Toward Improving

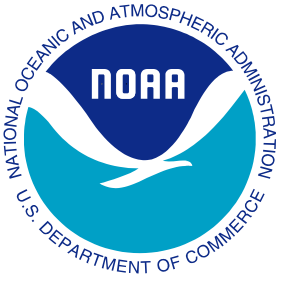
the NWS Hydrologic Services Program

Today and in the Future

Report of the
River Forecast Center Operations Team

April 2003

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Weather Service
Silver Spring, Maryland



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U.S. DEPARTMENT OF COMMERCE
Donald L. Evans, Secretary

National Oceanic and Atmospheric Administration
Vice Admiral Conrad C. Lautenbacher, Jr., Administrator

National Weather Service
John J. Kelly, Jr., Assistant Administrator

Preface

In September 2001 the River Forecast Center (RFC) Operations Team was charged with a vision for "An optimal use of National Weather Service (NWS) resources to meet the hydrologic service needs of partners and customers." The Team comprised representatives from all NWS Regions and Headquarters.

The work of the Team was facilitated by many groups and individuals called upon to provide essential information. A great deal of effort has been required for the Team to accomplish its task within the allowed time frame. The Team wishes to thank those who have supported our effort with information, time, and resources.

It is our hope that this work will lead the NWS toward an improved hydrologic services program today and in the future.

Robert K. Hartman
Team Leader

April 2003

Table of Contents

Preface ii

Team Members v

Executive Summary vi

I. Introduction 1

II. Information Collection and Assessment Activities 4

1. Assessment of External Information 5

A. External Customer and Partner Requirements for Hydrologic Service 5

B. Review of 1996 National Research Council Report 7

2. Assessment of Internal Information 8

A. Review of Internal Reports, Surveys, and Assessments 8

B. Corporate Insight 12

C. Operational Staff Survey 14

3. Lessons from History 16

4. Future Assumptions and Factors 17

III. Team Recommendations

1. Formulation 19

2. Primary Findings, Recommendations, and Suggested Actions 20

3. Secondary Findings, Recommendations, and Suggested Actions 30

4. Clarified Roles and Responsibilities 36

IV. Summary

1. Accomplishment of Tasks and Objectives 40

2. Summary of Team Recommendations 41

Appendix A Resource Bibliography A-1

Appendix B Assessment of External User Requirements B-1

Appendix C Review of Internal Assessments, Reports, and Evaluations C-1

Appendix D Review of External NRC Assessment D-1

Appendix E Operational Staff Web Survey E-1

Appendix F A Brief History of the Hydrologic Services Program Since 1945 . . . . . F-1

Appendix G Team Observations G-1

Appendix H Specific Supportive Information Associated with Primary and Secondary Findings H-1

Appendix I Review of Service Improvement Opportunities from the *Evaluation of Southern Region's 24x7 RFC Operations Test* I-1

Appendix J Acronyms J-1

Team Members

Rob Hartman, Team Leader
Hydrologist in Charge (HIC), California-Nevada River Forecast Center

Lee Anderson
Meteorologist in Charge (MIC), Eastern North Dakota Weather Forecast Office (WFO)

Curt Barrett
International Program Manager, International Affairs, NWS Headquarters

Steven Cooper
Chief, Climate, Water, and Weather Division, Southern Region Headquarters

Robin Radlein
Regional Hydrologist, Alaska Region
Hydrologist in Charge (HIC), Alaska-Pacific River Forecast Center

Rob Shedd
Development and Operations Hydrologist (DOH), Northeast River Forecast Center

Dave Smith
Senior Service Hydrologist (SSH), New Orleans WFO (retired)
National Weather Service Employees's Organization (NWSEO) Partner

Executive Summary

The RFC Operations Team was formed to address issues raised by a previous team that evaluated a test of routine 24-hour, 7-day (24x7) RFC operations in Southern Region. The Team engaged in an aggressive information and analysis process upon which all recommendations could be soundly based.

The Team found that the NWS is meeting the current basic needs of its customers and partners. The Team found no compelling evidence that suggests a significant change in structure would lead to improved customer service. The technical and service environment is, however, changing rapidly and the Team recommends that the structure of the entire NWS hydrology program be reviewed again in three to five years.

While basic customer and partner needs are being met, NWS partners and customers have requirements for enhanced service. These requirements for enhanced hydrologic service are fully consistent with those identified in the AHPS Concept of Operations and Service. The team recommends that the NWS address these requirements through (1) improving access to and awareness of existing information, (2) improving the technical hydrologic capabilities of the agency, and (3) developing mechanisms to remain in-tune with evolving customer and partner requirements.

Despite significant efforts, the NWS has largely failed to develop a consistent pattern and spirit of teamwork when it comes to WFO and RFC hydrologic activities. There are notable exceptions, but for the most part the potential of WFO/RFC interaction remains unfulfilled. Benefits of effective teamwork will accrue to WFOs, RFCs, and, most importantly NWS customers. WFO/RFC teamwork can be improved through (1) developing understanding, acknowledgment, and acceptance of WFO and RFC roles and responsibilities as defined in current policy, (2) utilizing RFC staff expertise as a resource for WFO staff and customer training and outreach where appropriate and feasible, (3) ensuring 24-hour RFC service availability, and (4) intentionally managing WFO/RFC teamwork as an agency goal.

Flash flood guidance is a weak link in the NWS flash flood program. In time, improved technology and science in the form of short time step distributed and coupled models and local small scale hydrologic models will provide improved public safety. In the interim, the NWS should improve the technical content and national consistency of flash flood guidance procedures. This effort must be lead by the NWS Office of Hydrologic Development Hydrology Lab (OHD/HL) with significant contributions by RFCs, WFOs, and the Regional Headquarters. Flash flood terminology and definitions are a source of confusion for many operational staff. Both WFO and RFC field office staff are calling for clearer definitions and terms. Once improved FFG is available for WFO use, training on the proper interpretation and use should be provided.

Training for NWS staff as well as NWS customers and partners is important today and will become even more important in the future as AHPS implementation takes place. New science and new products require more than a casual understanding. Training efforts should be focused toward improving the technical capabilities of NWS staff as well as the ability of NWS customers to properly interpret and use sophisticated NWS hydrologic products and services.

Meaningful forecast validation and performance measures and standards are essential to the future of the NWS hydrologic services program. Customers, partners, and WFOs all requested more accurate forecasts. Without validation and appropriate measures, improvements cannot be identified or quantified. NWS customers need and deserve information that quantifies the reliability of hydrologic forecast information produced for their use. Resource and emergency managers will be making increasing use of risk-based decision support tools that require an accurate assessment of forecast reliability. The Team recommends that the NWS develop, implement, and present effective and relevant performance measures, standards, and results.

In all, the RFC Operations Team identified eleven recommendations associated with three primary and three secondary findings.

1. The operational structure of RFCs should not be altered at this time.
2. Provide better access to and awareness of existing information.
3. Improve the technical capability of the agency.
4. Obtain consistent information on evolving customer and partner hydrologic service requirements.
5. Develop understanding, acknowledgment, and acceptance of WFO and RFC roles and responsibilities in the hydrologic services program.
6. Utilize RFC staff expertise in the WFO hydrologic training program for staff and customers and WFO hydrologic outreach.
7. Ensure 24-hour RFC service availability.
8. Identify, develop, and implement programs that encourage or require WFO/RFC collaboration.
9. Address and resolve the deficiencies associated with Flash Flood Guidance and its application.
10. Focus hydrologic training efforts for WFOs, RFCs, and NWS customers and partners.
11. Develop, implement, and present effective and relevant performance measures, standards, and results.

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I. Introduction

In December 1999, the NWS formed a team to observe and evaluate routine 24x7 River Forecast Center operations in the Southern Region. The team contained both NWS personnel and external partner representatives. The specifics of the evaluation are available in the team's report entitled *Evaluation of Southern Region's River Forecast Center 24x7 Operational Test*.

In their report, the team made the following recommendations:

1. The NWS should not implement RFC routine 24x7 operations nationally.

2. The NWS should clearly define the RFC real-time monitoring role in support of the flash flood program. Extended staffing policies should be developed taking this role into account.

3. The NWS should review WFO and RFC roles in the provision of hydrologic services. External partners should be included in this review.

4. The NWS should review the Service Improvement Opportunities outlined in this report, work with external partners to validate them, and implement them as appropriate.

The NWS Corporate Board accepted recommendations 2 through 4 and tasked the Office of Climate, Water and Weather Services (OCWWS) to form a team to address them. Recommendation 1 will depend on the results of recommendations 2 through 4. Recommendation 1 will be reviewed upon completion of the OCWWS study. Until then, RFC 24x7 operations may be implemented in accordance with existing policy.

The RFC Operations Team was chartered in September 2001 by OCWWS. The Team was directed to complete its work and deliver a report to the NWS Corporate Board by May 31, 2002. The vision, mission, scope, termination, and deliverables of the Team were as follows:

Vision: An optimal use of NWS resources to meet the hydrologic service needs of partners and customers.

Mission: 1) Clarify the roles and responsibilities of RFCs in the provision of flash flood and river forecast and warning services.

Propose an operational structure for RFCs which most effectively meets the needs of NWS customers (including staffing implications). Specifically address:

a) the generation, dissemination, and coordination of hydrologic forecast and warning information to internal and external partners;

b) user outreach and training; and
c) associated impacts on WFO hydrologic services.

2) Incorporate relevant Service Improvement Opportunities contained in the *Evaluation of Southern Region's River Forecast Center 24x7 Operations Test*. Report and recommend whether any should be implemented.

3) Bring to closure Actions #10 and #11 of the April 2001 NWS Corporate Board Meeting.

April 2001 NWS Corporate Board Meeting Minutes (excerpt)

RFC 24/7 (TAB 11)

DECISION #4. (re: NWS Postmaster 4/12/01 e-mail) The Board accepted recommendations 2 through 4 and tasked OS to form a team to address them. Recommendation 1 depends on the results of recommendations 2 through 4. Recommendation 1 will be reviewed upon completion of OS's study. Until then, RFC 24x7 operations may be implemented in accordance with existing policy.

ACTION #10 - OS. Provide the team's results.
DUE: 07/13/01 (Aug Corp Board - decision brief)

ACTION #11 - OS. Define customers' hydrologic needs (i.e., products and services) especially in NC, OK, and TX.
DUE: 07/13/01 (Aug Corp Board - info brief)

Scope of Authority/Limitations:

- Recommendations must be efficient and cost effective
- Analysis must be objective and unbiased
- Past or current practices, and organizational allegiances among the team members, must not be allowed to influence either the evaluation or the recommendations
- Travel expenses will be covered by each team member's Region/Office
- No change in the total number of field personnel assigned to each Region (Changes in the FT allocation to RFCs and WFOs may be considered)
- Recommendations must be budget/grade neutral
- Team consensus required for decision to be made or recommendation to be adopted
- Team will consult with internal and external partners and customers

Termination Date: The team will be formed and commence activities in September 2001 and remain assembled no longer than 9 months.

Success Criteria/Deliverables:

Develop consensus recommendations and a team report and provide to the NWS Corporate Board by May 31, 2002.

Approach

The team met in October 2001 to develop a strategy for achieving the vision and mission of the team as charged. The team agreed to an approach of information collection followed by group assessment and the formulation of specific recommendations. Aside from a consensus on the approach, the principal outcome of the October meeting was a series of information collection activities upon which well-founded recommendations could be based. Discussions of outcomes and recommendations were intentionally avoided until all data were collected and available.

Once all information was collected, the Team met again in March 2002. Each group of information and its associated facts were noted and organized. From these, the Team developed a set of general observations. The Team then engaged in non-critical brainstorming to identify structural or functional change alternatives. Many significant operational changes were discussed and their advantages and disadvantages identified and discussed. The Team then developed a set of primary and secondary findings, recommendations, and suggested actions that may lead to improved hydrologic service for NWS customers today and in the future.

II. Information Collection and Assessment Activities

To recommend changes and offer an improved operational structure for the RFCs, the Team collected and organized an abundance of information. Any recommendation for change must be justified and supported with clear objective information. The Team viewed their charge as a unique opportunity to assess and improve the way the NWS does business in hydrology. Information collection and assessment were limited to those activities that were achievable within the limited period the Team had to complete its work and deliver a report. A summary of the resources utilized by the Team can be found in Appendix A.

Information collection and analysis were broken up into four categories.

1. An assessment of external information. An assessment of customer and partner requirements with a specific focus on the identification of currently unmet needs. An assessment of published external reports that comment on the ability or performance of the NWS hydrologic services program.

2. An assessment of internal information. Information from published internal reports and assessments, insights from corporate experts, and the view of the field staff who operate the program were all considered.

3. A review of the history of hydrologic services in the NWS. Identify the factors that lead to today's structure for service preparation and delivery.

4. An assessment of future factors affecting the demand for forecast services and the NWS ability to provide them.

1. Assessment of External Information

A. External Customer and Partner Requirements for Hydrologic Service

The RFC Operations Team believed it was essential to work with users to identify the requirements that would need to be met within the National Weather Service hydrology program, both to save lives and property, and to enhance the National economy. The requirements could exist at many levels, from the needs of major governmental partners or value-added providers, to the needs of local communities, to the information that helps support international water commitments. The Team enlisted support from the Regional and National Hydrologic Services Divisions (HSD). These participants were asked to identify the service requirements for the range of users within their area. They identified in what way current NWS products and services were addressing those requirements, and what requirements, if any, remained unmet. In addition, they projected what needs might be identified in the near future. Finally, they examined what training, outreach, or feedback efforts were appropriate to help ensure that the service or product provided actually met the needs. A sample format was provided to each HSD to ensure similar data were collected for each area.

