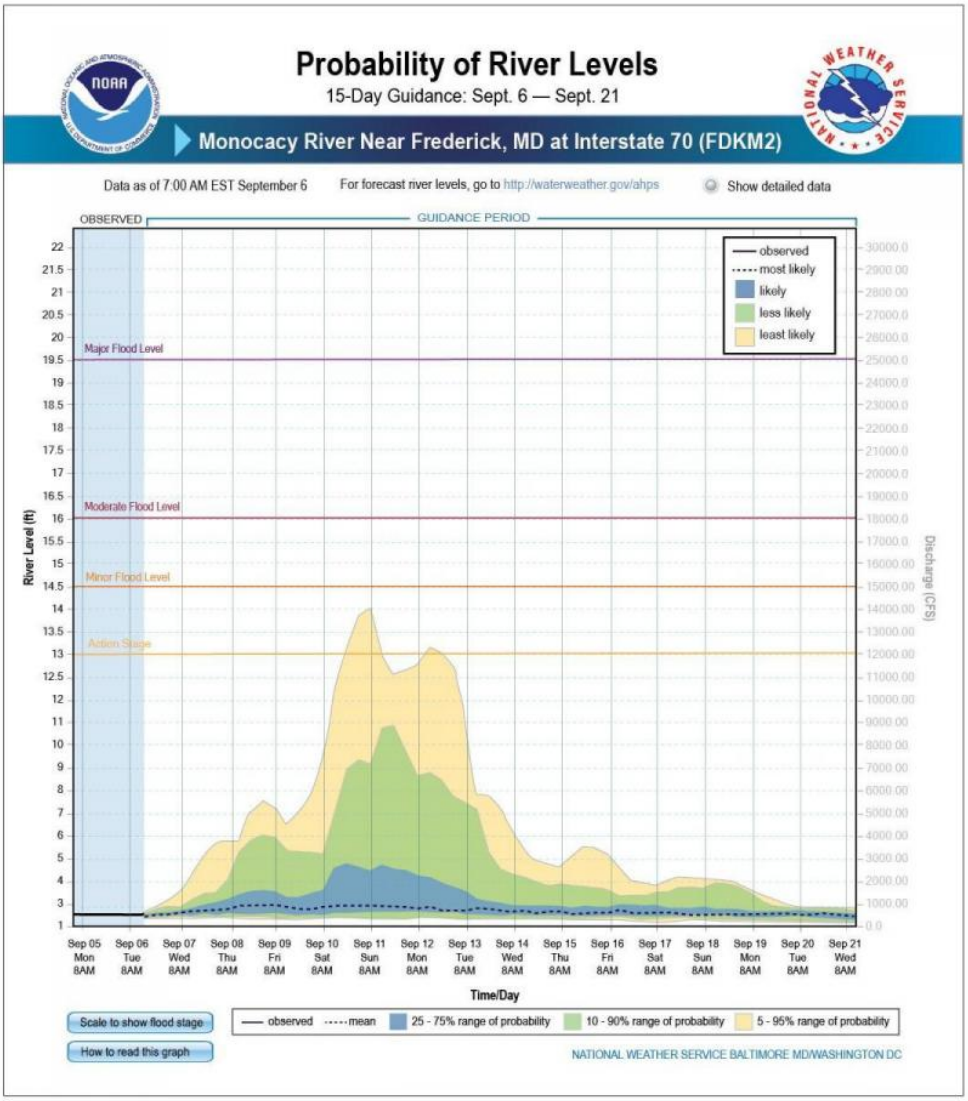
- ☐ Seek out more information (1)
- ☐ Talk to friends, family, and neighbors (2)
- ☐ Take action to secure outdoor property and reduce property loss from flooding (3)
- ☐ Make sure to have an emergency preparedness kit/stock up on food, water, and batteries (4)
- ☐ Keep an eye on the river (5)

How useful is this product?

- ○ Very useful (1)
- ○ Somewhat useful (2)
- ○ Neutral (neither useful nor not useful) (3)
- ○ Somewhat not useful (4)
- ○ Not useful (5)

How likely are you to use this product in the future?

- ○ Extremely likely (1)
- ○ Somewhat likely (2)
- ○ Neither likely nor unlikely (3)
- ○ Somewhat unlikely (4)
- ○ Extremely unlikely (5)



Vhat elements of this product are most useful in understanding the situation? (check all that apply)

- ☐ Title (1)
- ☐ Legends (2)
- ☐ Colors (3)
- ☐ Percentages (4)
- ☐ Time period (15 day outlook) (5)
- ☐ Flood levels (minor, moderate, and major) (6)
- ☐ River level (left axis/side) (7)
- ☐ Discharge (right axis/side) (8)
- ☐ "Most likely" line (9)
- ☐ Range of probable levels (different shades/colors) (10)

