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National Hurricane Program Hurricane Evacuation Study Tool End-User Engagement and Usability Analysis

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Abstract

The Hurricane Evacuation Study (HES) Tool prototype is a key component of the Federal Emergency Management Agency (FEMA) National Hurricane Program (NHP) Technology Modernization (TM) effort. To ensure the HES Tool captured the necessary capabilities and functionality, engagement with potential end-users and key stakeholders was considered a priority throughout development. Pilot studies with representatives from North Carolina and New York City were done to validate the HES Tool process with their current HES undertaking. These pilot studies let the development of additional capabilities and feedback on the needs of diverse regions. A usability study was carried out with key stakeholders identified by NHP leadership through individualized sessions with identified personnel. The results showed the value of the HES Tool compared to the current process as well as key issues that must be addressed to ensure a final transition.

ACKNOWLEDGMENTS

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NOMENCLATURE

DOE	Department of Energy
FEMA	Federal Emergency Management Agency
HES	Hurricane Evacuation Study
ICCOH	Interagency Coordinating Committee on Hurricanes
mph	Miles per hour
NC	North Carolina
NHP	National Hurricane Program
NYC	New York City
SNL	Sandia National Laboratories
TM	Technology Modernization
USACE	United States Army Corps of Engineers

1. INTRODUCTION

The Federal Emergency Management Agency (FEMA) National Hurricane Program (NHP) Technology Modernization (TM) effort represents a major opportunity for the NHP to improve on their current processes. The Hurricane Evacuation Study (HES) Tool prototype, a software tool for running through a complete HES, is a key component of the TM effort. While the technical capabilities of the HES Tool were the primary focus during development, the usability of the tool was a known priority. The NHP gap analysis report identified that usability of current tools for hurricane response, such as HURREVAC, was a known issue that may prevent its effective use [1]. The approach represented in this document encompasses a larger view of usability to include functionality, user-interface, and broader views of the application.

By taking into account this different views on usability, should allow increased functionality of the HES Tool as well as a more successful transition. Engaging with potential end-users allows for greater insight into the everyday challenges they encounter during the HES process. There are also challenges in addressing the needs of a diverse regions, from the very urban to very rural. These insights and challenges can then be translated into HES Tool capabilities. Early on in the development process emergency management personnel from North Carolina and New York City initiated discussion on how the HES Tool could be piloted for their area. Using the HES Tool to replicate the processes of these dichotomous regions not only allowed the testing of the tool's capability to generate a HES but to do so in regions with very different needs and approaches. These pilots were also an avenue for collecting end-user perspective on the usability of the HES Tool.

To then understand how the HES Tool would be integrated on a higher level, a usability study was carried out involving key stakeholders within the NHP. These stakeholders represented FEMA regional hurricane program managers, United States Corps of Army Engineers (USACE) HES Study leaders, and select leaders in the field of HESs such as certain state and local emergency managers. The usability study allowed for these stakeholders to have an individualized session with the HES Tool to address issues with the current HES Tool and its future capabilities. This also provided the perspective of those who will likely implement the HES Tool and be key to its transition.

1. PILOT STUDIES

Pilot studies for the HES tool were initiated by participants of the TM working group from the New York City Office of Emergency Management and North Carolina Emergency Management. Both New York City and the North Carolina were in the process of updating their respective hurricane evacuation studies. This provided an opportunity to evaluate the various features of the HES tool to ensure the tool captures the same information used by each organization. These two regions represented additional unique opportunities due to their dichotomous nature as coastal North Carolina represented a mostly rural area while New York City is a heavy urban environment. This was also beneficial for each locality as it gave the potential end-users the opportunity to interact with the tool and provide their feedback. Florida state emergency managers were later engaged to specifically focus on the HES tool's transportation analysis capability. Each locality was very supportive through the entire process and readily provided their documentation when requested.

2.1. North Carolina

2.1.1. Assumptions and Analysis

The current published HES for North Carolina (NC) was published in 2000 [2], but NC did provide an updated behavioral and vulnerability analysis [3, 4]. These reports provided some of the necessary input data for the HES Tool, for example, the behavioral assumptions used to complete a transportation analysis. An example of the evacuation zones and storm surge provided by the NC HES is shown in Figure 1 [4]. Using the HES Tool, the evacuated area was determined by finding the census blocks affected by storm surge flooding from a MOM. Evacuation behavioral parameters were then applied to these census blocks and then passed through the RtePM model for the transportation analysis. The outcome of each of these runs was a clearance time, evacuation road network, and end points.

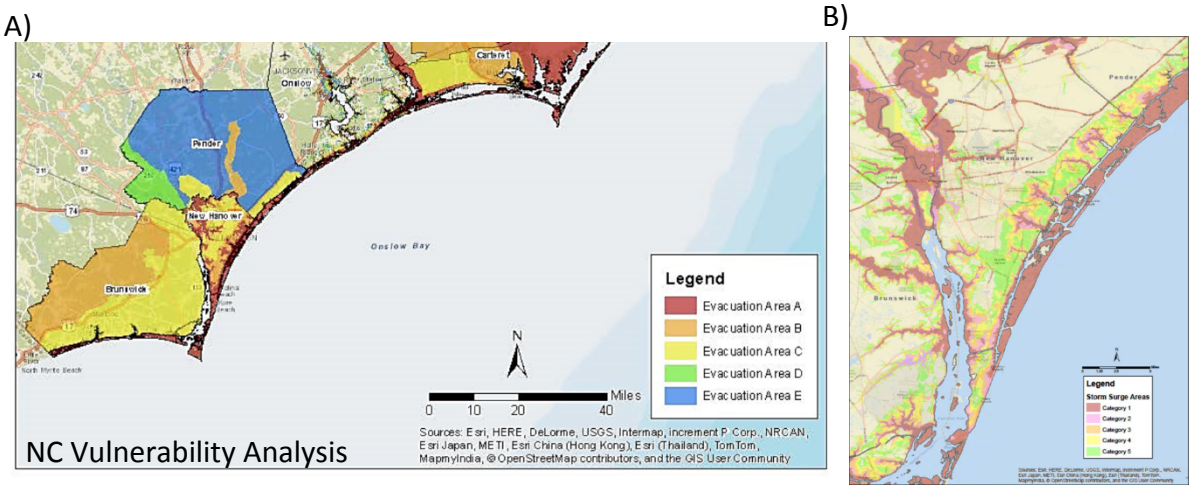


Figure 1. Example North Carolina A) Evacuation Zones and B) Storm Surge Flood Risk.

This process of generating a run through the HES tool was repeated for the different parameters shown in Figure 2, which comes from the NC HES published in 2000 [2]. While the same input factors were entered in the tool, it could not be considered a direct comparison to the NC HES values. For example, the HES Tool calculated a clearance time of 10 hours for the Pamlico South region for a case of a category 3 hurricane with low seasonal occupancy, a medium response, and heavy background compared to the 2000 NC HES calculation of 11 hours. Differences can be accounted for a variety of reasons including the population in the region has changed since 2000, the exact evacuation zone could not be uploaded into the tool, and the use of a different transportation model. The goal of the completed runs with the HES Tool were to drive engagement with the end-users, who in this case were members of the NC Department of Public Safety (DPS), Division of Emergency Management (DoEM).

	Low Seasonal Occupancy		High Seasonal Occupancy	
	Light Background	Heavy Background	Light Background	Heavy Background
Category 1-2				
Rapid Response	6 1/4	7	10 3/4	12 1/4
Medium Response	8 1/2	8 1/2	11	13 1/4
Long Response	11 1/2	11 1/2	11 1/4	14 1/2
Worst Household Commute Time:	1 to 1 3/4 hours		1 1/2 to 4 hours	
Category 3				
Rapid Response	9 1/2	10 1/2	14 3/4	16 1/4
Medium Response	9 1/2	11	14 3/4	17
Long Response	11 1/2	11 1/2	15 1/4	18 1/4
Worst Household Commute Time:	1 to 3 1/2 hours		2 1/4 to 6 hours	
Category 4-5				
Rapid Response	12 1/4	13	17 1/2	18 1/2
Medium Response	12 1/4	13 3/4	17 1/2	19 3/4
Long Response	12 1/2	14	17 3/4	20 3/4
Worst Household Commute Time:	1 1/2 to 4 3/4 hours		3 to 7 1/2 hours	

McDuffie, A; NC Hurricane Evacuation Restudy, 2002

Figure 2. Sample of Clearance Times from NC HES for Pamlico South region.

2.1.2. On-site Feedback

The HES Tool was demoed to members of the NC DPS, DoEM on August 25, 2015. Those in attendance represented a variety of organizations, including the NC DoEM and USACE, as well as different roles including the Director and Deputy Director of NC DoEM, a GIS specialist, a meteorologist, and HES study managers from USACE. The discussion first focused on the HES process itself and revealed the specific approach that North Carolina takes. For instance, while the NC HES showed detailed evacuation zones, early feedback indicated that in practicality, entire counties would be ordered to evacuate. Results from the HES Tool run were then presented to the group, such as the example shown in Figure 3. When the results from these HES Tool runs were presented, there was general agreement within the group on the results. There was also interest in how this tool can be used to model the effects of neighboring states on the evacuation process, such evacuating the northern coast of North Carolina at the same time as the Virginia Beach area. During discussions on using a current model embedded in the HES Tool that uses a national database, there was strong feedback on the matter of how the tool approaches critical infrastructure and the shelter database. The representatives from the NC DoEM highlighted their need to upload their own list of critical infrastructure and shelters as they keep a detailed, running list. This critical infrastructure data was later provided to be used as a case

study for a future capability of user-defined critical infrastructure. The resulting model is labeled "User Data Infrastructure Effects Under Threat Contours". This is an example of the creation of a new HES tool capability that was based on a combination of a known HES requirement and end-user engagement on their implementation processes.