The methods used to collect the Regional information varied slightly. Several Regions solicited assistance from the Weather Forecast Offices and River Forecast Centers within the Region. The Region then either forwarded the information intact, or assembled a summary of the information. Some Regions either had information available from recent Regional projects or were able to assemble the information directly from the Regional office. The Regional and National information was reviewed by the Team and a summary table of requirements for different economic sectors was compiled. This summary table is included as Appendix B.

In order to validate the information provided by the Regions, each Region was also asked to provide a list of hydrologic services customers and partners that the Team could then contact directly. A total of 45 customers and partners were contacted and interviewed over the telephone. A special emphasis was placed on contacting partners and customers in Oklahoma, Texas, and North Carolina in order to address Action #11 of the April 2001 NWS Corporate Board Meeting as required by the Team Mission. A summary of their input and responses are provided in Appendix B.

The information provided by the Regions and that collected through direct customer and partner contacts were deemed to be consistent. A comparison of the information is also provided in Appendix B. An analysis of this information is provided in the following statements organized by topic area.

<u>External Customer/Partner Findings</u>

> NWS is doing a very good job of meeting its customer's and partner's basic hydrologic service requirements.

NWS has many very satisfied customers and many NWS offices have great working relationships with customers.

Customers provided a clear indication of what would constitute enhanced service.

Identified Opportunities for Enhanced Service

Forecast Improvement

- Provide routine and consistently available forecast information
- Increase forecast accuracy and dependability
- Issue routine forecasts earlier in the day
- Expand forecast locations
- Provide forecasts for smaller, faster responding watersheds
- Increase temporal precision (i.e. hourly)
- Provide forecast likelihood
- Provide forecasts for a spectrum of durations (hours, days, weeks, months)
- Improve Quantitative Precipitation Forecasts (QPF) and Quantitative Precipitation Estimates (QPE)

Data and Product Improvements

- Provide on-line, real-time and historical data access
- Provide consistency of products and information
- Improve the timeliness of Cooperative Observer Program data collection
- Increase the density of data collection networks

Interaction Improvements

- Increase communication and coordination with counties
- Address intra and inter WFO/RFC partnership inconsistencies
- Improve public awareness and customer education

B. Review of 1996 National Research Council Report

In March 1995, NOAA requested that the National Weather Service Modernization Committee of the Commission on Engineering and Technical Systems of the National Research Council to review plans and progress of the NWS Modernization Program. This committee focused on assessing the need for changes and improvements in the hydrology and hydrometeorology products and services of the NWS with emphasis on the flash flood forecast and warning program. The Committee produced a report titled "Assessment of Hydrologic and Hydrometeorological Operations and Services." Review of this document revealed significant recommendations and findings that the RFC Operations Team assessed as significant and still applicable in evaluating today's hydrologic service operations. Appendix D contains a table of the pertinent conclusions and recommendations found in the report.

The following statements, organized by topic were drawn from the specific findings and recommendations.

Hydrologic Expertise

The NWS should review, and if warranted, modify its qualifications for hydrology positions. The NWS should require a degree or extensive formal education in hydrology for positions that involve a hydrology emphasis.

WFOs need hydrologic expertise to effectively translate RFC guidance products into public watches and warnings.

Training

Additional training in calibration and interactive operation is required for RFC staff to take advantage of the NWS River Forecast System (NWSRFS).

Appropriate hydrologic training at WFOs is crucial to the program.

.

WFO/RFC Interaction and Collaboration

Collocation of WFOs and RFCs has improved communication and collaboration, but potential benefits are still not fully realized.

Emphasis needs to be placed on the tools and scientific principles common to meteorology and hydrology within the NWS, while at the same time, recognizing the distinctive nature and requirements of each discipline.

Staffing

The number of service hydrologists should be increased so that each WFO has a qualified program leader for hydrologic operations.

The NWS should consider the need for more personnel in the hydrometeorological forecasting function.

Advanced Hydrologic Prediction Services (AHPS)

The successful development and implementation of AHPS will require involvement from NWS field office staff and the user community.

Operational Development

Local initiatives can be productive, both in the development of useful technologies and in building morale.

2. Assessment of Internal Information

A. Review of Internal Reports, Surveys, and Assessments

One approach in understanding the effectiveness of NWS hydrologic services is to examine various reports, evaluations, assessments, and documentation that describe the functionality of the organization in delivering products and services. Various reports and analyses can be characterized into internal and external assessments. The NWS is constantly internally re-evaluating the effectiveness of its products and services. For example, natural disaster survey reports or service assessments are conducted following significant flood events that have a major impact (loss of life or property losses) in a region. The NWS RFC Operations Team reviewed the following reports:

Disastrous Floods on the Trinity, Red and Arkansas Rivers May 1990
Disastrous Floods on the Trinity, Brazos, Colorado, and Guadalupe Rivers in Texas (Dec 1991-Jan 1992)
Puerto Rico Flash Floods January 5-6, 1992
The Great Flood of 1993
Tropical Storm Alberto Heavy Rains and Flooding Georgia, Alabama, Florida July 1994
Northeast Floods of January 1996
Hurricane Fran August-September 1996
Disastrous Floods from the Severe Winter Storms in California, Nevada, Washington, Oregon, and Idaho December 1996 - January 1997.
Red River of the North 1997 Floods
Ohio River Valley Flood of March 1997
Hurricane Floyd Floods of September 1999
Tropical Storm Allison Heavy Rains and Floods Texas and Louisiana June 2001
Evaluation of Southern Region's River Forecast Center 24x7 Operational Test
Advanced Hydrologic Prediction Services. Concept of Services and Operations.

The NWS Hydrologic Services Division of OCWWS (OCWWS/HSD) provided the team with resources to accomplish this significant task. All assessment reports were reviewed and a number of common findings and recommendations related to delivery of hydrologic products and services were identified. Appendix C contains the summary of all findings and recommendations pertaining to hydrologic services performed during the past twelve years.

Using the extracted information from the referenced documents, the team then formed and organized the following statements.

<u>Customer Service</u>

During extreme and/or prolonged events, WFOs may not be able to handle the workload associated with direct contact (telephone) customers. Customer satisfaction is, however,

often associated with direct contact availability. Emergency services and media partners appreciate accessibility and a "personal touch."

During significant flood events, support for and communication with Emergency Operations Centers (EOCs) is extremely important. When feasible, periodic on-site EOC support should be provided by WFOs.

There are too many hydrologic products and their use confuses both NWS staff and our customers.

Some NWS customers with large areas of responsibility prefer to work with a single point of contact.

Outreach/Education

The public isn't fully aware of the NWS role in providing river forecasts and warnings.

Many media do not understand hydrologic forecast techniques or the role of RFCs in the NWS hydrology program.

The media and the public do not fully understand hydrologic terminology, procedures, and forecast products.

Media workshops are an effective way to enhance understanding and exposure of the NWS.

During widespread flooding events, WFOs and RFCs need to coordinate media activities.

For large scale or national events, the NWS should establish a national media unit to provide beginning-to-end coverage.

RFC and WFO Operations

There is an identified requirement for RFCs to provide extended staffing during potentially dangerous flooding situations. RFCs should formalize contact procedures and coordinate staffing decisions with WFOs and external partners.

The hydrologic program at WFOs would benefit from the delivery of more information from the RFCs.

WFOs and NWS partners need up-to-date river forecasts with more detail than just daily stage values. RFCs forecasts should remain reflective of the current QPF.

WFOs need flash flood guidance that is scientifically sound and is consistent across RFC boundaries.

River and flood forecast information in digital form are needed for post-event analysis, research and development, model calibration, ensemble streamflow prediction and simulation requirements, climatological studies, and verification.

Flood hazards often arise during other severe weather events.

Service hydrologists are of tremendous benefit to those offices that have them.

A need exists for better forecasting capability for small, fast responding watersheds.

WFO/RFC Interaction

Effective coordination between WFOs and RFCs is vital to the success of the NWS hydrology program.

Service backup responsibilities related to WFO/RFC interaction should be as consistent as possible across regional boundaries.

Training

Hydrologic training of WFO staff is critical to the success of the program.

The NWS has a critical need for professional personnel trained in both hydrology and meteorology.

Cross-training and familiarization of RFC and partner water management agency staff facilitates routine operations and can substantially improve operations during significant floods.

RFC staff require a very high level of competency to recognize and understand processes (e.g., complex hydraulics, enhanced snow melt) at work during extreme floods.

B. Operational Staff Web Survey

To capture input from the NWS field offices, a web-based survey was conducted for a four-week period in January and February 2002. Separate surveys were available for WFO and RFC staffs. The WFO and RFC staff surveys consisted of 32 and 26 questions respectively. Most questions were multiple choice, some included an opportunity for comment, and others were open text response. The WFO and RFC surveys had 14 common questions to allow for direct comparison. The survey was approved by the NWSEO and all responses were provided anonymously. The survey was restricted to the greatest extent possible to NOAA sites.

Announcement of the survey was initially made through an article in NWS Focus as well as messages to the regional HSD chiefs. The survey was linked through the Team's web site where background information and preliminary data were posted for open review. After reviewing the response to the survey following the first three weeks, the Team issued an "all-hands" email message to the NWS staff. The Team noted that it was somewhat difficult to reach and encourage the field office staff to respond to the survey. A substantial jump in response occurred with the "all-hands" email suggesting that this was a fairly effective way to reach field office staff.

Survey responses were received from 791 WFO staff and 158 RFC staff. This response rate represents approximately 35% of the non-Electronics Technician staff at the WFOs and 80% of the RFC staff. While it would have been preferable to have a greater response rate from WFOs, it was the Team's determination that the response was a representative sample of the WFO population. The Team assumed that responses were provided by those most directly involved and interested in the hydrology program and its associated operations. It was clear from the responses that a broad cross sample of ideas and viewpoints were captured in the survey, representing all regions and all positions that have an involvement in the hydrology program.

The individual survey questions and charted responses are provided in Appendix E. The full digital results in database form were provided to the OCWWS/HSD and are available upon request. The individual survey responses were stored into a relational database structure that allows for very flexible analysis. The potential use of the collected information extends well beyond the mission of this team and others are encouraged to make use of this resource.

The team spent a considerable amount of time reviewing and discussing the survey responses. This review and analysis yielded the following statements:

<u>Roles and Responsibilities</u>

There is a general satisfaction with the current operational structure.

More than 90% of WFO and RFC staff believe that the WFO should issue flash flood watches and warnings.

Both WFO and RFC staffs believe that there is a joint (WFO and RFC) *responsibility* in the flash flood program.

Within the NWS there is substantial disagreement as to who (WFO or RFC) should issue flood watches and warnings. One-third believe the RFC should do it.

Customer Service

A large percentage of WFO and RFC staff believe that a single and local point of contact is important to NWS customers.

Opportunities for Improved Service

Both WFO and RFC staffs indicate that significant improvement is needed in the flash flood program. By far, the most common improvement identified was the flash flood guidance issued by the RFC.

WFO expectations for availability of RFC operational support are not being fully met. WFO and RFC staff appear to have very different expectations. Only 25% of WFO staff believe that the RFCs are always available when needed. In comparison, 86% of RFC staff believe they are always available when needed.

WFOs requested more forecast locations and more routine forecasts.

WFOs requested improved quality in RFC river forecast guidance and increased responsiveness to feedback and requests for updates.

The hydrology program would benefit from improved relations and communications between WFOs and RFCs.

Training

Training is important but forecaster experience is critical to developing real expertise.

Hydrometeorological Technician (HMT) staff are routinely involved in performing the hydrologic function but more than 20% indicate that they are not adequately trained.

C. Insight from Corporate Experts

The observations and insights of NWS employees and former employees with substantial experience in the hydrologic services program were viewed as potentially rich resource for supporting information. Five former and three active NWS employees were contacted and interviewed. Two provided information via email and six verbally. The individuals contacted were:

Tony Haffer	MIC, WFO Phoenix, former Western Region HSD Chief
Jerry Nibbler	Former APRFC HIC and Alaska Region Regional Hydrologist
Ed Johnson	Director NWS Strategic Planning, former Office of Hydrology Hydrologic Operations Division Chief
Al Kachic	Former Eastern Region HSD Chief
Tim Helble	OCWWS/HSD
Ed May	Former Southern Region HSD Chief
Dale Lillie	Former HIC Missouri Basin RFC (MBRFC) and Arkansas Basin RFC (ABRFC)
Lee Larson	Former HIC MBRFC, Central Region HSD Chief, and Office of Hydrology Hydrologic Research Laboratory Chief

Individuals were asked to provide their thoughts associated with "What feasible changes would most effectively improve the quality of service provided by the NWS hydrology program." Individual responses reflected a number of very consistent messages. Responses were collected and formed the following statements organized by topic area.

<u>RFC Operations</u>

Individual RFCs are different for very good reasons. The differences result from variation in hydrologic regime and the specific needs of local customers and partners. Complete standardization is neither feasible nor an effective way to serve RFC customers. RFCs should provide core consistency yet have the flexibility to meet differing customer/partner requirements.

RFCs need to become more directly involved in long-lead events.

RFCs need to provide more technical support for the flash flood program.

RFCs need to make much more of their developed information available to customers, partners, and the public.

24-hour service can be achieved without 24-hour staffing. Technology should be embraced to address availability and the delivery of service while off-site.

Collaboration and Integration of Scientific Advancements

Intergovernmental relationships need to be developed and enhanced.

The mechanism for introducing improved science and technology into RFC operations is not effective. The gap between academic research and operational implementation needs to be bridged.

The NWS needs to refocus efforts on developing and integrating GIS capability.

WFO/RFC Interaction

Improve interaction between WFOs and RFCs. Substantial improvements in service can be realized through effective teamwork.

Professional Competency and Training

Training still needs to be emphasized. Training for both WFO and RFC staffs.

RFCs must retain or in some cases regain a high level of hydrologic expertise.