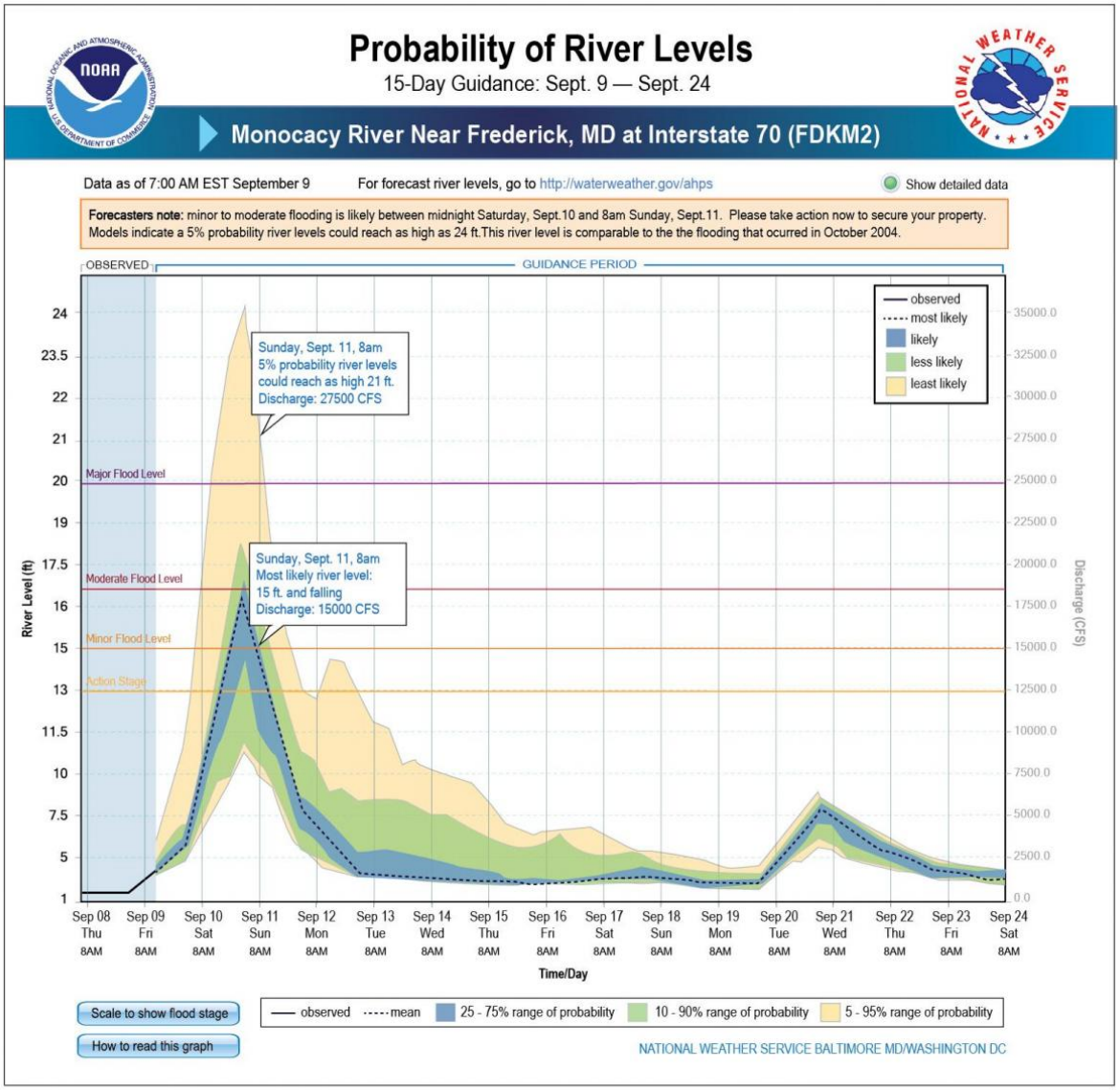
Vhat elements of this product are not useful or are confusing to you in understanding the situation? :heck all that apply)

- ☐ Title (1)
- ☐ Legends (2)
- ☐ Colors (3)
- ☐ Percentages (4)
- ☐ Time period (15 day outlook) (5)
- ☐ Flood levels (minor, moderate, and major) (6)
- ☐ River level (left axis/side) (7)
- ☐ Discharge (right axis/side) (8)
- ☐ “Most likely” line (9)
- ☐ Range of probable levels (different shades/colors) (10)

Vhy are these elements a problem?

_____

The graphic below presents some additional information that **may** be available in the future, including a forecaster's note and an ability to hover over a location on the graph for additional information.
A few questions follow the graphic.



With regard to the Forecaster's Note, how useful is the information included?

- ○ Extremely useful (1)
- ○ Very useful (2)
- ○ Moderately useful (3)
- ○ Slightly useful (4)
- ○ Not at all useful (5)

To what extent would the information in the Forecaster's Note influence your decision-making?

- ○ To a very large extent (1)
- ○ To a large extent (2)
- ○ To a moderate extent (3)
- ○ To a small extent (4)
- ○ Not at all (5)

What other information would be useful to you in a Forecaster's Note?

_____

With regard to the text boxes, how useful would this capability be to you?

- ○ Extremely useful (1)
- ○ Very useful (2)
- ○ Moderately useful (3)
- ○ Slightly useful (4)
- ○ Not at all useful (5)

To what extent would the information in the text boxes influence your decision-making?

- ○ To a very large extent (1)
- ○ To a large extent (2)
- ○ To a moderate extent (3)
- ○ To a small extent (4)
- ○ Not at all (5)