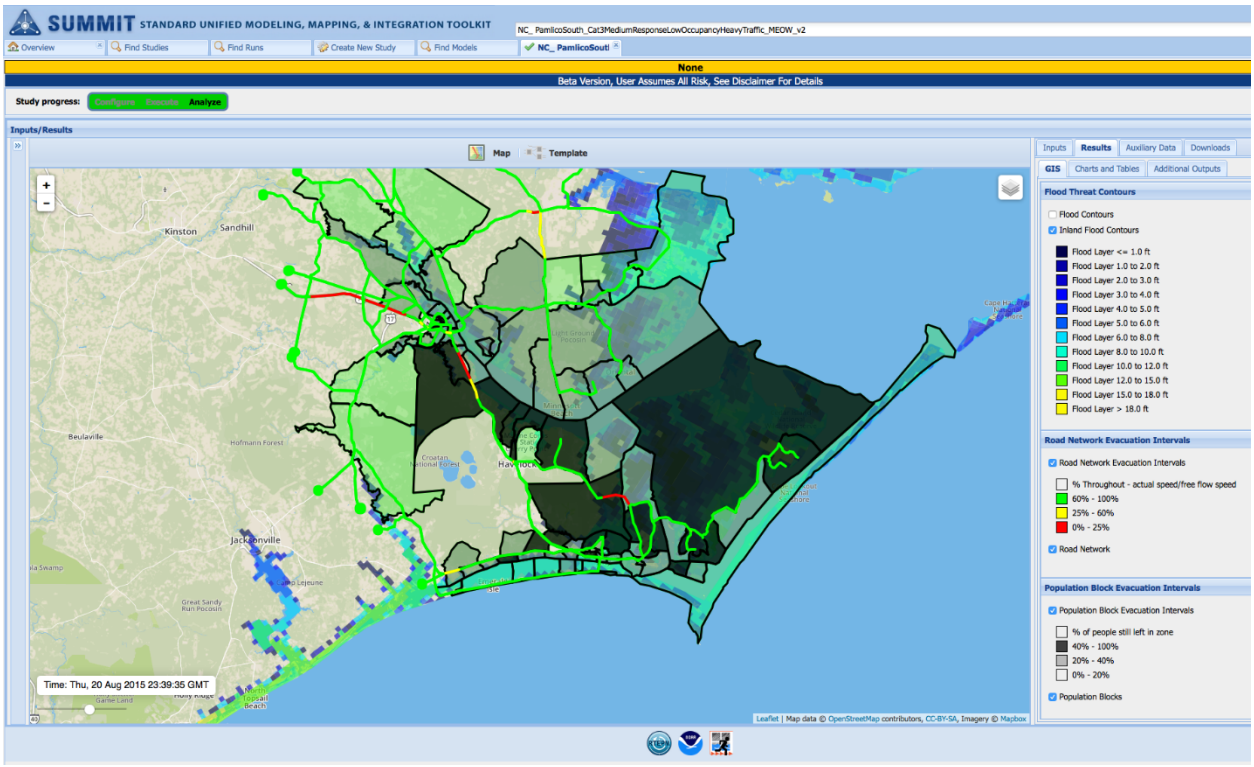
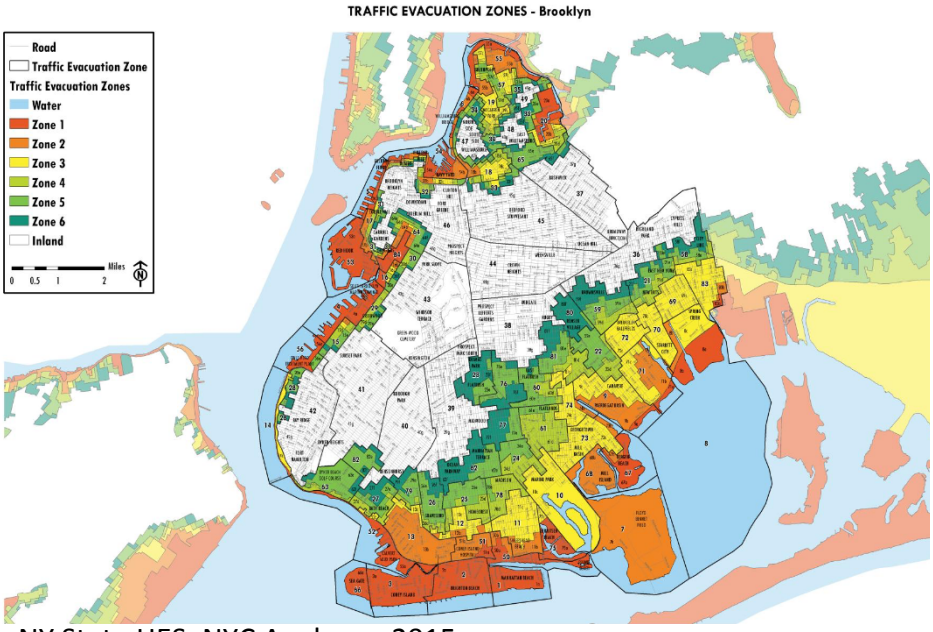


Figure 3. Example of HES Tool run for Pamlico South region.

2.2. New York City

2.2.1. Assumptions and Analysis

New York City's (NYC) most recent complete HES was published in 2009 as part of a larger study for the state of New York. [5] NYC received an updated transportation analysis in mid-2015. [6] An example of the updated evacuation zones for the Brooklyn borough, along with illustrating their approach for determining traffic evacuation zones (TEZ), is shown below in Figure 4, from the updated 2015 NYC transportation analysis[6]. Due to their recent HES updates and the focus area on a single city, there was a large amount of very specific data to pull from to utilize in the HES Tool. However, the information available was sometimes too detailed for the HES Tool to accommodate. For instance, detailed behavioral information was available according to income level within a TEZ, but the HES Tool is unable to account for income. The transportation analysis also included separate clearance times for those evacuating to a point within the borough compared to those exiting the region completely. Detailed information on the utilization of public transportation, such as estimated number of riders for each bus route, was also provided. [6] However the HES Tool only partially accounts for public transportation.



NY State HES: NYC Analyses, 2015

Figure 4. Example of New York City Evacuation Zones for Brooklyn.

To account for this high level of detail in the HES Tool, averages were taken for each borough for a subset of the behavioral data, such as mode of evacuation. Initial feedback from NYC highlighted their move towards using MEOWs instead of MOMs due to the type of storms that are typical for their region. For the initial test of the HES Tool for NYC, a MEOW for a Category 2 storm, at high tide, a West/NorthWest heading, and forward speed of 20 mph was used. Initially all five boroughs of NYC were selected within the tool determine the number of census blocks and corresponding population needed to evacuate as evacuation zones span the entire city. However, it was soon realized that the transportation model currently used within the HES Tool, RtePM, was not capable of handling a population of that size. While this was not a limitation of the HES Tool, it does highlight a potential challenge of using RtePM on broad scale. The analysis was then focused on the borough of Brooklyn. The average mode of evacuation for Brooklyn is 75% via private vehicle, 20% via public transportation including train, subway, and bus, and 5% via walking/biking. The average number of people per vehicle was 4.4. [6] Figure 5 below, from 2015 NYC Transportation Analysis[6], shows the predicted clearance times for the different evacuation zones for high or low levels of traffic and tourist occupancy. For low tourist occupancy, low traffic levels and along with the values stated previously, the HES Tool predicted a clearance time of 8.2 hours. It is difficult to compare this clearance time with those documented in Figure 5 due to the inability to define evacuation end points, use of inundated areas instead of the evacuation zone, averaging of behavioral response and the use of a different transportation model.

Zone	Heavy Background Traffic		Light Background Traffic	
	Low/High Tourist Occupancy		Low/High Tourist Occupancy	
	Times for Routes Out of NYC/Region	Times for Local Routes Out of Borough TEZs	Times for Routes Out of NYC/Region	Times for Local Routes Out of Borough TEZs
Zone 1	12.4 / 14.2	17.7 / 18.2	5.7 / 7.4	12.6 / 13.1
Zone 2	15.1 / 17.4	19.0 / 19.6	8.3 / 10.7	13.9 / 14.4
Zone 3	18.8 / 21.4	21.7 / 22.2	12.0 / 14.6	16.6 / 17.1
Zone 4	22.4 / 25.3	24.5 / 25.1	15.7 / 18.5	19.4 / 20.0
Zone 5	24.2 / 27.1	27.3 / 27.8	17.5 / 20.4	22.1 / 22.7
Zone 6	26.0 / 28.9	27.7 / 28.3	19.3 / 22.2	22.6 / 23.2

NY State HES: NYC Analyses 2015

Figure 5. New York City Clearance Times for Brooklyn for 100% participation.

2.2.2. On-Site Feedback

The HES Tool, utilizing the parameters listed above, was demoed to representatives from the NYC Office of Emergency Management (OEM), USACE, and FEMA in October 2015. Most of the representatives from NYC OEM were members of the Geographical Information Systems (GIS) office. At this time, additional information was learned about their current process and general approach, especially in light of the recent storms, Hurricane Irene and Hurricane Sandy, affecting their area. For instance, there was discussion on their process for initially evacuating vulnerable populations from hospitals and nursing homes. This would imply they may utilize the tool to run multiple evacuation scenarios to determine a clearance time for only the vulnerable population separate from the clearance time for the remaining population. More was learned about how the public transportation system is incorporating into their response plan. In this case the evacuation order must be given with enough lead time for those who will utilize public transportation as the mass transit system is shut down 8 hours before the onset of storm hazard. There was also discussion on the feasibility of incorporated the method of tracking the status of each train and bus during an evacuation. While the discussion of real-time tracking capabilities falls somewhat outside the scope of a planning tool and would be more applicable as a response capability, it still provided insight into the priorities of this particular potential end-user. In response to the HES Tool demo, the need to still apply behavioral information according to an additional classifier, in their case by median income, was stressed as need. This requirement translates to the capability of multiple user-defined evacuation zones that may overlap one another to apply different inputs over the same area. There was a very positive response to the transportation model's capability to display anticipated congestion during the evacuation process. While this same capability was captured in their most recent transportation analysis (Figure 6A), the HES Tool enables the user to view anticipated traffic congestion for each time point during the evacuation (Figure 6B).