The RFCs need to gain professional and public visibility. The NWS needs to be viewed as a scientific leader in hydrology and forecasting.

3. Lessons From History

Much information can be learned from reviewing the past and identifying the forces that helped shape today's NWS hydrologic services program. To accomplish this task, the team requested and received the assistance of OCWWS/HSD. The OCWWS/HSD staff has valuable experience in the formulation of the hydrology program and had developed related historical development documents in the past.

The History of the Hydrologic Services Program, summarized OCWWS/HSD staff, is provided in Appendix F. An analysis of this work yields the following statements as they relate to the mission of this team.

> Over the past 50 years the hydrologic services program has undergone many significant changes. All shifts in roles, responsibilities, and services were implemented to better serve the public and meet growing service requirements.
>
> Most RFCs were initially established through the political process following a significant flooding episode or episodes.
>
> The location of RFCs was affected by partner requirements and an effort to collaborate with the U.S. Army Corps of Engineers.
>
> The availability of technology and resources are major driving factors in the provision of improved service.
>
> The hydrology program has seen a significant increase in resources and staffing. There are more individuals involved in the program than at any time in the past.
>
> Many of today's problems are really yesterday's unresolved issues. These include a strong flash flood program and coordinated hydrologic development and support.
>
> Despite all the problems, the NWS is positioned to provide the best service in history.

4. Future Assumptions and Factors

Floods and droughts have a major impact on the global economy and human suffering. In the United States, 75 percent of all presidential declaration of natural disasters are due to floods. Flood losses in the U.S. continue to grow despite the application of many structural and nonstructural solutions to the nation's flood plains. Average annual flood losses have increased from two billion dollars in the 1970s to five billion dollars today. Water use has been growing at more than twice the rate of the population increase during this century, with shortages worsened by pollution.

Population increases in the nation's flood plains coupled with urbanization, increased agricultural production, and growth in industrial activities is causing stress to America's economy. In addition, forecasts of potential climate change suggest that the frequency and magnitude of hydrologic extremes will increase in the future. The combination of these factors will result in a greater competition for water use which will necessitate more objective decision making based on sound hydrometeorological data and forecasts.

Proper management of water resources will be essential to the nation's economy, quality of environment, and overall social well being. Water and emergency management agencies at all levels will need better information to manage limited water supplies at some times and flood waters during others. This growing need for forecasting of rivers and warning of floods will create an increased demand for NWS hydrologic products and services. Customers and partners will become more sophisticated in their needs and in their decision-making process. This process will result in a greater demand for the quantity and quality of forecasts.

In the future, more forecasts will be needed for more locations. Different types of products and information will be needed along with a requirement for greater accuracy and reliability. Still, a portion of NWS customers will always require basic products provided through simple media. This growing demand for a variety of products and information to a variety of users presents a significant challenge to the agency. The NWS will need to establish priorities in the delivery of products and services because meeting the fast-growing requirements of the user community for hydrologic products may be unrealistic without resource augmentation. To meet future requirements, the NWS will need to embrace technology, establish partnerships, and define clear priorities.

Other public agencies, universities, and private interests are already developing and implementing hydrologic forecasting capabilities in certain economic sectors and regions of the country to meet growing demand. Collaboration, coordination, and partnering will increase in the future. This interagency coordination will result in increased data and information exchange, continuity of operational forecasts and warnings, improved water and flood management decision-making and development and infusion of modeling technology and science.

Delivery of hydrologic products and services is evolving rapidly. Hydrologic users now receive a vast majority of data, forecasts, and information over the Internet. Wireless technology and remote communications will create an environment where customers expect the latest information all the time anywhere they are. As communication increases the demand for more frequent product updates, including routine forecasts, will increase.

Future hydrologic operations and services will change to meet the growing and changing demands of users. Evolving science and technology will provide tools to operational hydrology to expand the quantity and quality of services, often without a significant increase in required resources. Clearly, the NWS Science and Technology Strategy for the future and the implementation of AHPS (as outlined in the AHPS Concept document) provides the NWS with the opportunity to significantly improve services to the nation based on infusion of new science and technology.

The development and implementation of the Advanced Hydrologic Prediction Services (AHPS) represents the future framework for the NWS hydrologic services program. AHPS will provide improved short, medium, and long range hydrologic forecasts, risk-based information, and introduce visualization. AHPS will require improved science, greater hydrologic competency, improved WFO/RFC collaboration, and significant customer and partner outreach and education.

The effective use of both WFOs and RFCs in the effectuation of AHPS will be necessary for several reasons. The RFCs will aid in the development, implementation, calibration, and adjustment of hydrologic models utilized by internal and external customers. Hydrologists at the RFCs will provide expertise in AHPS product development in cooperation with all users. Although generated by RFCs, AHPS products will be promoted and introduced to local customers through WFOs. As such, the RFCs will have a requirement to train WFO staff on AHPS product interpretation and use. Effective improvement of AHPS products will be facilitated by local customer feedback provided through WFOs. WFO/RFC teamwork will be critical to the successful implementation and development of AHPS.

The demand for hydrologic products and services will clearly increase in the future. These demands will be driven by evolving customers needs. The NWS has the opportunity to significantly improve the quantity and quality of hydrologic forecasts in the next ten years due principally to the deployment of new science and technology. AHPS will provide an excellent environment within which the NWS can improve the quality, value, and relevance of its service.

III. Team Findings, Recommendations, and Suggested Actions

1. Formulation

The Team collected and reviewed a vast amount of information. From each source of information, the Team attempted to identify key issues in the form of observations. These observations are provided in Appendix G. The Team considered many alternative operational structures as potential solutions to the identified key issues.

Ultimately, the Team concluded that a major restructuring of the NWS hydrologic services program could not be supported with the information collected (Finding 1). The Team did, however, identify that the program can be improved through nonstructural measures. The need for these changes and their proposed resolution are addressed in the findings and recommendations located in sections III.2 and III.3.

The findings and recommendations offered by the Team are grouped into Primary and Secondary. Primary findings and recommendations are directly associated with meeting the Team's mission. Secondary findings and recommendations are indirectly associated with the Team's mission and are included because of their criticality to the overall success of the hydrologic services program. Each recommendation has at least one suggested action. These are provided as a suggested first step in resolving the issue or issues associated with the finding. The envisioned benefits of each recommended action are also provided. The suggested actions are not necessarily comprehensive. There may, and probably are, other viable actions that will yield positive results.

As directed, the Team considered the service improvement opportunities identified in the *Evaluation of Southern Region's River Forecast Center 24x7 Operational Test.* Each of these service improvement opportunities is also individually addressed in Appendix I.

2. Primary Findings, Recommendations, and Suggested Actions

Finding 1: The NWS is meeting the basic hydrologic service needs of its customers and partners.

Information provided by each Region and verified with customer and partner interviews revealed that the agency is doing a good job of meeting its customers basic needs for hydrologic information and forecasts. The summary of products and services reported by each Region was quite impressive and significant and systematic problems were not noted. Interviewed customers rated the quality and timeliness of NWS hydrologic products and services as either excellent or good.

Disaster survey reports written since 1990 provide many examples of outstanding customer service. At the same time, these reports do not identify any structural defects that led to service failures. While somewhat critical of training and the availability of hydrologic expertise, the National Research Council report was generally optimistic about the ability of the NWS to meet customer needs through the modernized structure.

Surveyed NWS operational staff are not calling for radical changes to the structure of the program. The public warning program clearly belongs in the WFO domain. WFOs have established relationships with the emergency services community for all weather and flood related hazards. The value of local customer relationships and the ability of customers to interact with a single NWS entity for all service needs was evident throughout the information collected by the Team.

There is no compelling evidence that suggests that significant changes in the current operational structure would lead to a higher level of customer service. Specific facts drawn from the Team's data collection activities that support this finding and the recommendation below are provided in Appendix H.

Recommendation 1: The operational structure of RFCs should not be altered at this time.

Suggested Actions:

1. The technical and service environment is changing rapidly. The NWS should reevaluate the structure of the hydrologic services program again in 3 to 5 years.

Finding 2: NWS customers and partners have requirements for enhanced hydrologic service.

While the agency is successfully meeting current basic customer needs, the Team found that NWS customers have growing needs for enhanced hydrologic service. Customers clearly identified a long list of desired enhancements. These enhancements were quite predictable: better accuracy, more locations, more temporal and spatial details, more frequent updates, and better access to underlying and supporting data and information. WFOs are also calling for improved and enhanced service from their supporting RFC(s). These enhancements and the associated operational capability are fully consistent with those outlined the AHPS Concept of Service and Operations. The fact that the Team's findings are consistent with the AHPS Concept of Service and Operations lends credibility to both. Specific facts drawn from the Team's data collection activities that support this finding and the associated recommendations are provided in Appendix H.

Requirements for enhanced hydrologic service fall into two basic categories: those than can be easily met and those that will require significant effort and/or improved capability. The Team's recommendation deals with both of these categories as well as the basic underlying requirement to remain in-tune with shifting and evolving customer and partner needs.

Some enhanced service needs can be met by providing better access and awareness of existing information. Both of these attributes, access and awareness, are critical. It is not enough to pack web sites with all sorts of information and data. The NWS needs to ensure that (1) the provided information is relevant to customer needs, (2) customers are aware that the information exists and (3) customers are provided interpretive guidance.

Other needs for enhanced service can only be met through a substantial investment in the technical capability of the agency. Improving the technical capability of the agency should be addressed on several fronts. The integration of new science, the improvement of staff expertise, and collaboration with customers, partners, and the private sector are essential components of this effort.

Customer expectations and requirements for hydrologic service have certainly changed over time and will continue to change in the future. In order to remain relevant, the NWS needs to establish or maintain a very close relationship with customers and partners. Consistent interaction will allow the NWS to remain aware of evolving requirements and perhaps anticipate future requirements.

Recommendation 2A: Provide better access to and awareness of existing information.

Suggested Actions:

2A1. WFOs and RFCs collect and develop a wealth of information that can partially meet NWS customers needs for enhanced service. Many field offices have excellent web sites that provide a great deal of information and detail on hydrologic conditions. The development of consistent and informative WFO and RFC web sites should be encouraged. At the same time, an outreach effort should be initiated to inform NWS customers of this information resource.

Benefits:

- Allows NWS customers and partners to access needed information.
- Automated generation of web information is not labor intensive.
- Creates awareness of NWS hydrology program capabilities.
- Product links can create the appearance of one-stop shopping for local, regional, and national customers.

2A2. Public awareness and customer education needs improvement. RFCs should work with each WFO they serve to develop and implement a NWS hydrology customer/partner outreach and education plan.

Benefits:

- NWS products, services, and information are more effectively utilized by well-informed customers.
- Office to office disparities in service observed by our customers can be addressed and resolved.
- Yields a better understanding of customer and partner requirements.
- Promotes the notion of a NWS team to meet customer needs.
- Affirms WFO/RFC teamwork.

Recommendation 2B: Improve the technical capability of the agency.

Suggested Actions:

2B1. Aggressively pursue and implement the technical capabilities associated with AHPS.

Benefits:

- AHPS is the established mechanism through which improvements in hydrologic service will be realized.
- The technical and scientific capabilities required to achieve AHPS goals are recognized and well understood.

2B2. Strengthen the hiring and promotion practices associated with hydrology positions. While meteorologists selected for hydrology positions under the broad Office of Personnel Management (OPM) standards for GS-1315 can become proficient hydrologic forecasters, their ability to contribute to hydrologic science development is limited. Strong

consideration should be given to the selection of university-educated hydrologists for those positions requiring hydrologic forecasting or development.

COOL templates for all NWS GS-1315 positions should be reviewed to ensure proper weighting is given to formal education, training, and experience in hydrology, hydraulics, water supply management, probability and statistics, and hydrologic modeling.

While very difficult, the NWS should pursue a new OPM series for a *hydrologic forecaster* that includes the specific skills and abilities needed by the NWS.

Benefits:

- Strengthens NWS ability to develop, implement, and use advanced hydrologic models and techniques.
- Provides for a recurring infusion of concepts and science through highly qualified new-hires.
- Interaction with university and research interests is more likely, leading to enhanced integration of new science and technology.
- A reputation for scientific excellence and workforce expertise attracts highly qualified new employees, potential funding, and additional resources.
- Customer and partner confidence will increase.
- Improves the WFO's ability to interpret and support complex hydrologic information available through AHPS.
- Improves the ability of WFOs to perform on-station hydrologic training for staff as well as customers and partners.
- Training costs will be reduced or can be used for specialized expertise as opposed to fundamental knowledge.

2B3. Develop stronger collaborative relationships with respected hydrology, hydraulics, and water management departments at colleges and universities.

Benefits:

- Improves acquisition and integration of new science appropriate for operations.
- Improves opportunities for universities to gain operational insight and to work on applied research directly applicable to NWS programs.
- Improves access to applied research funds and resources.
- Demonstrates that the NWS values hydrologic expertise and the development of improved scientific techniques.
- Enhances recruitment opportunities for university educated hydrologists.

2B4. Establish closer working relationships with other agencies involved in hydrologic forecasting and water resource management.

Benefits:

- Enhances the service that hydrologic agencies provide to each other by increasing our understanding of the data, model, and service needs of the other agencies.
- New advances in hydrologic modeling developed jointly or by one agency can be evaluated and incorporated by other agencies as appropriate.
- Produces synergistic integration of agency strengths into the overall hydrologic forecasting process. For example, collaboration with the USGS (strong in GIS applications) would substantially improve NWS GIS use in model parameter estimation and flood mapping.
- Redundant activities can be reduced resulting in resources available for development and service improvement.
- Produces advocacy for forecasting systems and models as opposed to competitiveness.
- Strong interagency relationships provide for greater program stability (financial/political) which leads to a more consistent level of customer service.

2B5. Identify and develop areas of interaction with private industry and other sophisticated users to take advantage of the increased availability of forecasts and information from the RFC, WFOs, and NCEP.

Benefits:

- Cooperative partnerships with the users and the valued added community will help foster efficient and productive use of NWS information, products, and services.
- Enhances user, public, and media awareness of the role that the NWS plays in forecasting the Nation's waterways.
- NWS assumes leadership of hydrologic forecasting profession by facilitating partnerships and increasing delivery of products and services to economic segments not possible by the NWS alone.

Recommendation 2C: Obtain consistent information on evolving customer and partner hydrologic service requirements.

Suggested Actions:

2C1. Establish and conduct annual customer/partner hydrology workshops nationally, regionally, and by RFC.

Benefits:

- Practical, direct, effective, and affordable given limited resources.
- Avoids the legal hurdles associated with establishing formal user groups.
- Feasible and places leadership into the regional and national headquarters to assure it is an ongoing and coordinated function.

Finding 3. NWS customers and partners would benefit from improved WFO/RFC interaction and teamwork.

This is a repetitive theme of any assessment that delves into issues involving NWS hydrologic operations. The need to improve WFO/RFC teamwork was evident through virtually all of the Team's data collection activities. Customers noted intra and inter WFO/RFC partnership inconsistencies and periodic difficulties gaining access to adequate hydrologic expertise. Disaster survey reports noted difficulties associated with staffing and coordination. The NRC report suggested that the potential of WFO/RFC teamwork was not being realized even at collocated offices. Corporate experts agreed that the gap between WFOs and RFCs needs to be bridged and hydrometeorology emphasized. The web survey of operational staff identified differences in expectations, some confusion, and some attitude issues. Specific facts drawn from the Team's data collection activities that support this finding and the associated recommendations are provided in Appendix H.

It is equally clear that improved WFO/RFC teamwork will yield improved customer service. Although it is not specifically stated, the goals of AHPS cannot be achieved without a very high level of WFO/RFC teamwork and collaboration. As such, efforts to improve WFO/RFC are well justified. The Team does not want to discount or minimize the improvements made to date. Nonetheless the potential benefits of continued and additional improvements are substantial.

The Team envisions improvements through four strategies. First, some dysfunction arises from an uncertainty of roles and responsibilities. Uncertainty leads to inaccurate expectations which may lead to dissatisfaction and even animosity. The recently released NWS Policy Directive 10-9 provides clarity for RFC and WFO operational responsibilities and requires little in the way of enhancement. NWS field office staff must, however, be fully aware of, understand, acknowledge, and accept these directives.

Second, available hydrologic expertise at RFCs exceeds that at individual WFOs. Properly accessed, this technical resource can be used to elevate the capability of the WFOs and customers while establishing a pattern of NWS teamwork. The Team does not propose that the RFCs be responsible for the WFO hydrologic training and outreach program, rather, they be a willing and eager participant.

Third, formal measures should be initiated to establish and ensure the 24-hour operational availability of RFCs. In the past, uncertainty in operational availability has lead to unrealized expectations. The Team has specific suggestions that should lead to reliable 24-hour RFC service availability. Ensuring 24-hour RFC service availability supports the NWS mission and facilitates solid NWS teamwork.

Fourth, the NWS needs to make improved WFO/RFC teamwork an intentional activity. Managers should be tasked with facilitating WFO/RFC teamwork and specific collaboration plans should be developed, implemented, and tracked. Programs, initiatives, and ideas that work should be identified, recognized, and shared.

Recommendation 3A: **Clarify WFO and RFC roles and responsibilities in the hydrologic services program.**

Suggested Actions:

3A1. Modify NWS Policy Directive 10-9 to address RFC support for WFO training and outreach (suggested actions 3B and 3C1-5).

Benefits:
- Effective and feasible.
- Affirms NWS teamwork.

3A2. Conduct annual on-station NWS Policy Directive 10-9 training to establish and maintain an accurate understanding of WFO and RFC roles and responsibilities.

Benefits:
- Effective and feasible.
- Locally flexible.
- Establishes appropriate expectations.

Recommendation 3B: **Utilize RFC staff expertise in the WFO hydrologic training program for staff and customers and WFO hydrologic outreach.**

Suggested Actions:

3B. RFC staff have technical expertise that typically exceeds that available at individual WFOs. Although the fundamental responsibility for WFO training and outreach activities resides at the WFO, supporting RFCs can and should provide assistance where feasible and appropriate.

Benefits:
- Improves the ability of WFOs to train staff and customers and conduct meaningful hydrologic outreach.
- Creates RFC interaction with WFO staff and WFO customers.
- Affirms NWS teamwork.

Recommendation 3C: **Ensure 24-hour RFC service availability.**

Suggested Actions:

3C1. During periods of observed or expected moderate or major flooding, RFCs should extend hours to 24-hours per day.

Benefits:

- Provides for reliable and consistent access to RFC expertise when needed most.
- Extended staffing of the HAS forecasters as well as the hydrologists will provide support for WFOs in monitoring areas of additional heavy rainfall.
- Affirms WFO/RFC teamwork.

3C2. Decisions to extend RFC hours during periods of observed or expected minor flooding should be made by the management of the RFC following coordination with affected WFOs. Major cooperators and external users, such as state or regional emergency managers, should be notified of the RFC's extended availability.

Benefits:

- WFO requests for operational support may be based on lack of hydrologic expertise within the available staff for the extended period or on the expectation of conditions that will result in changes to forecast stages.
- Affirms WFO/RFC teamwork.

3C3. Decisions to extend RFC hours to provide hydrometeorological support during widespread or expected flash flood events should be made by the management of the RFC following coordination with affected WFOs. Major cooperators and external users, such as state or regional emergency managers, should be notified of the RFC's extended availability.

Benefits:

- Increases available WFO resources for monitoring areas of heavy rainfall.
- Where automated rainfall reports and radar precipitation estimates are available, the RFC may be able to update flash flood guidance and precipitation products more frequently.
- Affirms WFO/RFC teamwork.

3C4. Establish consistent off-hour RFC contact procedures for WFOs and external partners.

Benefits:

- Establishes a uniform and standardized 24-hour availability for all RFCs.
- Impacts on RFC staff resources are minimal.
- The required technology and tools are readily available.
- Affirms WFO/RFC teamwork.

3C5. Establish a consistent methodology for off-duty, off-site RFC personnel to monitor hydrometeorological conditions and operational system status as needed during periods when the RFC is not staffed.

Benefits:

- Establishes a uniform and standard 24-hour awareness, readiness, and responsibility for all RFCs.
- Impacts on RFC staff resources are minimal.

- The required technology and tools are readily available.
- Affirms WFO/RFC teamwork.

3C6. Pursue the development of technology that supports off-site RFC operational capabilities.

Benefits:
- Facilitates rapid product and service support by off-site RFC staff.
- Integrates with developing off-site RFC backup capabilities and plans.
- Integrates well with developing trends toward remote workplaces.
- Affirms WFO/RFC teamwork.

Recommendation 3D: Identify, develop, and implement programs that encourage or require WFO/RFC collaboration.

Suggested Actions:

3D1. Include a WFO/RFC collaboration element in the performance plan of all MICs and HICs.

Benefits:
- Establishes improved WFO/RFC collaboration as a clear agency objective.
- Makes WFO/RFC collaboration something that must be assessed and measured at each office.
- Affirms WFO/RFC teamwork.

3D2. Task each WFO and RFC with the development of a hydrologic collaboration plan to increase the sharing of technology and information as well as improved support for customer and partner education.

Benefits:
- Meets training and outreach requirements associated with AHPS implementation.
- Establishes a documented and intensional effort that has a high likelihood of success.
- Affirms WFO/RFC teamwork.

3D3. Identify and build on successful activities. Task each Regional Office with collecting, describing, and promoting "best practices" that facilitate or lead to improved WFO/RFC communication and/or collaboration. Regional practices should be shared nationally. Examples may include employee exchange, office visits, periodic conference calls, newsletters, RFC participation in local meetings, etc.

Benefits:
- Promotes successful efforts and allows offices to implement proven activities.
- Affirms WFO/RFC teamwork.

3. Secondary Findings, Recommendations, and Suggested Actions.

The findings, recommendations and suggested actions provided in this section are viewed by the Team as secondary. They are classified as secondary only because they cannot be strictly associated with specific elements of the Team mission as defined in Section I. Nonetheless, the Team judged that these findings were critical to the success of the NWS hydrologic services program and should be included in the report.

Finding 4. Flash Flood Guidance is currently a weak link in the flash flood program.

Flash flooding represents a significant hazard for many U.S. communities and is a significant challenge for WFO forecasters. RFCs have attempted to support WFO efforts by providing Flash Flood Guidance (FFG). FFG is an integral part of the Flash Flood Monitoring Program (FFMP) deployed through AWIPS across the country. Unfortunately, the quality of FFG is suspect. Improvements in FFG were requested by customers and partners, identified in disaster survey reports, and requested by WFO operational staff. When asked what the RFCs could do to improve support for the flash flood program, the number one answer as "improve FFG." Specific facts drawn from the Team's data collection activities that support this finding and the associated recommendations are provided in Appendix H.

The critical need is for the development and implementation of a nationally consistent flash flood guidance system that addresses the known technical deficiencies. Deficiencies in the current methodology for developing flash flood guidance include (1) spatial discontinuities and inconsistencies in the required inputs for ThreshR, (2) the inappropriate use of 6-hour time step model parameters and states in one and three-hour evaluations, and (3) the extrapolation of model parameters and states into distant and potentially dissimilar watersheds.

In time, it is reasonable to assume that the development and implementation of high resolution distributed hydrologic models will eclipse the need for empirical FFG and monitoring techniques. This process will, however, take time and success cannot be guaranteed. Given the frequency of events and the benefits of improved flash flood warnings, investment in an intermediate system that provides improved service is justified.

The Team's recommendation has three components. First, the methodology for developing FFG needs to be improved to address the known deficiencies. At the time of this writing, both National and Regional teams are attempting to address this issue. Every effort should be made to ensure the success of these teams and the resulting improvements in FFG. Second, the flash flood program suffers from imprecise and inconsistent terminology and definitions. Field office staff are not sure what constitutes a flash flood or what is required to verify a flash flood warning. While difficult, strict and well-engineered definitions will facilitate development and improvement in this important program. Third, once refined, WFO operational staff need to be provided with up-to-date training on the use and interpretation of improved FFG.

Recommendation 4: Address and resolve the deficiencies associated with Flash Flood Guidance and its application.

Suggested Actions:

4A. Improve the technical capability and national consistency of flash flood guidance. Scientific and programmatic leadership should be provided by OHD/HL with significant contributions from RFCs, WFOs, and Regional Headquarters.

Benefits:

- Provides access to consistent values of FFG across the country.
- Improved FFG may improve flash flood recognition, save lives, and mitigate property damage prior to the development and implementation of sophisticated distributed techniques, five or more years from now.
- Affirms WFO/RFC teamwork.

4B. Review and clarify flash flood terminology and definitions for NWS field office staff.

Benefits:

- Reduces confusion and uncertainty at field offices which leads to improved service for NWS customers.
- Reduces current ambiguity in current verification programs.

4C. Provide up-to-date training on the use and interpretation of improved Flash Flood Guidance and flash flood procedures.

Benefits:

- Increases technical and operational capability of both WFO and RFC staff.
- Affirms WFO/RFC teamwork.

Finding 5: Hydrologic and hydrology program training for NWS personnel as well as NWS customers and partners is essential to the success of the NWS mission.

The need for hydrologic training was consistent among all of the information the Team collected. NWS customers and partners requested training and surveyed customer responses revealed more than a few misconceptions about products, services and the role of the NWS. Disaster survey reports identified cases where NWS training or available staff expertise was lacking or customer training would have improved product interpretation. The NRC report makes strong recommendations about the need for hydrologic expertise and additional hydrologic training. Operational staff who responded to the web survey consistently identified a need for additional hydrologic training, especially in the flash flood program. Perhaps the most compelling case for improved training comes when we look forward to the implementation of AHPS. The development of advanced products, spanning minutes to months with associated probability, will require an extremely high level of expertise on the part of both RFC and WFO staff. Specific facts drawn from the Team's data collection activities that support this finding and the associated recommendations are provided in Appendix H.

The need for more focus in the hydrologic training program seems obvious and this report would be incomplete without identifying the need for this effort. That effort should be directed toward improving the technical capabilities of NWS staff as well as the ability of NWS customers to properly interpret and use NWS hydrologic products and services.

Recommendation 5: Focus hydrologic training efforts for WFOs, RFCs, and NWS customers and partners.

Suggested Actions:

5A. Design and implement a training plan with the NSTEP (National Strategic Training and Education Program) infrastructure to address deficiencies in RFC technical and operational competency. The process should begin with an assessment of all RFC personnel involved in hydrologic operations.

Benefits:

- Specifically targets and addresses current deficiencies in technical and operational competency.
- If successful, the technical and operational capability of the RFCs will improve.

5B. Design and implement a training plan within the NSTEP infrastructure to address deficiencies in WFO technical and operational hydrologic competency. The process should begin with an assessment of all WFO personnel, including HMTs, involved in the provision of hydrologic services.

Benefits:

- Specifically targets and addresses current deficiencies in technical and operational competency.
- If successful, the technical and operational hydrologic capability of the WFOs will improve.

5C. Significantly strengthen the technical and scientific requirements for SHs to the point where they are equipped to provide a high level of hydrologic science training to WFO operational staff.

Benefits:

- Provides an on-site hydrologic expert at those WFOs with a SH. WFOs without a SH would also benefit, but to a lesser degree.
- The act of teaching and instructing leads to enhanced personal capability and skill resulting in a higher level of SH proficiency.

5D. Organize, structure, and implement an education and outreach effort for external customers and partners. Structural and oversight responsibilities should reside at the national and regional level to ensure consistency but local adaptation should be encouraged to meet local requirements.