A) B)

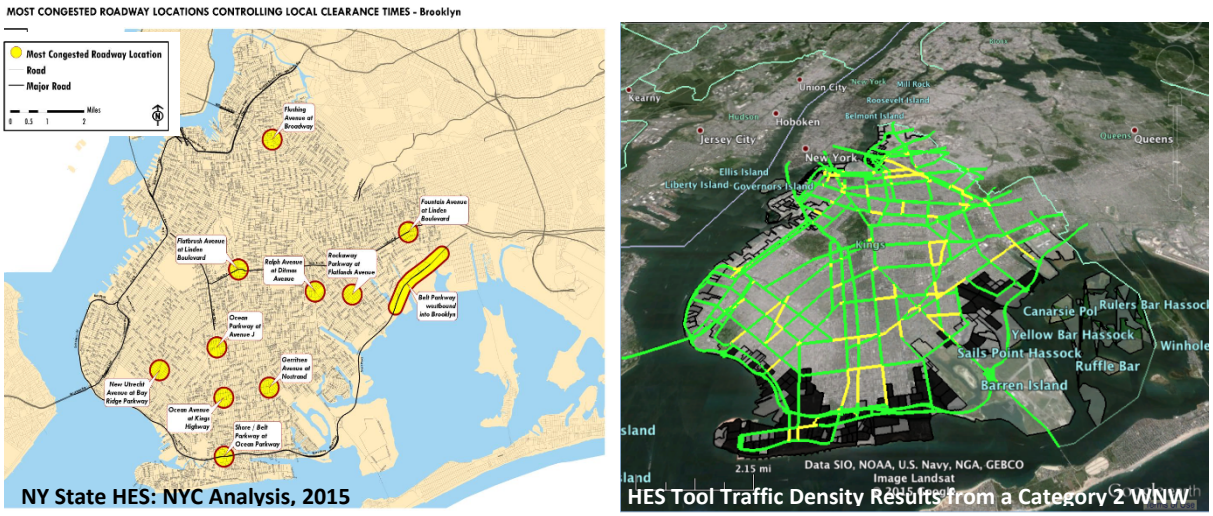


Figure 6. Comparison of Project Traffic Congestion from A) NYC HES and B) HES Tool Simulation.

2.3. Outcomes

The two pilots of the HES Tool with NC and NYC provided an important opportunity to engage with potential end-users to not only learn about HES planning approaches for two unique regions but to also identify potential gaps within the current tool. The identification of these gaps early on in the development process allowed for the generation of new capabilities, including the "User Data Infrastructure Effects Under Threat Contours" model and the "Polygon Multiple Evacuation Zone Generator" model. Upon displaying the process and outputs of each region specific demo of the HES Tool, there was general consensus and buy-in from the stakeholders present. Key factors that were consistently well-received included the speed of the tool when completing a run, the tracking and display of the transportation analysis results over time, and the ability to easily change an input for new runs. There were some concerns on the usability of the HES Tool in its current form due to the challenging user-interface, and was understandable as the HES Tool at the time of each demo was still in a beta/researcher format. This feedback on the user-interface was valuable in designing the future usability analysis as well as framing future discussions with additional end-users.

2. USABILITY STUDY

Through initial conversations with potential end-users for the HES tool, the issue of the usability of the HES Tool became apparent and needed to be addressed through a systemic approach. It was determined by DHS S&T and NHP leadership that a usability study would be carried out at the 2016 Interagency Coordinating Committee on Hurricanes (ICCOH) meeting in North Carolina. The goals of this study would be:

1. Inform high level stakeholders on the HES Tool functionality
2. Determine possible missing functionality
3. Determine the usability of the HES Tool from the stakeholder, and potential end-user perspective

To accomplish these goals, individual sessions with personnel identified by NHP leadership were arranged to occur during the 2016 ICCOH meetings. Sample mock-ups for the proposed HES Tool user-interface were generated to guide the discussion along with the current HES Tool prototype. Finally, a survey was given to each participant following the individual session to further ascertain their views on the HES Tool and its potential.

3.1. Approach

3.1.1. User-Interface Mock-ups

As one of the goals of the usability study was to determine the usability from the stakeholder and end-user perspective, samples mock-ups depicting the proposed HES Tool user-interface were generated (Appendix A: User-Interface Mock-Up). These mock-ups are meant to present a view of how the tool could look to the final end-users and to provide general guidelines for the tool's user-interface design rather than strict requirements. When generating these mock-ups, feedback was incorporated from previous discussions with key stakeholders and potential end-users through the pilot program and TM working groups. A sample of these mock-ups is provided below. Figure 7 displays a screen shot of a potential user-interface for inputting data associated with the vulnerability analysis. The ability of the HES Tool to generate an entire library of runs by varying the amount of inputs for each variable is reflected in multiple boxes checked under "Infrastructure" and "Category". This signifies to the user that an individual run will be completed to account for every possible combination of the variables checked. Part of the initial feedback included the importance of not overwhelming the end-user with multiple inputs which is why each analysis component is provided as a drop down menu.

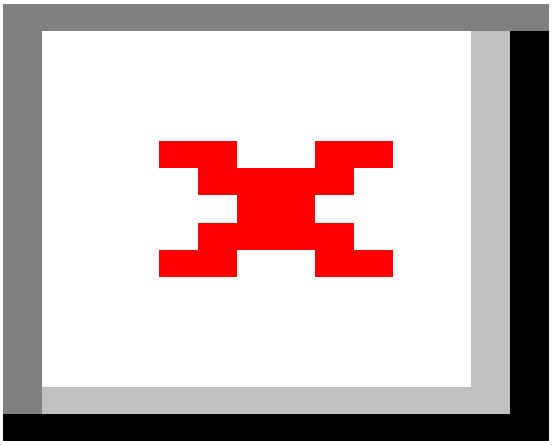


Figure 7. Sample user-interface mock-up for inputs to vulnerability analysis

Sample mock-ups for the vulnerability analysis output are provided in Figure 8. Check-boxes are again used to display the selected outputs on each graph. In the given example, demographic data, specifically the population density of households with a member over the age of 65, from the databases originally selected from the inputs can now be visualized on the map. Additional data layers from different HES analyses, such as the storm surge inundation from the hazard analysis, can also be overlaid onto the map at the same time. These mock-ups provided a framework for discussion with participants during the individual sessions.

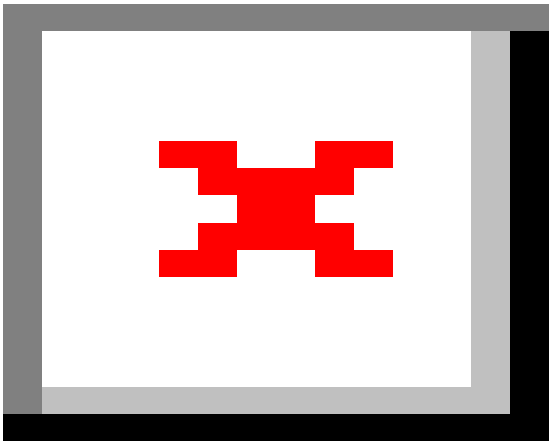


Figure 8. Sample user-interface mock-up for outputs of vulnerability analysis

3.1.2. Individual Sessions

To ensure feedback from key stakeholders was achieved, a list of individuals was provided by Christopher Penney, the NHP Program Manager at FEMA. The list of suggested names was comprised mostly of FEMA and USACE personnel along with additional experts in the hurricane evacuation study field. All participants were contacted prior to ICCOH to arrange individual sessions. The complete list of individual, along with their organizations, who participated in usability analysis in person at ICCOH are listed below in Table 1.

Table 1. Usability Analysis Participants

FEMA	USACE	State and County Officials and Other Organizations (i.e. Red Cross)
Brice Acosta (Region II)	Colton Bowles (Charleston)	Jeff Alexander (St. Johns County)
John "J.D." Boesch (Region VI)	Don Cresitello (New York)	Chris Moore (TX)
Brandon Bolinksi (Region IV)	Ashleigh Fountain (Jacksonville)	Rick Schofield (Red Cross)
Victor Dejesus (Region IX)	Jazon Glazener (Wilmington)	Andrew Sussman (FL)
Rebecca Jennings (Region IV)	Erik Karlkvist (Philadelphia)	John Wilson (Governor's Hurricane Conf.)
Rob Mahoney (HQ)	Ed Mason (Galveston)	
Paul Morey (Region I)	Paul Moye (Norfolk)	
Dave Odegard (Region III)	Mike Schuster (Baltimore)	

Each session was approximately 30-40 minutes in length. The first 20-30 minutes of each session focused on the HES Tool and it's features. As some participants had previous experience with the HES Tool, such as through the pilot studies or prior working groups, each of the participants was given the option of working through the current tool or the sample mock-ups. Throughout the session, participants provided feedback on various aspects of the tool, either from their perspective or how they anticipated their local stakeholders would view the tool. The final 10 minutes was left for the participant to complete an anonymous survey.

3.1.3. Survey

An anonymous survey was used following each session to understand prior familiarity, understanding of current functionality, and potential usability of the HES Tool. The complete list of questions is given below in Table 2. Each question was rated by the participants using a Likert scale of 1 (not very) to 5 (very much). Additional fields were provided for the participants to list comments and provide their "years in experience with HES planning". It was left to the participant to determine what determined as experience in HES planning, where interpretation of experience in HES planning was left open to the participant and in some cases, may have been perceived as general emergency management experience.

Table 2: List of survey questions used in usability study

Usability Study Survey Questions	
Familiarity	How familiar were you with the HES Tool before today's session?
HES Tool Functionality	How well does the tool utilize information for a traditional Hazard analysis?
	How well does the tool utilize information from a traditional Behavioral analysis?
	How well does the tool utilize and display information for a traditional Vulnerability analysis?
	How well does the tool utilize and display information for a traditional Shelter analysis?
	How well does the tool utilize and display information for a traditional Transportation analysis?
Usability	How comfortable do you feel with the tool after today's session?
	How satisfied do you feel with the tool after today's session?
	How applicable do you see the HES Tool for support of HES generation?

3.2. Analysis

Data from each session came in the form of the direct feedback from participants during each session in addition to the survey results. While the overall feedback was generally positive, especially at the idea of a flexible tool capable of generating useful results quickly, there were areas identified for future improvement.

3.2.1. User Feedback

A consistent form of feedback was the general appreciation in the efforts to continually reach out to the community for feedback regarding the HES Tool. Participants also generally looked "forward to using the tool". As the HES Tool enables users to easily share runs between other users, the collaborative nature of the tool was another key functionality that was consistently highlighted. In light of this collaboration functionality, it was also appreciated that the mock-ups showed how access control could be implemented. In this case, certain users may have administrator privileges while others may only have read-and-approval access. To quote one participant, "I really think this tool will be valuable to the NHP and its ability to conduct timely and well collaborated HES data".