Benefits:

- Provides a process for significantly enhanced use and application of NWS hydrologic products and services by customers and partners.
- Enhances public recognition and support for the NWS hydrologic services program.
- Enhances customer and partner feedback and interaction needed to effectively tune services.
- Affirms WFO/RFC teamwork.

Finding 6: Performance measures and standards establish appropriate customer expectations, provide direction, and document progress.

The body of direct evidence that supports this finding and the associated recommendation is limited. Indirect evidence supporting this finding is, however, easily derived from the information collected by the Team. Specific facts drawn from the Team's data collection activities that support this finding and the associated recommendations are provided in Appendix H.

Customers and partners have requested improved forecast accuracy. The AHPS Concept of Services and Operations says that " ...enhanced services will be verified to document improvements in forecast and warning accuracy." Surveyed WFO staff requested more accurate and reliable river forecast guidance from supporting RFCs. Improvements cannot be defined without an accurate assessment of service quality. That assessment requires the development of meaningful measures related to the product attributes of greatest interest to NWS customers.

Customers need to develop confidence and place appropriate reliance on NWS hydrologic forecasts. Resource managers will be making increasing use of risk-based decision support tools that require an accurate assessment of reliability. NWS teamwork will be affirmed when RFCs can provide WFOs with clear information on the reliability of issued hydrologic forecasts and guidance.

The Team's recommendation has three simple parts. First, meaningful metrics for hydrologic forecast information needs to be identified and developed. They must be relevant to our customer's use of the information as opposed to convenient to define and compute. Second, a system must be implemented to provide customers with up-to-date information on the quality of service at each point of interest. The provided information should lead to a clear expectation of the level of service provided by the program. Third, a system for customer feedback should be implemented to ensure that the provided reliability information continues to meet customer requirements. All of the activities fall squarely into the AHPS implementation strategy.

Recommendation 6: Develop, implement, and present effective and relevant performance measures, standards, and results.

Suggested Actions:

6A. Identify meaningful performance metrics for hydrologic products and services.

Benefits:

- Clarifies program objectives and identifies data collection requirements.
- Demonstrates to customers and partners that the NWS is interested in measuring and improving the quality of its hydrologic forecast information.
- An essential component of establishing performance standards.

6B. Collect, process, analyze, and present hydrologic forecast performance information in a fashion that allows customers and partners to clearly understand and gage NWS capability and track progress.

Benefits:

- Allows customers and partners to appropriately manage their risk in using NWS forecast information.
- The provision of accurate reliability information may, in some cases, improve the confidence that customers and partners have in NWS hydrologic forecasts.
- Quantifies and documents improvements yielded by investments in development and training programs.
- Provides consistent feedback to forecasters and program managers.

6C. Develop a system for quick and reliable feedback from hydrologic customers and partners related to the value and reliability of NWS hydrologic forecast information.

Benefits:

- Allows for the development of target standards based on customers and partners requirements for reliable forecast information
- Provides continuous access to evolving customer and partner needs.
- Allows for rapid feedback on new products and services.
- Identifies products and services that may no longer have "value" for the customer.

4. Clarified Roles and Responsibilities

The Team's proposal does not include a realignment of roles and responsibilities or structural changes at WFOs or RFCs. The Team's charge includes a requirement to clarify the roles and responsibilities of WFOs and RFCs in the hydrologic service program. These roles and responsibilities are, in the Team's judgement, appropriate and clear as defined in NWS Policy Directive 10-9. Two adjustments are suggested as discussed in the previous section under Recommendation 3. What is needed is the full awareness and acceptance of current policy by field office staff. WFOs and RFCs should perform local on-site training to ensure that all operational staff understand, acknowledge, and accept the current policy.

The recommended adjustments to existing policy involve the use of the RFC as a training and outreach resource for WFOs and the assurance of 24-hour RFC service availability. Both of these adjustments should lead toward improved hydrologic service through improved NWS teamwork.

RFC responsibilities should be expanded to serve as a training resource for WFO staff and customers where appropriate and feasible. RFCs may also be able to effectively assist WFOs in their outreach programs. RFC staff have considerable expertise that can be used to elevate the overall capabilities of the entire program. The Team is not suggesting that the RFC be responsible for WFO hydrologic training and outreach. Where appropriate and feasible, RFC should help supported WFOs improve their hydrologic expertise and that of their customers. The Team recognizes that staff resources at the RFC are limited. This additional teamwork activity can be appropriately managed by HICs, MICs, and Regional Offices.

The operational availability of RFCs has not been adequately defined or supported in policy. This has lead to uncertainty and unrealized expectations. The Team has specific suggestions that should lead toward reliable 24-hour RFC service availability. Ensuring 24-hour RFC service availability supports the NWS mission and facilitates solid NWS teamwork.

WFO and RFC roles and responsibilities which include the Team's recommendations are provided on the following three pages. *Clarified* roles and responsibilities are denoted with one asterisk (*) and *new* roles and responsibilities are denoted with two asterisks (**).

Flash Flood Program

WFO Responsibilities	RFC Responsibilities
Primary monitoring, data collection, and quality control of hydrometeorological observations.	* 24-hour service availability - as required - as requested by WFOs - can be RFC initiated
Issue public watches and warnings.	Issue updated FFG at least once/day. * A resource for WFO staff training on FFG use and interpretation.
Maintain, enhance, and develop a relevant and informative web site that contains information, data, and forecasts related to the flash flood program.	Maintain, enhance, and develop a relevant and informative web site that contains information, data, and forecasts related to the flash flood program.
Flash flood warning verification.	**FFG verification.
Collection of case study information.	
User outreach and training.	* A WFO resource for user outreach and training.

River Flood Program

WFO Responsibilities	RFC Responsibilities
Primary monitoring, data collection, and quality control of hydrometeorological observations.	* 24-hour service availability - as required - as requested by WFOs - can be RFC initiated
Issue public watches and warnings including specific flood potential statements.	Provide up-to-date river forecast guidance.
Issue routine non-watch/warning public hydrologic forecast products.	Issue large-scale graphical significant flood outlook products.
Maintain, enhance, and develop a relevant and informative web site that contains information, data, and forecasts related to the river flood program.	Maintain, enhance, and develop a relevant and informative web site that contains information, data, and forecasts related to the river flood program. * A resource for WFO staff training on the interpretation and use of river flood forecasts. * A resource for WFO outreach and training.
Outreach and training for emergency management and local customers.	Outreach and training for regional and water management customers. A resource for WFO outreach and training.
Media contact within CWA.	WFO media resource for wide-spread floods.
Verification of warnings, including those based on site-specific model information.	Verification of RFC forecasts.

Long Range Program

WFO Responsibilities	RFC Responsibilities
Primary monitoring, data collection, and quality control of hydrometeorological observations.	Generate long range hydrologic forecasts.
CWA management of the Drought Program	Coordinate water supply forecasts with partner agencies.
Issue public long range flood outlook products.	Make water supply forecasts available to partner agencies and water management customers.
Issue public water supply outlooks and discussions.	
Maintain, enhance, and develop a relevant and informative web site that contains long range hydrologic information, data, and forecasts.	Maintain, enhance, and develop a relevant and informative web site that contains long range hydrologic information, data, and forecasts.
. Outreach and customer training for emergency managers and local customers (may include local water managers).	* A resource for WFO staff training on the interpretation and use of long range hydrologic forecasts.
	* A resource for WFO outreach and training.
	Outreach and customer training for water management and regional customers. A resource for WFO outreach and training.

IV. Summary

1. Accomplishment of Tasks and Objectives

The Team has, through its data collection and analysis, determined that the current operational structure for the RFCs effectively meets the current needs of NWS customers. The roles and responsibilities of WFOs and RFCs in the provision of flash flood and river forecast and warning services, as defined in NWS Policy Directive 10-9 are clear and do not require significant modification. These directives are not, however, consistently understood, acknowledged, and accepted by NWS field office staff. Local on-station efforts should be initiated to resolve this.

The Team recommends minor adjustments to the role of the RFC. These involve the participation of the RFC in the WFO training and outreach program and formal actions that will lead to the assurance of 24-hour RFC service availability. Both of these role adjustments are couched under the objective of improving WFO/RFC teamwork and collaboration. WFO and RFC roles and responsibilities that include this Team's recommendations are outlined in Section III.4.

Service Improvement Opportunities contained in the *Evaluation of Southern Region's River Forecast Center 24x7 Operations Test* were considered and integrated throughout the process. Implementation of the suggested actions in sections III.2 and III.3 should lead to improvements in the NWS hydrologic service program today and in the future.

The completion of this report brings closure to Action #10 of the April 2001 NWS Corporate Board Meeting. Customers' hydrologic needs across the nation were collected and organized. These data were fundamental to the Team's decision making process. The summary of customers' hydrologic needs is provided in Appendix B. This summary and its integration into this report bring closure to Action #11 of the April 2001 NWS Corporate Board Meeting as directed.

2. Summary of Team Recommendations

The following recommendations are extracted directly from the Sections III.2 and III.3.

1. The operational structure of RFCs should not be altered at this time.

2. Provide better access to and awareness of existing information.

3. Improve the technical capability of the agency.

4. Obtain consistent information on evolving customer and partner hydrologic service requirements.

5. Develop understanding, acknowledgment, and acceptance of WFO and RFC roles and responsibilities in the hydrologic services program.

6. Utilize RFC staff expertise in the WFO hydrologic training program for staff and customers and WFO hydrologic outreach.

7. Ensure 24-hour RFC service availability.

8. Identify, develop, and implement programs that encourage or require WFO/RFC collaboration.

9. Address and resolve the deficiencies associated with Flash Flood Guidance and its application.

10. Focus hydrologic training efforts for WFOs, RFCs, and NWS customers and partners.

11. Develop, implement, and present effective and relevant performance measures, standards, and results.

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Appendix A

Resource Bibliography

Natural Disaster Survey Report
Disastrous Floods on the Trinity, Red and Arkansas Rivers May 1990
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Silver Spring, Maryland
May 1990

Natural Disaster Survey Report
Disastrous Floods on the Trinity, Brazo, Colorado, and Guadalupe Rivers in Texas (Dec 1991-Jan 1992)
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Silver Spring, Maryland
April 1994

Natural Disaster Survey Report
Puerto Rico Flash Floods January 5-6, 1992
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Silver Spring, Maryland
July 1992

Natural Disaster Survey Report
The Great Flood of 1993
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Silver Spring, Maryland
February 1994

Natural Disaster Survey Report
Tropical Storm Alberto Heavy Rains and Flooding Georgia, Alabama, Florida July 1994
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Silver Spring, Maryland
December 1995

Assessment of Hydrologic and Hydrometeorological Operations and Services
National Research Council
December 4, 1996

Hydrometeorological Service Operations for the 1990's
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
Office of Hydrolgoy, Silver Spring, Maryland
March 1996

Natural Disaster Survey Report
Northeast Floods of January 1996
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Silver Spring, Maryland
March 1998

Service Assessment
Hurricane Fran August-September 1996
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Silver Spring, Maryland
July 1997

Natural Disaster Survey Report
Disastrous Floods from the Severe Winter Storms in California, Nevada, Washington, Oregon, and Idaho December 1996-January 1997
Prepared by Western Region Headquarters
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Silver Spring, Maryland
October 1997

Service Assessment and Hydraulic Analysis
Red River of the North 1997 Floods
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Silver Spring, Maryland
August 1998

Service Assessment
Ohio River Valley Flood of March 1997
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Silver Spring, Maryland
August 1998

Service Assessment

Hurricane Floyd Floods of September 1999
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Silver Spring, Maryland
May 2000

Service Assessment
Tropical Storm Allison Heavy Rains and Floods Texas and Louisiana June 2001
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Silver Spring, Maryland
December 2001

Evaluation of Southern Region's River Forecast Center 24x7 Operations Test
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Silver Spring, Maryland
May 2001

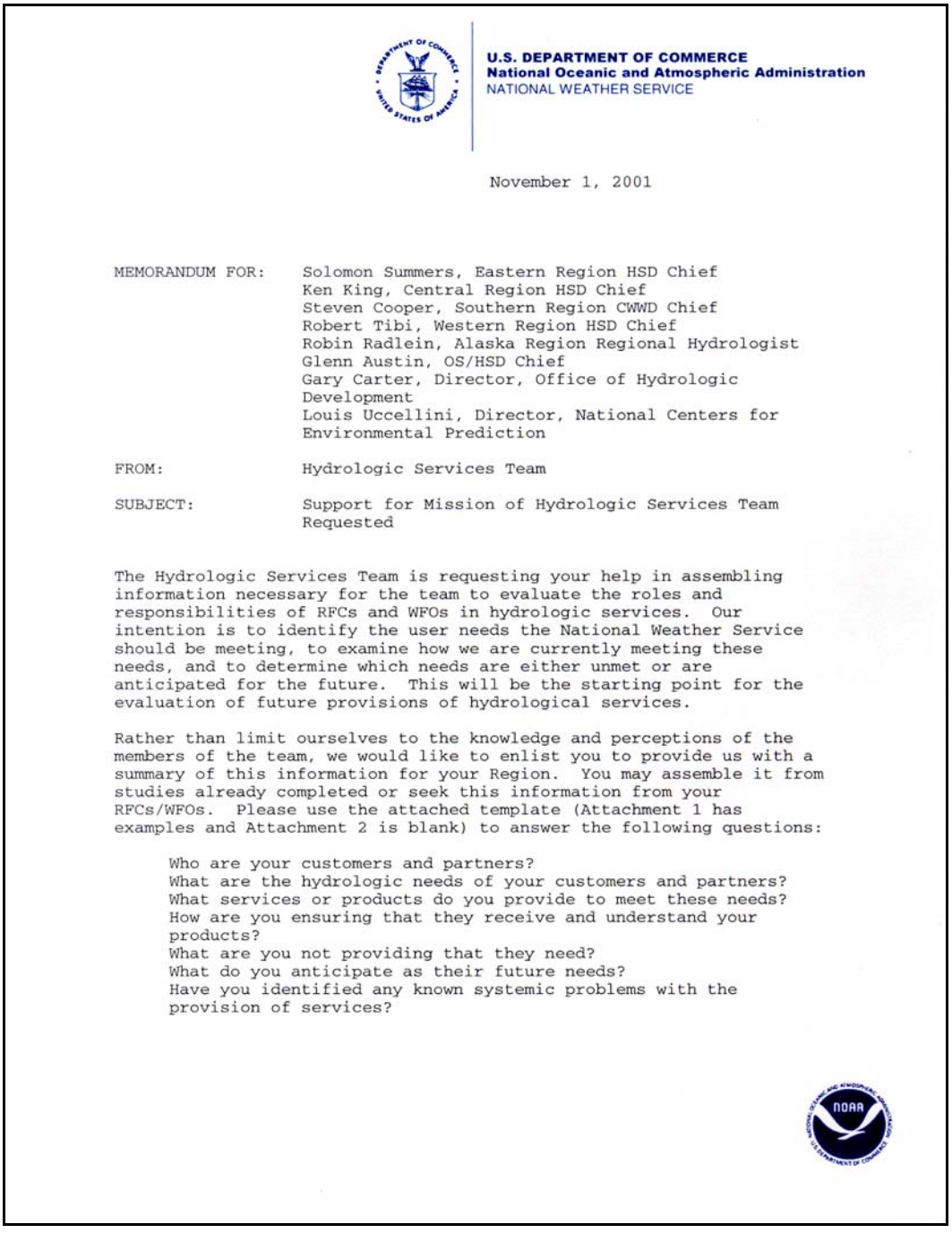
Advanced Hydrologic Prediction Services. Concept of Services and Operations.
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Silver Spring, Maryland
April 2002

External Customers and Partners

Appendix B

Assessment of External User Requirements

1. Request Letter Sent to Regions and NWSHQ



U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL WEATHER SERVICE

November 1, 2001

MEMORANDUM FOR: Solomon Summers, Eastern Region HSD Chief
Ken King, Central Region HSD Chief
Steven Cooper, Southern Region CWWD Chief
Robert Tibi, Western Region HSD Chief
Robin Radlein, Alaska Region Regional Hydrologist
Glenn Austin, OS/HSD Chief
Gary Carter, Director, Office of Hydrologic Development
Louis Uccellini, Director, National Centers for Environmental Prediction

FROM: Hydrologic Services Team

SUBJECT: Support for Mission of Hydrologic Services Team Requested

The Hydrologic Services Team is requesting your help in assembling information necessary for the team to evaluate the roles and responsibilities of RFCs and WFOs in hydrologic services. Our intention is to identify the user needs the National Weather Service should be meeting, to examine how we are currently meeting these needs, and to determine which needs are either unmet or are anticipated for the future. This will be the starting point for the evaluation of future provisions of hydrological services.

Rather than limit ourselves to the knowledge and perceptions of the members of the team, we would like to enlist you to provide us with a summary of this information for your Region. You may assemble it from studies already completed or seek this information from your RFCs/WFOs. Please use the attached template (Attachment 1 has examples and Attachment 2 is blank) to answer the following questions:

Who are your customers and partners?
What are the hydrologic needs of your customers and partners?
What services or products do you provide to meet these needs?
How are you ensuring that they receive and understand your products?
What are you not providing that they need?
What do you anticipate as their future needs?
Have you identified any known systemic problems with the provision of services?

We ask that you provide contact information for up to five of the Region's most representative or key customers or partners as provided by your RFCs/WFOs. With these names, please include any feedback provided by these key customers/partners. We will be doing follow-up calls in December to speak with these groups.

Once we have received your package, the team will identify those needs and requirements common to all Regions; common to similar geological, hydrological, or political areas; or unique to a Region or smaller area. Requirements at all levels must be addressed in the evaluation of operations.

Please email your data to Steven Cooper at Steven.Cooper@noaa.gov by November 30, 2001. He will ensure its distribution to the team.

After the team has compiled these data, we may again ask for your help in contacting our field offices to solicit suggestions and opinions as part of voluntary directed brainstorming.

2. External Customer Needs Assessment Follow-up - Survey Form

National Weather Service (NWS)
RFC Operations Team - Customer Follow-up

Name: _____ Region: _____
Agency: _____ RFC/WFO: _____
Phone #: _____
Date: _____

Findings consistent w/ initial survey ___Yes ___No

Questions:

1. How would you describe you agency's partnership with the NWS? (list options)
   - ❑ NWS uses your products and services
   - ❑ You use NWS products and services
   - ❑ An exchange of products and services
   - ❑ Other _____

2. The next question refers to the NWS products and services that you use. Please indicate which products and services you use: (list each)
   - ❑ weather observations (e.g. precipitation, temperature, wind)
   - ❑ graphical weather products including maps and charts
   - ❑ weather forecasts
   - ❑ climate forecasts
   - ❑ hydrologic observations (stage, discharge)
   - ❑ river and reservoir forecasts
   - ❑ graphical hydrologic products, including hydrographs and maps
   - ❑ Other _____

3. What is the primary way you receive NWS products and services? (don't list options)
   - ❑ NOAA Weather Radio
   - ❑ NOAAPort Receive System
   - ❑ NWS Web Pages
   - ❑ Email/FTP
   - ❑ Personal contact
   - ❑ Commercial data provider or forecast service
   - ❑ Other _____

4. How would you judge the quality of NWS products and services your agency uses?
   ❑ Excellent ❑ Good ❑ Fair ❑ Poor ❑ Unacceptable

5. How would you judge the timeliness of NWS products and services your agency uses?
   ❑ Excellent ❑ Good ❑ Fair ❑ Poor ❑ Unacceptable

6. How important is it to you to have a single point of contact for NWS products and services?
   ❑ Very important ❑ Somewhat important ❑ Not important

7. How important is it to you to have a local NWS point of contact?
   ❑ Very important ❑ Somewhat important ❑ Not important

8. What is the primary shortcoming of current NWS hydrologic products and services used by your agency?

9. Do you have any suggestions for ways in which the NWS could increase the usefulness of its products and services to your agency?

10. Do you have any suggestions for ways in which the NWS could improve its interactions with your agency?

11. Does your agency engage in weather or hydrologic forecasting to meet your specific needs?
    - ❑ weather
    - ❑ hydrologic

12. Does your unit operate (list each)
    - ❑ 7 days a week and 24 hours a day
    - ❑ 7 days a week but less than 24 hours a day
    - ❑ business hours with extended hours during flood episodes
    - ❑ business hours

Comments:

3. Summary of Information Received from Regions and NWSHQ.

Economic Segment **Customer/Partner**	**User Requirement**	**NWS Product or Service**	**Comments/Issues**
Weather Industry Value-Added Service Providers (National - All Regions)	Routine river forecast product in a Nationally consistent SHEF-encoded format	Stage summary and forecast (RVD)	Routine daily forecasts not universally available (or required); some differences in length of forecasts
International International Boundary River Commissions (National - All Regions)	Exchange of observations and forecasts for variable time periods	Data summaries, Radar observations, Stage and flood forecasts QPF & Water Supply forecasts	
Federal Agencies US Army Corps of Engineers (COE) (National- All Regions)	Exchange of observations, forecasts, and operation plans to support COE project operations and NWS forecasts. Actual data needs will vary by project type.	Precipitation data and summaries Routine forecasts: stage and flow on navigable waterways; reservoir/lake inflow forecasts; reservoir outflow stage forecasts; seasonal volume & peak flow forecasts; snowmelt forecasts; Event forecasts: Flood watches, warnings and statements	Timing, accuracy, and accessibility of forecast information still needs work in many cases
Federal Agencies US Natural Resource Conservation Service (NRCS) (MultiRegional)	Exchange of observations, snow water content, water supply information, and river and weather forecasts to support NRCS projects and NWS forecasts. Interactions primarily in Northern tier states	Precipitation data and summaries Routine forecasts: stage and flow summaries & forecasts; seasonal volume & peak flow forecasts; snowmelt and water supply forecasts;	Timing and accessibility of forecast information still needs work in many cases; may want additional access to historical data
Federal Agencies US Geological Survey (USGS) (National - All Regions)	Exchange of field survey data, observations, weather forecasts, short-term and long-term hydrologic forecasts, and climatological data to support USGS research and field operations and NWS forecasts.	Precipitation data and summaries Routine forecasts: stage and flow summaries & forecasts; seasonal volume & peak flow forecasts; snowmelt and water supply forecasts; Event forecasts: Flood watches, warnings, and statements	Spatial distribution of observation and forecast points not always adequate; funding issues in both agencies result in changes to distribution of sites; availability and delivery of data not always timely

Economic Segment **Customer/Partner**	**User Requirement**	**NWS Product or Service**	**Comments/Issues**
Federal Agencies Bureau of Reclamation (BOR) (MultiRegional)	Exchange of observations, forecasts, and operation plans to support BOR project operations and NWS forecasts. Actual data needs will vary by project type. Interactions primarily in the Western states.	Precipitation data and summaries Routine forecasts: stage and flow summaries & forecasts; seasonal volume & peak flow forecasts; snowmelt and water supply forecasts; Event forecasts: Flood watches, warnings, and statements	Enhancements to forecast duration and accuracy are desired
Federal Agencies National Marine Fisheries Service (NMFS) (MultiRegional)	Access to hydrometeorological observations and river and small stream forecasts, including reservoir inflow and seasonal forecasts, to support NMFS operations.	Precipitation data and summaries Routine forecasts: Quantitative Precipitation Forecasts (QPF); stage and flow summaries & forecasts; seasonal volume & peak flow forecasts; snowmelt and water supply forecasts flash flood and headwater guidance	Improvements to forecast accuracy, and accuracy and temporal resolution of flash flood guidance desired
Federal Agencies National Forest Service (NFS) (Regional - AR)	Access to meteorological and hydrologic observations, including historical data, to support NFS operations	Precipitation data and summaries Routine forecasts: stage and flow summaries & forecasts	Access to historical data and observations on NWS web pages
Other Governmental Fishery and resource management (Regional - WR)	Access to meteorological and hydrologic observations and forecasts, including QPF	Precipitation data and summaries Routine forecasts: stage and flow summaries & forecasts; flash flood and headwater guidance; QPF	Additional local observation and forecast points and improvements to accuracy and temporal resolution of flash flood guidance desired
Other Governmental State Climatologist (Local - LA)	Access to rainfall observations and analyses and river stage data and forecasts	Precipitation data and summaries Web based precipitation analyses Stage and flow summaries & forecasts;	

Economic Segment **Customer/Partner**	**User Requirement**	**NWS Product or Service**	**Comments/Issues**
Agriculture Dairy farmers, general agriculture (Regional - WR)	Access to river and water supply observations and forecasts	Precipitation data and summaries Routine forecasts: stage and flow summaries & forecasts; seasonal volume & peak flow forecasts; snowmelt and water supply forecasts	
Water Management River Authorities Irrigation Districts Water Districts Water Associations (National- most Regions)	Access to real-time precipitation observations and analyses, QPF, stage and discharge observations, reservoir inflow forecasts, river forecasts, flood warnings, drought or flood outlooks, and water supply forecasts to support optimum multi-purpose use of limited water resources	Precipitation data and summaries Routine forecasts: Flood and Drought Outlooks Quantitative Precipitation Forecasts (QPF); stage and flow summaries & forecasts; seasonal volume & peak flow forecasts; snowmelt and water supply forecasts; extended streamflow predictions flash flood and headwater guidance Event forecasts: Flood/flash flood watches, warnings, and statements {AHPS probabilistic graphics or inundation mapping at some sites} Direct contact or briefings during significant events	Sophisticated users would like more access to advanced data for local models as well as probabilistic forecasts and inundation mapping. Some users want web graphics that permit rapid visual evaluation of status. Others need additional observation or forecast points Better access to real time data as governmental entities serving public interest
Water Management Storm Drainage Districts Water Quality City Water Supply Waste Water Treatment (National?)	Access to real time precipitation observations, analyses, and forecasts; stage and discharge observations and forecasts; and water supply outlooks to support best management practices of municipal water resources	Precipitation data and summaries Routine forecasts: Flood and Drought Outlooks Quantitative Precipitation Forecasts (QPF); stage and flow summaries & forecasts; snowmelt and water supply forecasts Event forecasts: Flood/flash flood watches, warnings, and statements	