Most suggested areas of improvement focused on the HES Tool in its current form. For instance, many comments pertained to how the input fields were arranged and worded. As one participant noted, "The user interface needs to ask specific simple questions and clearly explain how values are quantified". There were additional concerns that the "tool could be intimidating to local emergency managers not familiar with HES and new technology" due to its cluttered and long layout. The need to validate terminology was mentioned when viewing the input and output fields with the current HES Tool. This led to the compilation of all terminology currently used within the HES Tool which was then validated or corrected by NHP leadership. A final list of the decided on terms is presented in Appendix B: HES Tool Terminology.

Another set of comments focused on how the HES Tool shall be transitioned to end-users and into the current HES process. For instance, one comment was "still unclear as to how the HES tool will improve efficiency". There were also additional comments on how the products of the HES Tool shall be used to generate the final HES report, either through generation of graphics alone or the use of a report template. Participants also stressed the importance of training end-users after deployment of the HES Tool with one comment specifically pointing out "the managers (USACE) will need to know how to use this tool in a very productive manner". A complete list of the feedback received is provided in Appendix C: Usability Study Direct Comments.

3.2.2. Survey Analysis

In addition to the comments from the survey, the results from the survey itself provided insights to the attitude towards the HES Tool and its future application. The analysis was approached by first summarizing the results for the participants as a whole and then by subgroups. While the survey was anonymous, due to time stamps on each survey, the organization of each survey result could be determined. The name of each participant was not included on any of the survey results.

3.2.2.1. Analysis by general survey results

In total, there were 22 responses to the survey. Most participants had less than 10 years of experience in HES planning with the average at 11.2 years (Figure 9). It should be noted that each participant was responsible for self-reporting what they determined as their years of experience in HES planning.

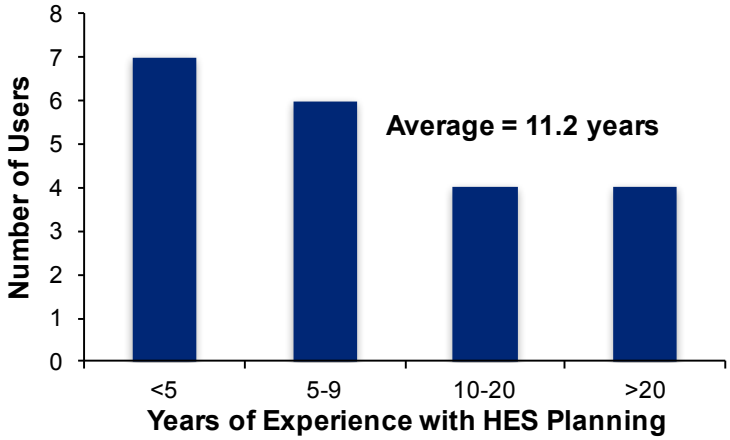


Figure 9. Participant years of experience in HES planning

The level of initial familiarity of the participants with HES Tool, prior to the individual session, was relatively low, with an average of 2.45. The distribution of response can be seen in Figure 10. However, 5 out of the 22 scored their previous familiarity as 4 or higher.

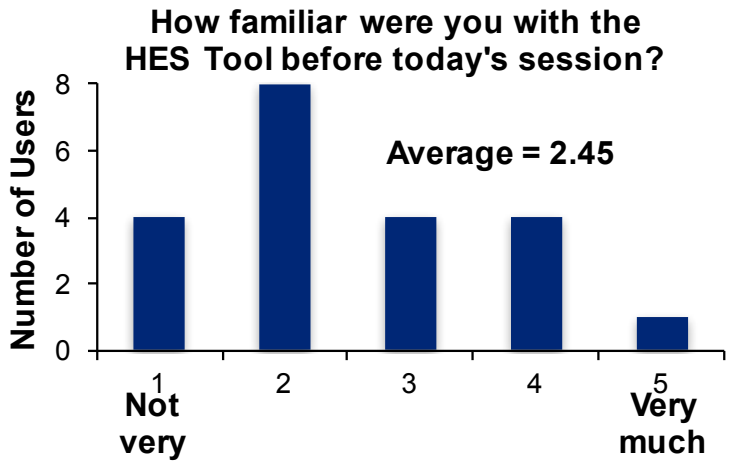


Figure 10. Initial familiarity with the HES Tool

Each participant judged how the current HES Tool utilizes and displays information for each of the traditional HES components (Figure 11). These HES components include: hazard, behavioral, vulnerability, shelter, and transportation analysis. Overall, users felt the current HES Tool best captured a traditional hazard, vulnerability, and transportation analysis. The behavioral and shelter analysis scored slightly lower.

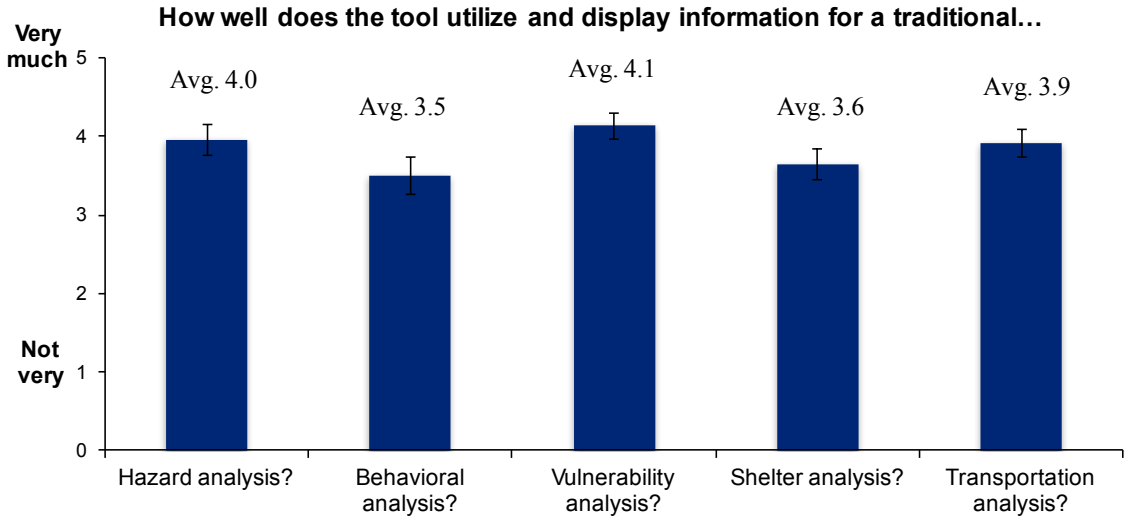


Figure 11. Ability for the HES Tool to utilize and display information for traditional HES components

The final set of questions addressed how the participants felt on the usability session itself as well as the future application of the tool (Figure 12). The overall comfort and satisfaction with the tool received average ratings of 3.3 and 3.6, however this may be explained by the low level of initial experience. Despite these average level rating on the current HES Tool, participants felt the tool would be very applicable (average 4.2) in the support of generating future HESs.

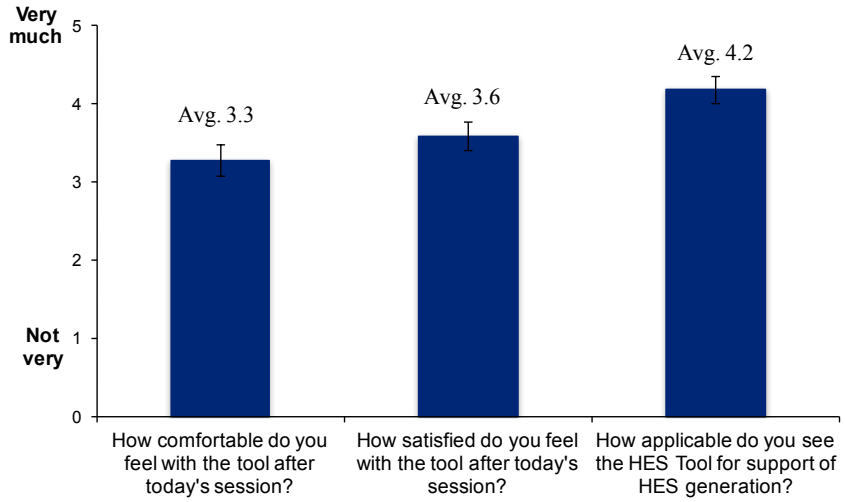


Figure 12. Post-session evaluation of the HES Tool

3.2.2.2. Analysis by initial understanding of the HES Tool

To determine how the participants previous experience with the HES Tool affected their view, the analysis was then repeated according to that familiarity. The average response to each question was the calculated according to how each participant answered the question of "How familiar were you with the HES Tool before today's session?". This initial familiarity did affect how the participants viewed the capability of the HES Tool to utilize and display information for each HES component (Figure 13). Those who had the least and most initial familiarity with the HES Tool were the most satisfied with how the HES Tool utilizes and displays information for each of the HES components.

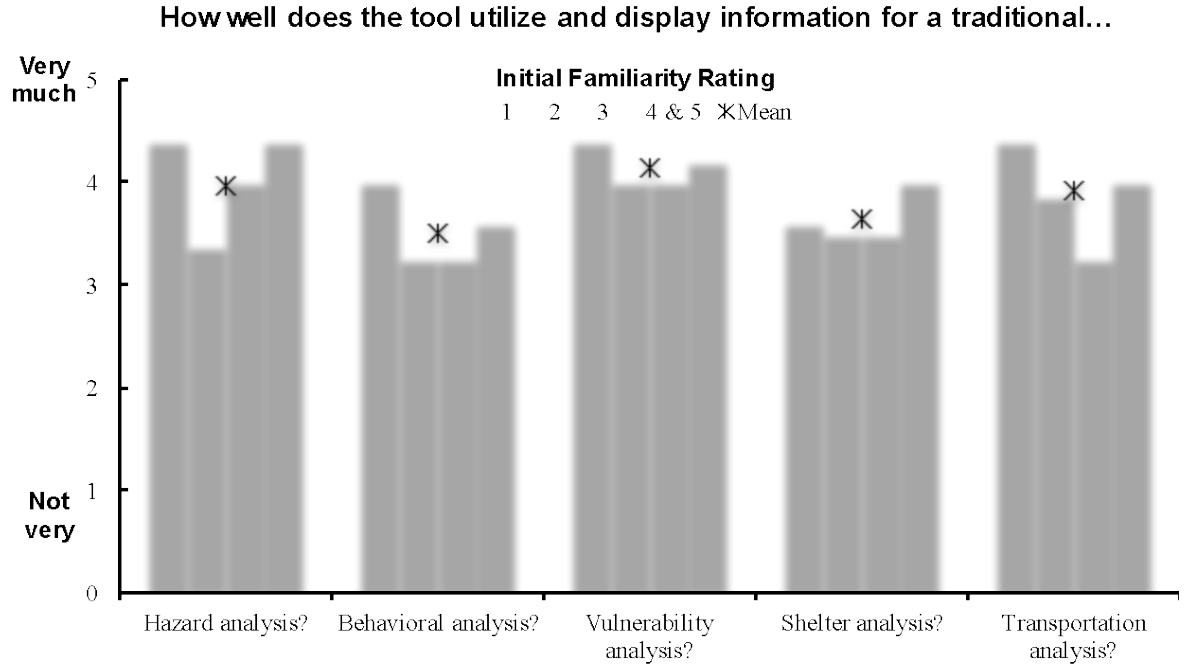


Figure 13. Ability for the HES Tool to utilize and display information for traditional HES components according to initial familiarity rating

There were less differences on the post-session evaluation of the HES Tool based on the initial familiarity rating (Figure 14). The group with the largest difference was found in those with the least familiarity with the HES Tool in regards to their satisfactory with the tool after the session. In this group there was a significant increase as may be expected given their previously minimal experience.

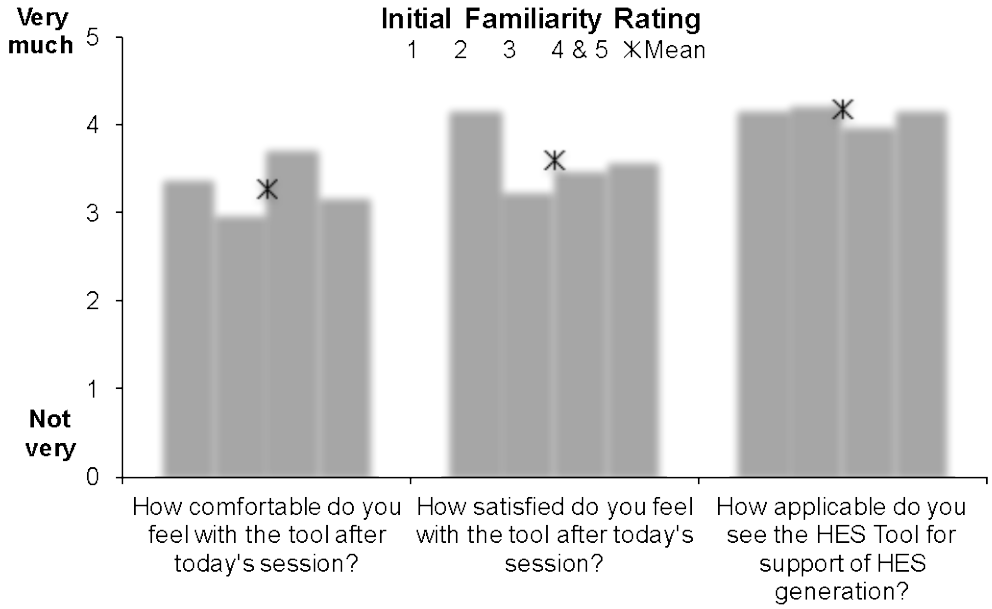


Figure 14. Post-session evaluation of the HES Tool according to initial familiarity rating

3.2.2.3. Analysis by organization

The survey results were also analyzed according to the organization each participant represented as each organization plays a unique role in and certain perspective of the HES process. The participant responses were then divided according to their organization: FEMA, USACE, and EM/Other. The category of "EM/Other" includes state and local emergency managers along with representatives from additional stakeholders such as the Red Cross and Governor's Hurricane Conference. On average, this group of "EM/Other" was most familiar with the HES Tool before the session (Figure 15).

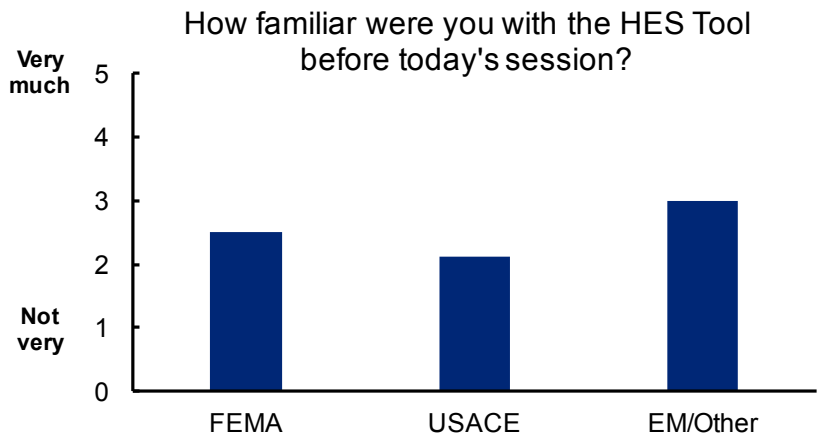


Figure 15. Initial familiarity with the HES Tool according to organization

FEMA personnel showed the greatest difference in views on how the HES Tool utilizes and displays information for the traditional HES components (Figure 16). FEMA personnel were the most satisfied group for how HES Tool currently utilizes the hazard, behavioral, and shelter analysis. Conversely, the EM/Other group tended to be least satisfied with how the current HES Tool utilizes each HES component.

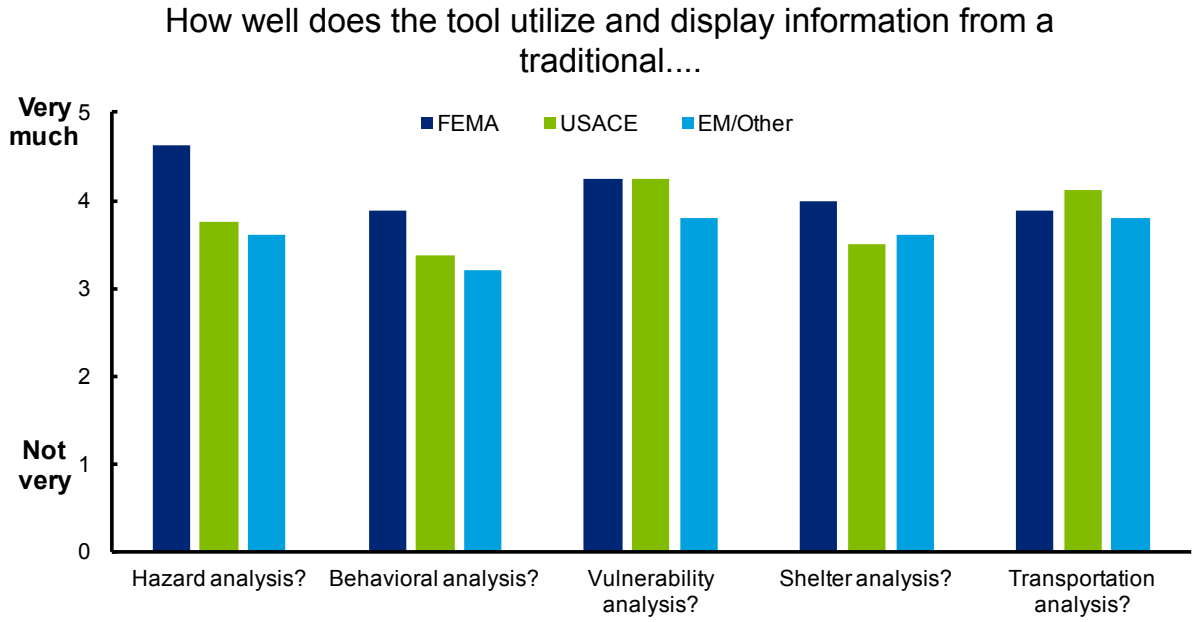


Figure 16. Ability for the HES Tool to utilize and display information for traditional HES components according to organization

In terms of the post-session evaluation (Figure 17), the EM/Other group felt most comfortable with the HES Tool and most applicable for future HES generation. The USACE groups felt the least comfortable with the HES Tool after the individual session, however they scored similar to FEMA and EM/Other groups in having strong positive feels for using the HES Tool to support future HES generation.

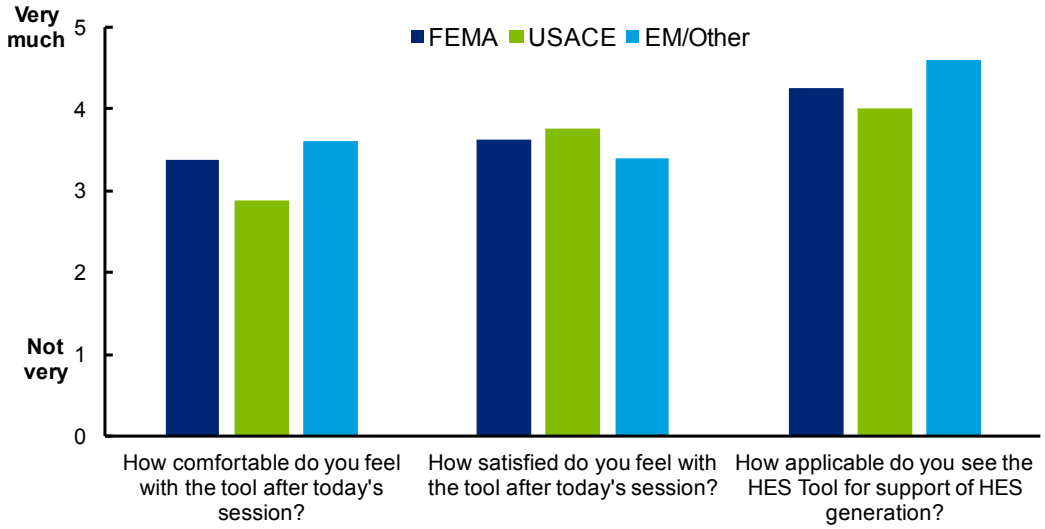


Figure 17. Post-session evaluation of the HES Tool according to organization

3.2.2.4. Analysis by years of experience

The final analysis was categorized responses according to self-reported years of experience in HES planning. Those with >20 and 5-9 years of experience tended to score similarly in terms of how the HES tool utilizes each HES component (Figure 18). These groups also tended to score each of the components the highest compared to the 10-20 years of experience group which tended to score each of the components lower.