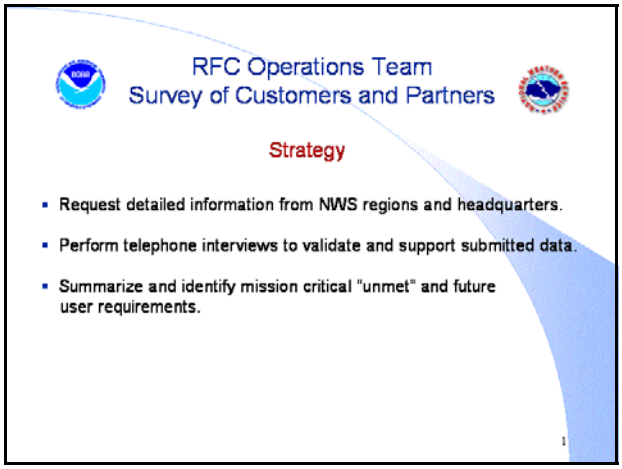
Economic Segment **Customer/Partner**	**User Requirement**	**NWS Product or Service**	**Comments/Issues**
Power Generation Power Companies Utility Companies Power Administrations Power Commissions (National- All Regions)	Exchange of observations and operation plans to support project operations and NWS forecasts. Access to NWS products will vary by project type but may include precipitation forecasts, short term and long term stage and discharge forecasts including reservoir inflow, seasonal outlooks, and snowmelt or water supply forecasts.	Precipitation data and summaries Routine forecasts: stage and flow summaries & forecasts; reservoir/lake inflow forecasts; seasonal volume & peak flow forecasts; snowmelt & water supply forecasts; Event forecasts: Flood watches, warnings and statements {AHPS probabilistic graphics or inundation mapping at some sites}	Observations and forecasts may be needed at additional locations. Probabilistic forecasts could allow basis for decision-making.
Manufacturing Riverside industrial (MultiRegional)	Access to real time hydrometeorological observations and forecasts	Precipitation data and summaries Routine forecasts: stage and flow summaries & forecasts; Event forecasts: Flood watches, warnings and statements {AHPS probabilistic graphics or inundation mapping at some sites}	
Other Governmental National Emergency Management (National - All Regions)	Access to quick look National graphics and outlook products identifying areas with risks of significant flooding; access to detailed information in high risk areas	National Flood Outlook Product RFC Flood Outlook Products and Summaries	
Other Governmental Regional Emergency Management (MultiRegional)	Access to detailed flood information, including flood mapping and probabilistic forecasts, and detailed hurricane inland flooding projections for tropical coastal areas	Graphic products showing expected extent and severity of flooding	

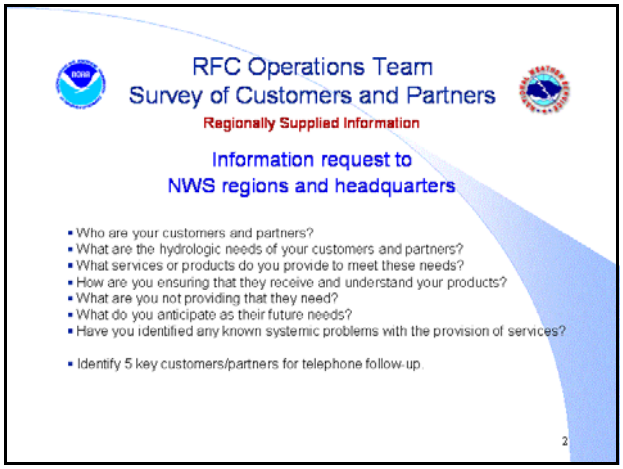
Economic Segment **Customer/Partner**	**User Requirement**	**NWS Product or Service**	**Comments/Issues**
Other Governmental State and Local Emergency Management (National - All Regions)	Timely access to accurate, real time precipitation observations, analyses, and forecasts; stage and discharge observations and forecasts; and information on impacts of projected flooding to support management of emergency operations (such as flood inundation mapping)	Precipitation data and summaries Routine forecasts: stage and flow summaries & forecasts; QPF Event forecasts: Flood or flash flood watches, warnings and statements {AHPS probabilistic graphics or inundation mapping at some sites} Frequent personal contacts during significant events	Hydrologic experts not always available at WFO. Additional observation and forecast points needed, including information on snowpack. One consistent statewide product needed. Dissemination methods not universally useful, in part because of isolation or technology levels of users; all dissemination needs to be faster and more reliable. Graphical inundation mapping good.
Other Governmental Dam Safety Agencies (WR)	Exchange of data on dam inspections, dam modifications and statistics for rainfall and stage or discharge observations and forecasts to ensure both groups have the necessary data to perform their functions	Precipitation data and summaries Routine forecasts: stage and flow summaries & forecasts; QPF Informational meetings	Many agencies are unaware of the NWS role in forecasting associated with dam breaks.
Transportation Railroad Company (MultiRegional)	River level observations and forecasts to facilitate safe movement of freight and passengers on bridges and tracks during high water.	Routine forecasts: stage and flow summaries & forecasts; Event forecasts: Flood or flash flood watches, warnings and statements	
Transportation/Navigation Shipping Associations Barge Companies Port Authorities (National-Most Regions)	Access to observations and forecasts (short term and very long term) of river stage, discharge, velocity, and ice formation or breakup to support navigation and load planning and scheduling	Routine forecasts: stage and flow summaries & forecasts Extended streamflow forecasts River ice breakup summaries Sea/shore ice summaries Event forecasts: Ice jam warnings and statements	Longer range and more accurate forecasts are needed. One stop shopping for information on navigable routes needed.

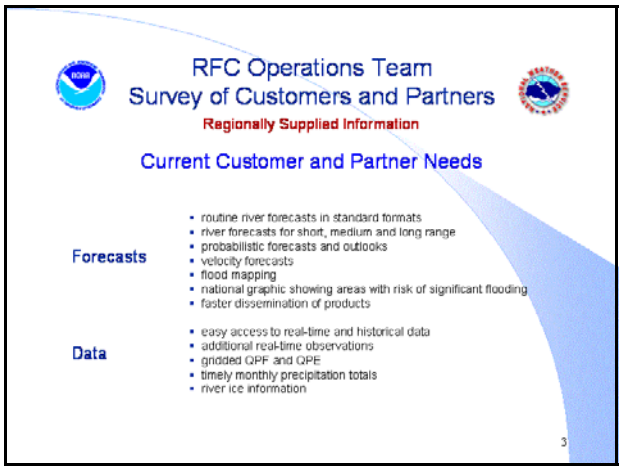
Economic Segment **Customer/Partner**	**User Requirement**	**NWS Product or Service**	**Comments/Issues**
Recreational Users Scenic River Commissions Canoers/ Kayakers/ Boaters/ Rafters Recreational fishermen Sport fishermen Water tour companies (National - All Regions)	Access to weather and river observations and forecasts, with focus on comparisons to normal and extreme data points to allow for trip planning and safe operations	Precipitation data and summaries WFOs: Zone forecasts Routine forecasts: Stage and flow summaries & forecasts Extended streamflow forecasts Recreational river summaries/ forecasts Event forecasts: Flood & Flash Flood watches, warnings and statements Web page hydrographs (some AHPS) Phone recordings	Need to improve accuracy, timeliness and availability of products to increase confidence of users. Need to have high quality observations available on more of the wild or scenic rivers. Knowledge level at WFOs inconsistent.
Media Press Television Radio (National- All Regions)	Some exchange of rainfall data and access to timely, accurate, quality-controlled precipitation and river observations and forecasts for 3-5 days with descriptions of impact to assist media in informing their audiences.	Precipitation data and summaries Routine forecasts: Stage and flow summaries & forecasts Event forecasts: Flood & Flash Flood watches, warnings and statements Web page hydrographs (some AHPS) Interviews and background information	
Public Riverfront homeowners (National - All Regions)	Access to timely, accurate river and flood observations and forecasts with enough advance warning to allow actions to minimize loss of life and property damage	Precipitation data and summaries Routine forecasts: Stage and flow summaries & forecasts Seasonal outlooks Event forecasts: Flood & Flash Flood watches, warnings and statements Web page hydrographs (some AHPS)	Need more gage sites in flood prone areas. Need to improve accuracy of flood information to improve public confidence.
Public General Public Travelers (National - All Regions)	Access to timely, accurate precipitation, river, and flood observations and forecasts with enough detailed information and recommended actions to minimize risk to life and property	Precipitation data and summaries Routine forecasts: Stage and flow summaries & forecasts Seasonal outlooks Event forecasts: Flood & Flash Flood watches, warnings and statements Ice breakup summaries and forecasts Web page hydrographs with 3-10 day forecasts (some AHPS)	No universal dissemination technique guaranteed to reach all users- different technological capability of users, differences in NWR coverage, differences in public media coverage

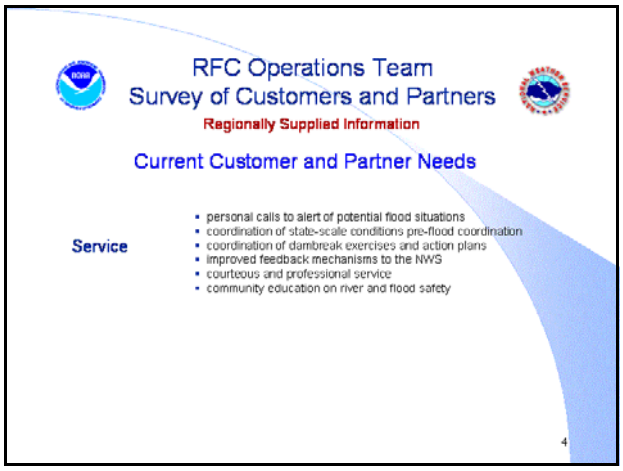
Economic Segment **Customer/Partner**	**User Requirement**	**NWS Product or Service**	**Comments/Issues**
Research Community Universities Schools Value Added Providers (National- All Regions)	Access to current accurate precipitation, river, and flood observations and forecasts and historical data to support evaluation of existing theories and procedures and development of new techniques and the advancement of hydrologic science	Precipitation data and summaries Routine forecasts: Stage and flow summaries & forecasts Seasonal outlooks Event forecasts: Flood & Flash Flood watches, warnings and statements Periodic contact Participation in seminars and conferences	
NWS Offices Weather Forecast Offices Weather Service Offices National Centers (National - All Regions)	Exchange of hydrometeorological observations and forecasts; consultation on observational metadata such as flood stage; access to flash flood tools and support during flash flood episodes; access to hydrologic expertise and field support to ensure successful hydrologic forecast program	Precipitation data and summaries QPF, QPS, QPE Stage and flow summaries and forecasts Seasonal outlooks Guidance for event forecasts (flash flood tools and crest forecasts) Hydrometeorological discussions Field work support Routine coordination and contact Hydrologic expertise Outreach support Development of new AHPS tools and products	Need more widely distributed representative precipitation and stage/ discharge observations. Need to complete basin calibrations to support distributed modeling. Need to enhance and improve flash flood tools. Need better quality control on observations from all office types

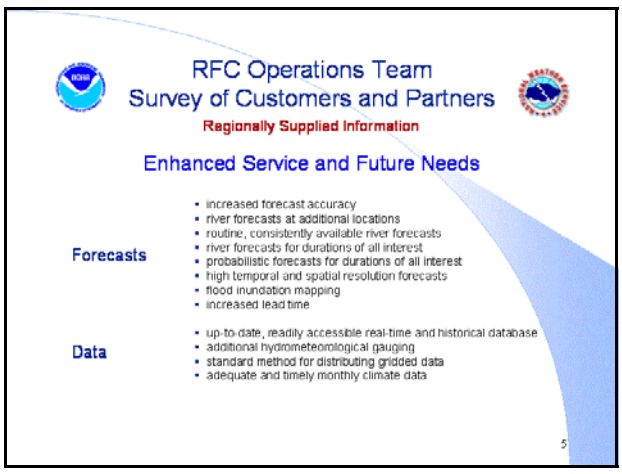
4. External Customer Needs Assessment - Results











RFC Operations Team
Survey of Customers and Partners

Telephone Follow-up

Validation of national needs assessment

Key customers and partners provided by regions
- 45 contacts
- all RFCs represented
- Emphasis on OK, NC, and TX per Team Charter.

Survey conducted by phone

7

RFC Operations Team
Survey of Customers and Partners

Telephone Follow-up

Surveyed Customers and Partners

Federal

U.S. Forest Service (RK)
U.S. Geological Survey(AK,CA,NC,OK-2,TX)
Natural Resources Conservation Service (AR,OR)
U.S. Army Corps of Engineers (MO,MS,NC,OK,OR)
U.S. Bureau of Reclamation (CO,OK,JD)
FEMA Region IV (NC)

Regional

Ohio River Valley Water Sanitation Commission
Susquehanna River Basin Commission
Potomac River Basin Commission
Salt River Project
Lower Colorado River Authority (2)
San Antonio River Authority
Trinity River Authority

State and Local

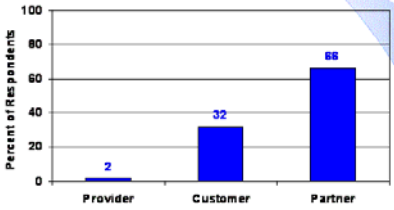
Harris County, TX Flood Control Dist.
Harris County, TX Office of Emergency Mgt.
Oklahoma Dept. of Emergency Mgt.
City of Tonkawa, OK
LeFlore County, OK
City of Miami, OK
Oklahoma Scenic River Commission
North Carolina Div. of Water Resources
North Carolina Dept. of Emergency Services
Edgecombe County, NC
Franklin County, NC
South Florida Water Mgt. Agency, FL
Wyoming Water Development Commission
Steuben County, NY
NYS Canal Corp., NY
Kenai Peninsula Borough, AK
Walsh County, ND
City of Wichita, KS
Humboldt Bay Municipal Water Dist., CA

8

RFC Operations Team
Survey of Customers and Partners

Telephone Follow-up

Relationship with NWS

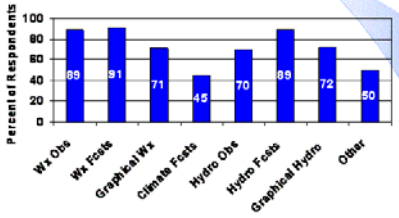


9

RFC Operations Team
Survey of Customers and Partners

Telephone Follow-up

NWS Products and Services Used

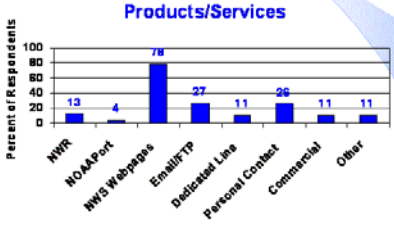


10

RFC Operations Team
Survey of Customers and Partners

Telephone Follow-up

How Customers Get NWS Products/Services

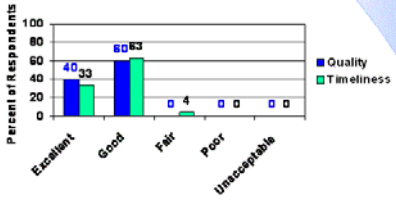


11

RFC Operations Team
Survey of Customers and Partners

Telephone Follow-up

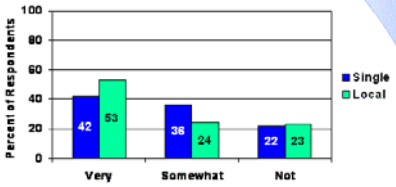
Quality/Timeliness of NWS Products and Services