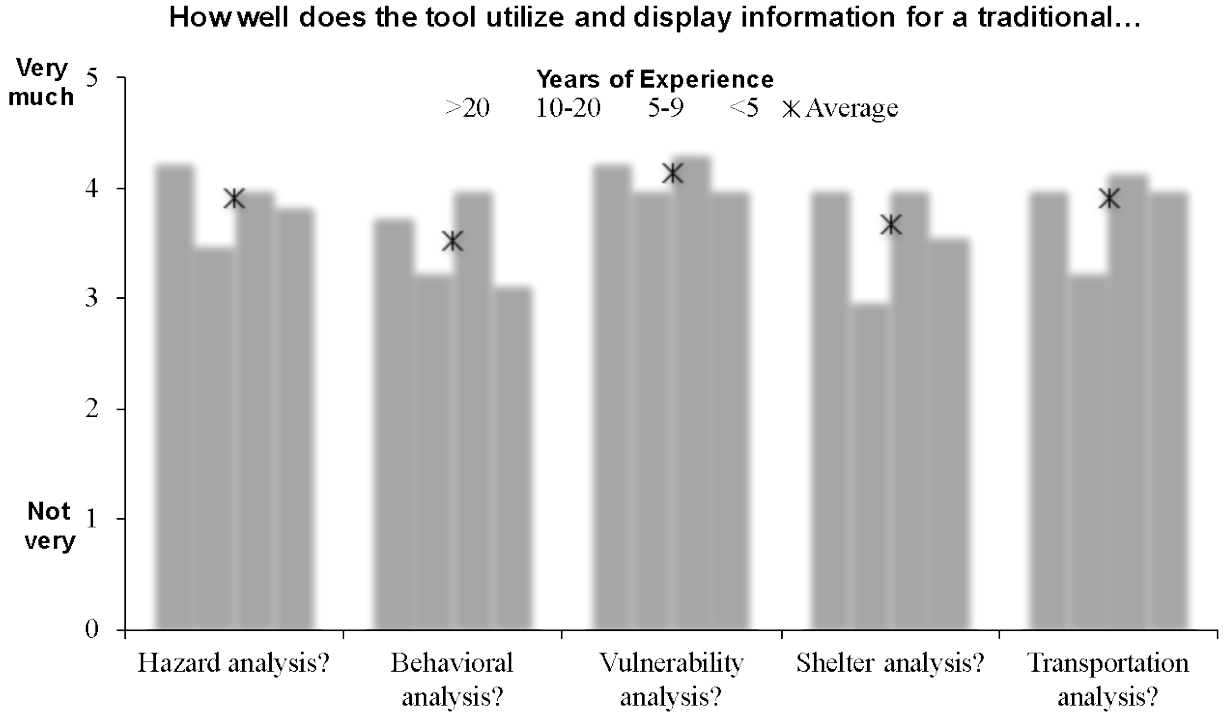


Figure 18. Ability for the HES Tool to utilize and display information for traditional HES components according to years of experience

In terms of post-session evaluation of the HES Tool and its future capabilities (Figure 19), those with >20 years of experience scored each factor the highest. The remaining experience groups scored the HES Tool similarly. However, those with 10-20 years of experience had the most reservations with how applicable the HES Tool will be in future HES generation.

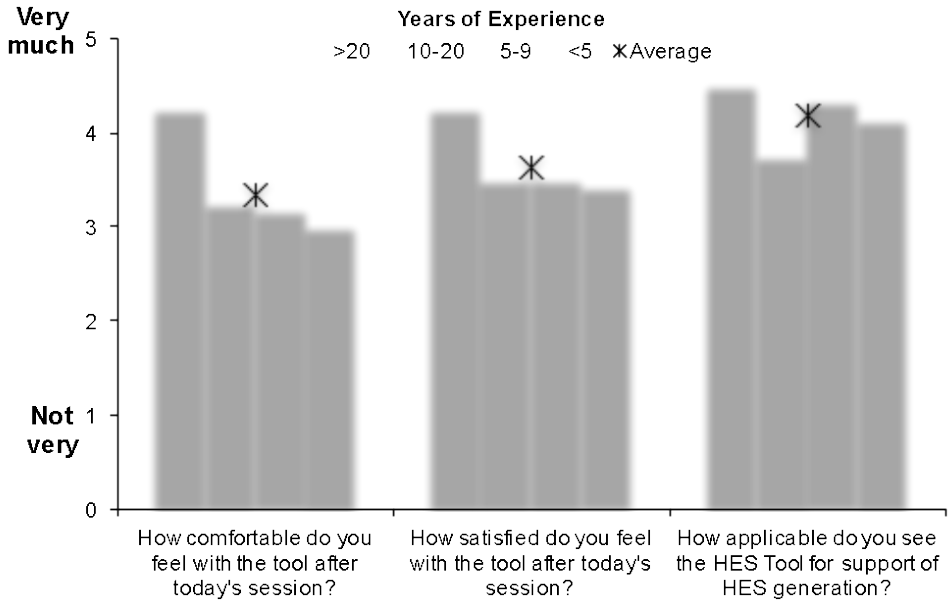


Figure 19. Post-session evaluation of the HES Tool according to years of experience

3.3. Outcomes

The usability session at ICCOH allowed for key stakeholders to engage with the HES Tool in its current form on a personalized level. This individualized engagement allowed for specific feedback related to improvements of the current HES Tool and important factors related to its future transition. Overall feedback was positive for the potential the HES Tool can bring in terms of increased collaboration and speed of analysis. However, there were concerns on how the HES Tool will fit within the current HES process along with how the training and transition for the tool will be carried out.

Analysis of the usability survey enabled a quantifiable approach to judging how different user groups viewed the current HES Tool along with its future potential. For instance, while users may not have felt completely comfortable with the HES Tool after the individual session, they still indicated that it would be very applicable to support HES generation. This high level of support was consistently high even when participants were broken across different groups. Evaluating users post-session feedback based on their initial familiarity of the tool was an attempt to remove the bias of original perspectives or previous history. Those with the greatest and least familiarity with the HES Tool rated its capability of incorporating each component of a traditional HES the highest. Greater initial familiarity with the HES Tool by EM/Other may have translated to the greater level of comfort after the usability session. The EM/Other group typically scored the individual HES components lower than FEMA or USACE, but they were the group that felt the HES Tool would very much support HES generation in the future. USACE tended to score the HES components and general comfort with the HES Tool lower, but they

were also the group with the least familiarity with the HES Tool coming into the session. These differences between the different groups show that providing training and ensuring cross-communication will be important in the final transition process.

3. CONCLUSIONS AND RECOMMEDNATIONS

Throughout the development of the HES Tool, the views of the potential end-user were considered in order to maximize the tool's potential impact. The ability for a HES to be generated via an automated process represents key goal of the NHP TM effort. However, if the HES Tool does not capture current key capabilities or present the information in a clear manner, there may be resistance to wide-spread adoption. This highlights the importance of engaging with both end-users and stakeholders.

The pilot studies with NC and NYC, served as a method for gaining user perspective as well as validating the HES Tool capabilities. Using the data from their previous HESs, the HES Tool was able to work through the HES generation process and creation of final products such as clearance time, impacted road networks, inundated area, and others. While this process validated current capabilities, such as MOM or MEOW look-up, it also revealed gaps such as the need for user-defined critical infrastructure and multiple, overlapping evacuation zones with unique behavioral parameters. As these were realized during the development process, these capabilities were then added as a result. Although future capabilities may still need to be added to the HES Tool as additional jurisdictions are engaged, it is likely that the same modular nature of the tool that allowed the addition of previous capabilities can be used again.

While local end-users represent one key perspective on the usability of the HES Tool, higher-level stakeholders also represent a target audience. The NHP leadership purposefully identified these stakeholders due to their experience with the HES process. The resulting individualized usability sessions carried out with each of these stakeholders provided important feedback on the current HES Tool prototype as well as how the tool could be used in the future. There was generally positive feedback on the collaborative nature of the tool and excitement at getting the tool transitioned. However, there were concerns about overwhelming the local end-user and the actual transition process. To ensure the local end-users will feel comfortable with the HES Tool input/output fields, a validated list of terminology was created (Appendix B: HES Tool Terminology). Further engagement will be needed during the final HES Tool user-interface to ensure the wording of each field is clear, such as framing each input field in the form of a question. In terms of the transition process, continuous engagement with stakeholders will be needed as additional features may be added, such as a report generation function. As engagement with stakeholders continues, the organization of each user, years of experience with HES planning, previous experience with the HES Tool will likely frame the discussion and should be taken into consideration during the engagement.

These diverse perspectives from end-users and stakeholders of different levels highlight the importance of taking usability under consideration in a modernization effort. By taking into account the usability of the tool, the HES Tool now has a higher level of functionality and a proposed plan for a final user-interface.

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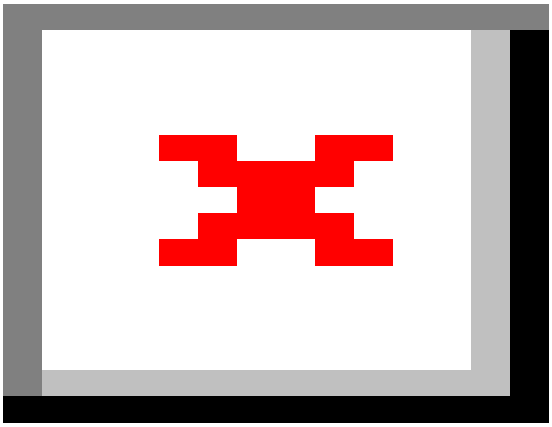
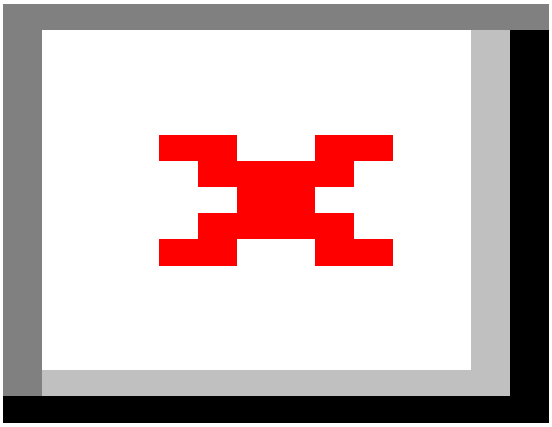
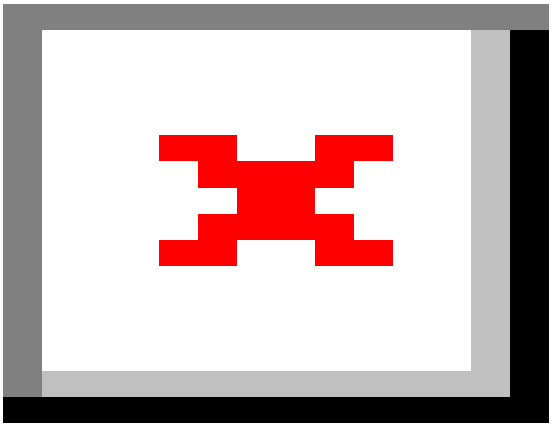
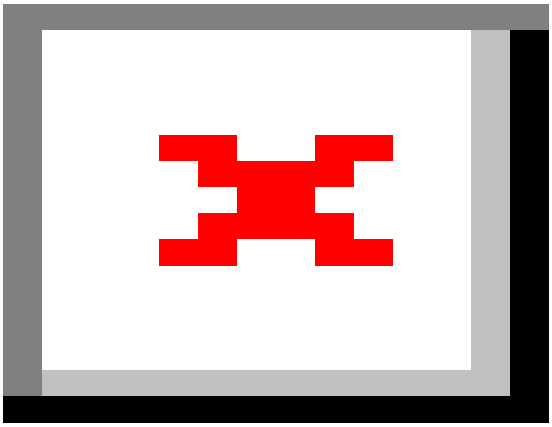
APPENDIX A: USER-INTERFACE MOCK-UP

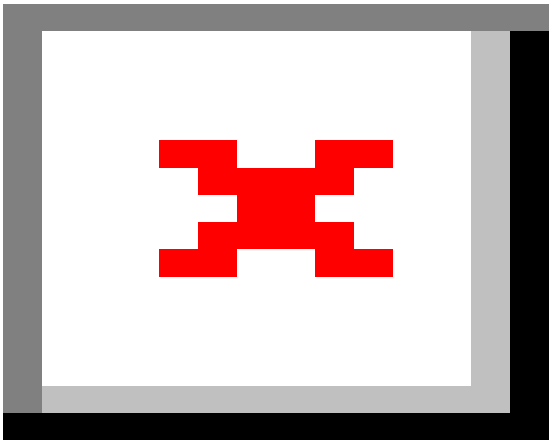
The following mock-ups represent general guidelines for the final HES Tool user interface. Their look and feel have been vetted with stakeholders through the HES Tool Usability Study at ICCOH, but the details of their implementation have not been completely defined. The basic idea behind their implementation is that the user selects inputs for each HES analysis, and those inputs map to HES Tool templates that are run behind-the-scenes. The UI keeps track of the inputs provided and automatically selects and runs the appropriate templates so that the user does not have to select and run templates. The user can also define more inputs than necessary for a single template, and the HES Tool UI should run multiple templates to satisfy their request. The user can define multiple inputs for each parameter in order to do a sensitivity analysis. When viewing outputs of the HES Tool analysis, the user can select data layers from different HES Analyses to overlay on the map at the same time. However, the tool should only display the results of one transportation scenario at a time.

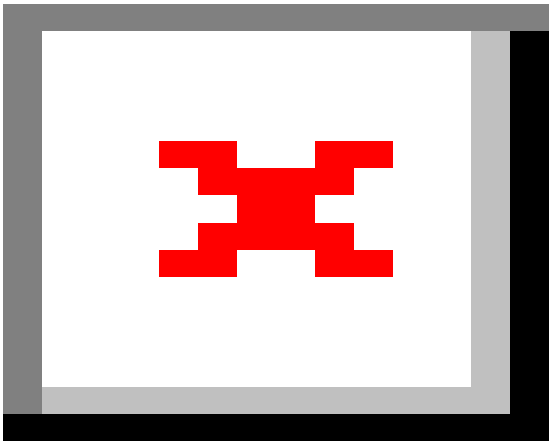


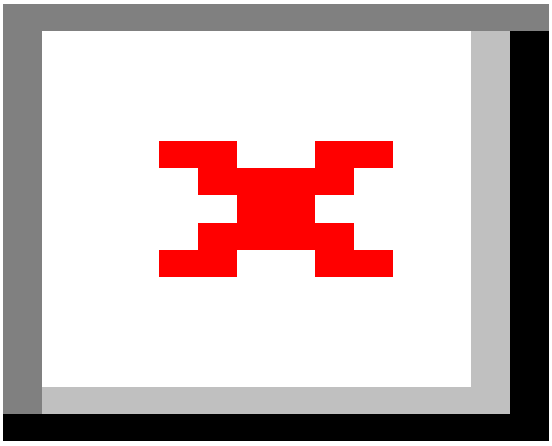


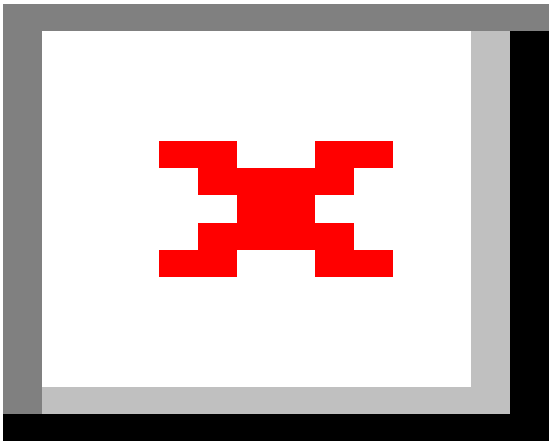


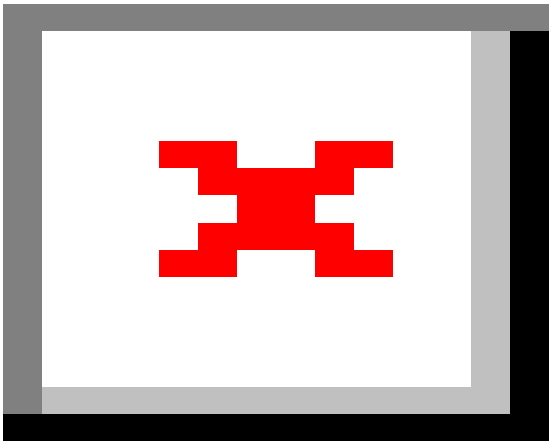


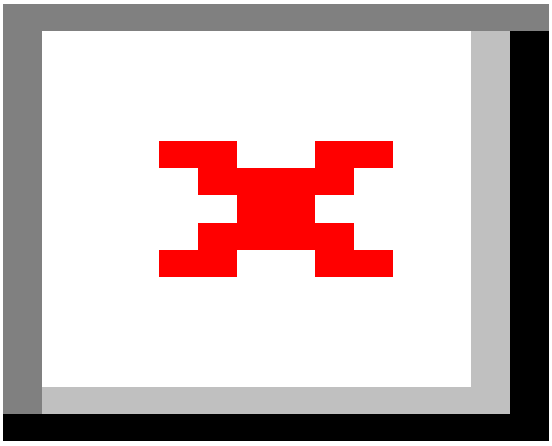


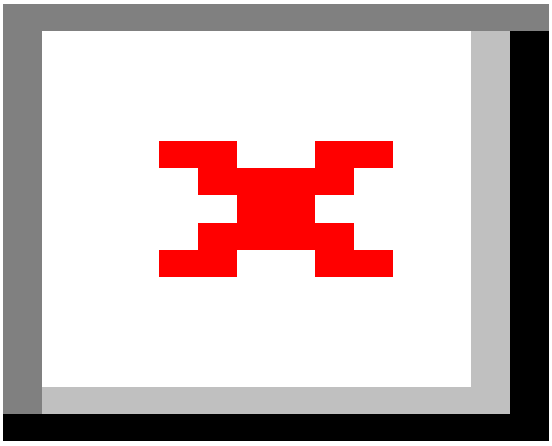


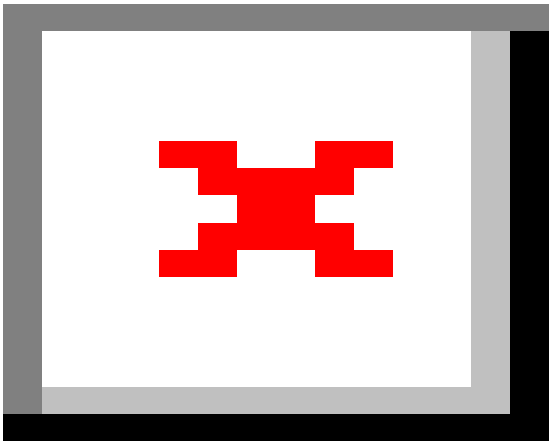


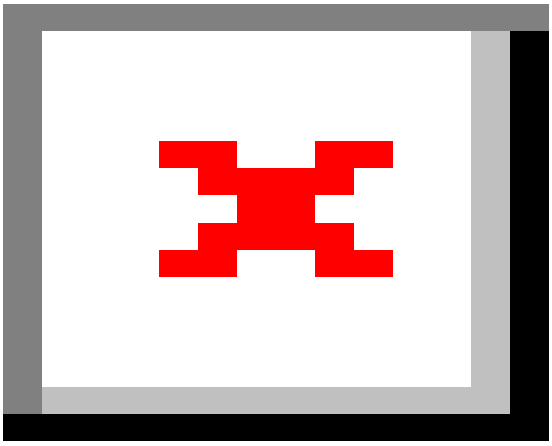


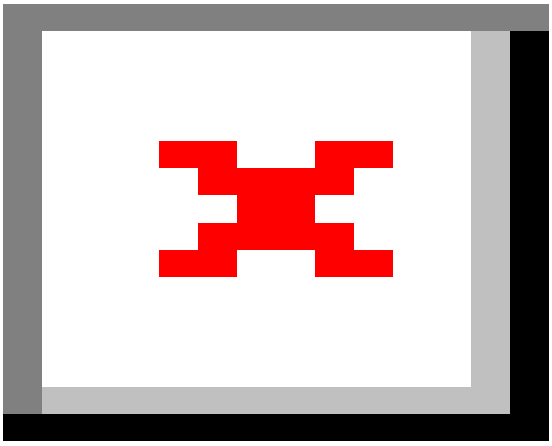


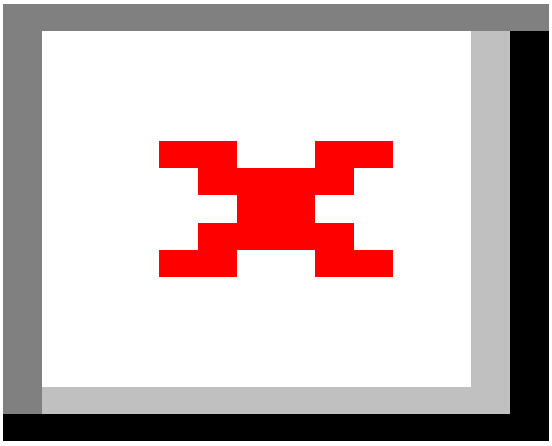


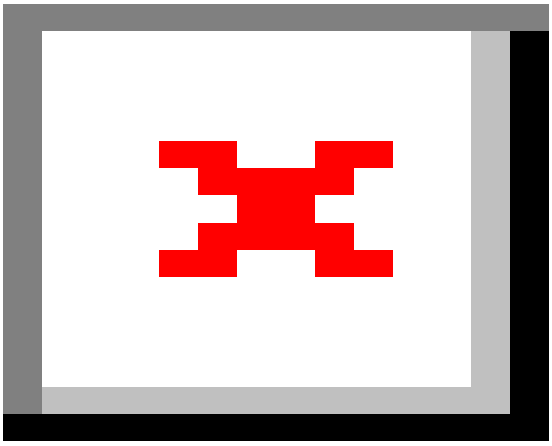


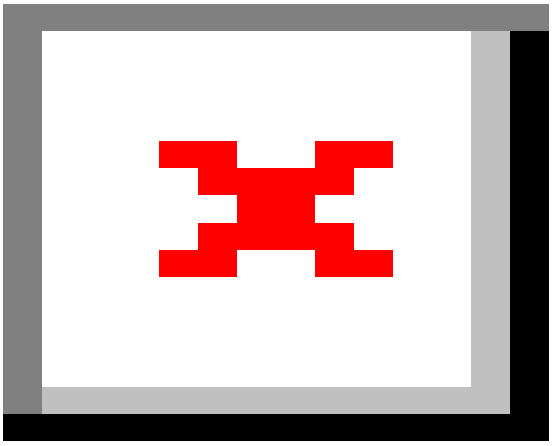


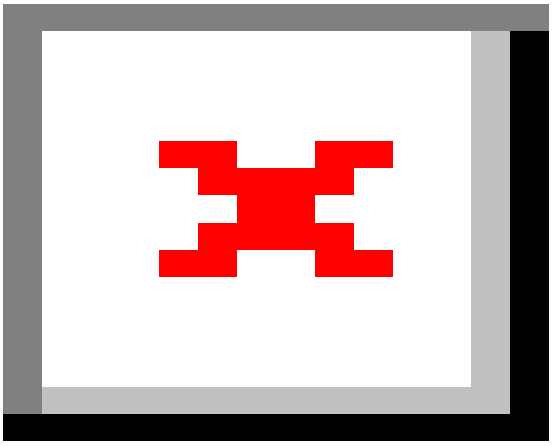


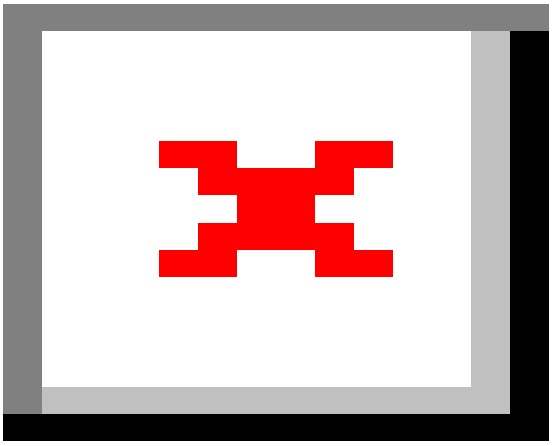


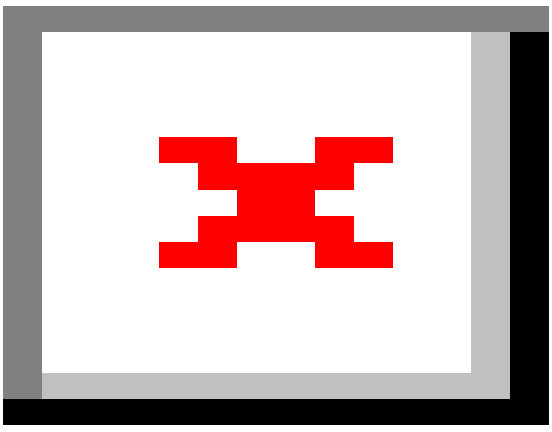












APPENDIX B: HES TOOL TERMINOLOGY

Table 3: HES Tool Terminology for Models Associated with the Hazard Analysis

HES Tool Terminology: Hazard Analysis	
Model	MOM Lookup (Above Vertical Datum)
	MOM Lookup (Above Ground Level)
Inputs	Hurricane Category
	Hurricane Basin ID
	Tide Level
Outputs	Storm Surge Flood Contours
Model	MEOW Lookup (Above Vertical Datum)
	MEOW Lookup (Above Ground Level)
Inputs	Hurricane Category
	Hurricane Basin ID
	Tide Level
	Hurricane Forward Speed
	Hurricane Heading Direction
Outputs	Storm Surge Flood Contours
Model	Probabilistic Storm Surge Lookup
Inputs	Probability of Exceedance
	Date
Outputs	Storm Surge Flood Contours
Model	User Defined Storm Surge Shapefile
Inputs	Shapefile
Outputs	Storm Surge Flood Contours

Table 4: HES Tool Terminology for Models Associated with the Evacuation Zone Mapping

HES Tool Terminology: Evacuation Zone Mapping	
Model	Inundation Evacuation Zone Generator
Inputs	Storm Surge Flood Contours
	Area of Interest
	Minimum Inundation Height
Outputs	Evacuation Road Network
	Census Blocks
	Evacuation Road End Points
Model	User-Defined Multiple Evacuation Zone Generator
Inputs	Evacuation Area
	Excluded Road Endpoint Region
Outputs	Evacuation Road Network
	Census Blocks
	Evacuation Road End Points
Model	Multiple User Evacuation Zone Generator
Inputs	Polygon Evacuation Zones
Outputs	Evacuation Road Network
	Evacuation Road End Points
	RtePM Evacuation Zones
Model	Inundation Evacuation Zone Generator
Inputs	Storm Surge Flood Contours
	Area of Interest

Table 5: HES Tool Terminology for Models Associated with the Vulnerability Analysis

HES Tool Terminology: Vulnerability Analysis	
Model	HSIP Freedom 2012 Affected Infrastructure Under Contours
Inputs	Threat Contours
	Selected Infrastructure
Outputs	Affected Infrastructure
Model	HSIP Gold 2012 Affected Infrastructure Threat Contours Intersection
Inputs	Threat Contours
	Selected Infrastructure
Outputs	Affected Infrastructure
Model	User Data Infrastructure Effects Under Threat Contours
Inputs	Selected Infrastructure
	Threat Contours
	User-Defined Infrastructure Data - Excel
Outputs	Affected Infrastructure
Model	MultiPolygon Census Data Lookup Model
Inputs	Area of Interest
	Population Area Aggregation Resolution
	Demographic Property
Outputs	Demographic Contours

Table 6: HES Tool Terminology for Models Associated with the Transportation Analysis

HES Tool Terminology: Transportation Analysis	
Model	RtePM Evacuation
Inputs	Evacuation Road Network
	Census Blocks
	Evacuation Road End Points
	Start Time
	Background Traffic Level
	Use Daytime Work Week Population
	Use One Day Response
	Day 1 End Hour (multi-day)
	Day 1 Proportion (multi-day)
	Day 2 Start Hour (multi-day)
	Day 2 End Hour (multi-day)
	Day 2 Proportion (multi-day)
	% as Pedestrians
	% using Public Transit
	% using Private Vehicles
	People per Vehicle
	Percentage Change in Population
	% of Evacuees to Shelters
	Evacuation Participation Rate
	Evacuation Response Rate
	% Vehicles Towing
Outputs	Clearance Time
	Total Vehicles Evacuated
	Evacuation Road Network - Vehicle Flow Over Time
	Census Block - Population Remaining Over Time
	Evacuation Road End Points - Arriving Vehicles Over Time

APPENDIX C: USABILITY STUDY DIRECT COMMENTS

Table 7. Usability Study Comments from Participants

Organization	Comment
FEMA	The success of this program is directly related to how intuitive it is for the user types.
	Being able to interface or export or directly connect to other users platforms to eliminate "interpretation" and allow for the tools of the HES to be leveraged on a variety of platforms in the field for users who may be planners, first responders, etc. and not part of the HES or planning process.
	keep getting local state and SME input
	Off to a good start. I like the collaboration functionality, as well as the help function.
	Getting to the total, final technical data report [seems] to be the current disconnect for me. That being a place where "all" the data is housed. Otherwise, I am more comfortable and can see the benefits from this modernization effort.
	I am very interested in the application's usability in the Hawaiian islands since it is a very unique and challenging environment to conduct a traditional evacuation..
USACE	would this tool take into account the importance of describing the evacuation zones delineations that is generates? These descriptions are important in explaining to the public who exactly is being asked to evacuate.
	Ensuring the accuracy of the output will be crucial to get EM buy in on this product. I really think this tool will be valuable to the NHP and its ability to conduct timely and well collaborated HES data; however, the managers (USACE) will need to know how to use this tool in a very productive manner.
	Tool could be intimidating to local emergency managers not familiar with HES and new technology.
	look forward to using this tool
	I understand better the purpose of this tool I believe that it has useful potential and am looking forward to additional hands on training.
	Nice work.
	It works pretty well!
	Still unclear as to [how] the HES tool will improve efficiency. The actual process of improving efficiency and how will the contractors still be involved.
EM/Other	Continue [seeking] feedback and compare with other products, beg, borrow, and steel all the good ideas you find to makes this better. Make it easier for users to work with and provide recommendations to improve.
	Love it pending key data common ranges/definitions
	Real time decision support, flexibility in developing evacuation decisions, incorporating the necessary data inputs for [decision] support.
	You are headed in the right direction! Still more to get it fully helpful at the local level. DO NOT cut down or simplify information [available], without leaving the more detailed data [available].
	The user interface needs to ask specific simple questions and clearly explain how values are quantified

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