12

RFC Operations Team
Survey of Customers and Partners
Telephone Follow-up

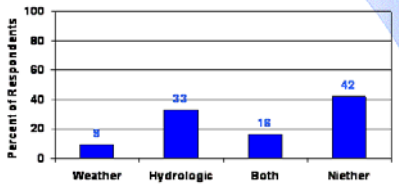
Importance of a Single/Local NWS Point of Contact



13

RFC Operations Team
Survey of Customers and Partners
Telephone Follow-up

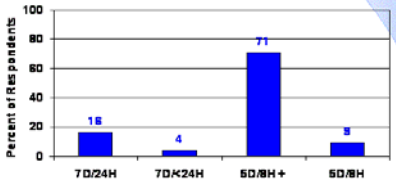
Customers/Partners Engaged in Forecasting



14

RFC Operations Team
Survey of Customers and Partners
Telephone Follow-up

Customer/Partner Hours of Operation



15

RFC Operations Team
Survey of Customers and Partners
Telephone Follow-up

Primary Shortcomings of NWS Hydrologic Products/Services

- not enough forecast locations
- no forecasts provided for user's area
- limited forecast services for smaller streams
- inadequate accuracy of crest forecasts
- inadequate accuracy of long-lead river forecasts
- 6 hr time step is too long
- awkward to run NWSRFS remotely

- not enough personal contact
- not enough outreach and customer training
- difficult to work closely with several WFOs
- service varies from office to office

- inadequate accuracy of QPF and QPE
- quality of QPF varies with personnel on shift

- no comprehensive product
- dissemination is unreliable
- rural areas are hard to reach with graphical products

- monthly coop precip data is untimely
- not enough data sites
- undependable gauging during ice buildup/breakup
- WSR88D storm total precip start times inconsistent

16

RFC Operations Team
Survey of Customers and Partners
Telephone Follow-up

Suggestions to Improve Usefulness of NWS Hydrologic Products/Services

- increase hydrographs and include forecasts
- issue routine forecasts earlier in the day
- update forecasts more often
- shorten model time step
- indicate forecast likelihood
- increase details in flood information
- develop forecast models for Florida hydrology
- refine hydrologic forecast model
- implement flood mapping
- include effects of water mgt activities in ESP

- increase advertising and improve public awareness
- improve/enhance customer education
- increase interagency coordination on environmental issues

- relate forecast stages to past events
- put everything on the web and allow full access
- get observations onto internet faster
- make radar precip estimates available
- provide access to historical data
- archive the ASOS data and provide access
- update TP40

- create a more reliable dissemination system
- hire emergency services specialists

17

RFC Operations Team
Survey of Customers and Partners
Telephone Follow-up

Suggestions to Improve Interactions

- increase collaborative interest at NWS offices where it is lacking
- develop more local programs (training, demonstrations, etc.)
- increase visibility and get involved (advisory groups, etc.)
- increase face-to-face time
- increase availability and opportunities to meet staff
- conduct annual meetings
- provide a local point of contacts

18

RFC Operations Team
Survey of Customers and Partners

General Conclusions

- Contacted customers validated and supplemented the information provided in the regional surveys.
- Regional survey had more details on "how" to accomplish improved service.
- Results suggest our customers are more interested in "what" we provide than "how" we provide it.

19

RFC Operations Team
Survey of Customers and Partners

Activity Findings

- NWS is doing a good job of meeting customer's and partner's basic hydrologic service requirements.
- NWS has many very satisfied customers and many NWS offices have great working relationships with their customers.
- Customers provided a clear indication of what would constitute enhanced service.

20

RFC Operations Team
Survey of Customers and Partners

Customer and Partner Needs for Enhanced Service

- Forecast Improvements
- Products and Data Improvements
- Interaction Improvements

21

RFC Operations Team
Survey of Customers and Partners

Forecast Improvements

- Provide routine and consistently available forecast information
- Increase forecast accuracy and dependability
- Issue routine forecasts earlier in the day
- Expand forecast locations
- Provide forecasts for smaller, fast responding watersheds
- Increase temporal precision (i.e.. hourly)
- Provide forecast likelihood
- Provide variable (multiple) duration (hours, days, weeks)
- Improve QPF and QPE

22

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Data and Product Improvements

- Provide on-line real-time and historical data access
- Provide consistency of products and information
- Improve timeliness of coop program data collection
- Increase density of data collection networks

23

RFC Operations Team
Survey of Customers and Partners

Interaction Improvements

- Increase communication and coordination with counties
- Address intra and inter WFO/RFC partnership inconsistencies
- Improve public awareness and customer education

24

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Appendix C

Review of Internal Assessments, Reports, and Evaluations

Natural Disaster Survey Report
Disastrous Floods on the Trinity, Red and Arkansas Rivers May 1990
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Silver Spring, Maryland
May 1990

Natural Disaster Survey Report
Disastrous Floods on the Trinity, Brazo, Colorado, and Guadalupe Rivers in Texas(Dec 1991-Jan 1992)
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Silver Spring, Maryland
April 1994

Natural Disaster Survey Report
Puerto Rico Flash Floods January 5-6, 1992
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Silver Spring, Maryland
July 1992

Natural Disaster Survey Report
The Great Flood of 1993
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Silver Spring, Maryland
February 1994

Natural Disaster Survey Report
Tropical Storm Alberto Heavy Rains and Flooding Georgia, Alabama, Florida July 1994
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Silver Spring, Maryland
December 1995

Natural Disaster Survey Report
Northeast Floods of January 1996
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Silver Spring, Maryland
March 1998

Service Assessment
Hurricane Fran August-September 1996
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Silver Spring, Maryland
July 1997

Natural Disaster Survey Report
Disastrous Floods from the Severe Winter Storms in California, Nevada, Washington, Oregon, and Idaho December 1996-January 1997
Prepared by Western Region Headquarters
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Silver Spring, Maryland
October 1997

Service Assessment and Hydraulic Analysis
Red River of the North 1997 Floods
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Silver Spring, Maryland
August 1998

Service Assessment
Ohio River Valley Flood of March 1997
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Silver Spring, Maryland
August 1998

Service Assessment
Hurricane Floyd Floods of September 1999
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Silver Spring, Maryland
May 2000

Evaluation of Southern Region's River Forecast Center 24x7 Operational Test

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Silver Spring, Maryland
March 2001

Service Assessment
Tropical Storm Allison Heavy Rains and Floods Texas and Louisiana June 2001
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Silver Spring, Maryland
December 2001

Event / Publication	Finding	Recommendation	Page
Disastrous Floods on the Trinity, Red and Arkansas Rivers, May 1990	WGRFC was not staffed the evening of May 1 even though area lakes were full, the upper Trinity River was above flood stage in several locations, and QPF indicated 4 to 5 inches of rain by the next morning. However, the RFC forecaster responsible for the Trinity River was aware of the situation and was in telephone contact with WSFO Forth Worth.	RFCs should remain open during potentially dangerous flood situations...The Modernization and Restructuring of the NWS that is presently underway calls for RFC staffing levels which will allow operations 16 hours a day, 7 days a week. This should greatly relieve river forecasters who are overburdened during prolonged floods.	D-1 to D-2
	River forecasts prior to the levee failure very properly made no mention of potential structure failure. River forecasts should not speculate on the integrity of structures. However, warnings should be issued when there is potential for overtopping. The forecasts called for the river to rise to 2.35 feet below the assumed top of the levees, and mention was made of the levees.	The MIC and SH must ensure that the staff at WSFOs and WSOs are trained in and carry out hydrologic data collection tasks. This becomes critical during extended floods when SH becomes overloaded.	D-2
	The long duration of this flooding episode placed an unusual burden on the staff of the Oklahoma City WSFO, and especially the SH, because of time-consuming direct telephone contact with the affected public.	The NWS should examine its policy on what level of service be available to individuals during flood situations. If telephone contacts are to be encouraged, an extra desk may be needed during flood situations to handle these. If telephone contacts are to be discouraged, alternative forms of dissemination are needed. Local WSFO managers should be encouraged to staff a desk full time during flood situations to handle needed warnings and to deal directly with the public. If WSO and WSFO staff are to continue answering public questions on flood events, more training or guidance should be considered to help them give the best possible answers to the public's questions. In the modernized NWS, RFCs should provide improved direct contact services with our principle cooperators, senior emergency management officials, and the media.	D-3

Event / Publication	Finding	Recommendation	Page
Disastrous Floods on the Trinity, Brazo, Colorado, and Guadalupe Rivers in Texas(Dec 1991-Jan 1992)	4-2 The public may not have understood the role of the NWS in the issuance of warnings and river forecasts.	4-2 WPMs and MICs should continue to make a concentrated effort to educate all uses about the NWS, including providing information about what the NWS does and what products it is responsible for. In addition, it would be helpful for the media to see and understand NWS local partnerships and their important roles in the warning/safety process.	83-84
	4-6 SHs prepared and conducted excellent training for forecasters at their offices, but limited attention was provided to the WSOs.	4-6 Hydrologic training should be provided by the SH to personnel at the WSO level. Local offices involved in the flood warning system should also be invited to attend.	84
Puerto Rico Flash Floods January 5-6, 1992	Chapter 2, 2.2 Forecasters at WSFO San Juan did not envision the rapid development of the convective activity nor the potential for it to stall over the interior of the island Chapter 2, 2.3 With the heavy workload involved in coordination and issuance of watches, warnings, forecasts, and statements–and inaccessible staff due to the holiday–no additional personnel were called in to augment the WSFO staff as the even unfolded. Chapter 2, 2.5 The staffing level at WSFO San Juan is currently below the model staffing level due to budgetary constraints.		7
The Great Flood of 1993	2.4 RFCs do not routinely store river and flood forecast information and products in digital form Similarly, the National Meteorological Center (NMC) does not routinely archive quantitative precipitation forecasts (QPF) products in digital form. These data and forecast products are critical for post-event analyses, research and development, model calibration, extended streamflow prediction and simulation requirements, climatological studies, and forecast verification.	2.4 Routine procedures must be implemented at the NMC and the RFCs, as part of modernized system capabilities, to archive all data and products in digital format that are pertinent to ongoing developmental, operational, and verification programs.	9-2

Event / Publication	Finding	Recommendation	Page
The Great Flood of 1993	2.7 The modernized NWS has a critical need for professional personnel trained in both hydrology and meteorology and has developed qualification criteria for these new hydrometeorologists.	2.7 NWS and NOAA managers and personnel offices must ensure that personnel, recruitment, qualifications, and promotion processes appropriately reflect requirements for hydrometeorologists.	9-3
	6.11 Many meteorological forecasters did not feel proficient handling prolonged and major hydrologic operations when an SH was not in the office or on staff. Consequently, it was much more difficult to maintain a high-quality hydrologic program without immediate access to specialized hydrologic expertise. Those offices with SH positions reported them indispensable on the capacity of local expert who coordinates hydrologic training of office staff, data flow, user interaction, media contacts and forecast services.	6.11 In the modernized weather service, the NWS should revisit its planned staffing allocations for SHs necessary to support those WSFOs that have high levels of significant hydrologic activity.	9-18
	6.13 Both MBRFC and the NCRFC provided extended coverage for most of the protracted flood events on a 7-days-a-week schedule well into the evening (usually until 10 or 11 p.m.). Nevertheless, certain users cited an inability to acquire needed information during hours when the RFCs were not in operation, and many end-users require 24-hour RFC support during major flood events. The NCRFC provided around-the-clock coverage for 4 days during the event. The MBRFC provided 24-hour coverage for 2 days.	6.13 RFCs should be staffed for 24-hour coverage during major flood events.	9-19
	6.15 The NCRFC staff stated that if planned staffing for Hydrometeorological Analysis and Support forecasters in the modernized weather service had been on board, the NCRFC would have been able to analyze, in greater depth, the radar rainfall estimates and QPF products.	6.15 Within currents budget constraints, NWS Headquarters and regional offices should do everything possible to complete the modernized staffing levels for the RFCs.	9-19

Event / Publication	Finding	Recommendation	Page
The Great Flood of 1993	6.17 During the flood event, a large number of flood products were issued including Flood Warnings, Flash Flood Warnings, and Urban and Small Stream Flood Advisories. The appropriate choice of product headers, and when to use them, at times confused NWS meteorological forecasters.	6.17 The SHs should ensure that all office staffs are trained on the appropriate use of product types.	9-20
	6.18 Extra personnel rotated into the RFCs and WSFOs and worked many hours overtime. The scheduling of leave or training for WSFO and RFC staff became a factor in maintaining adequate staffing levels.	6.18 During long, widespread record events of this type, essential personnel should return to their duty stations from long-term assignments. Anyone withdrawn from long-term training under these conditions should reschedule for a later date.	9-20
	7.7 Emergency operations centers (EOC) were established at several locations including Kansas City, Minneapolis, Des Moines, and St Louis. These centers were staffed by key personnel from a variety of Federal, state, and local agencies involved in coordinating flood operations and disseminating information. WSFO and North Central RFC\WSFO Minneapolis maintained a periodic presence at EOCs through much of the flood event. Given limited staffing available, it is out of the question for any NWS office to provide around-the-clock, on-site staffing support for EOCs. Although other WSFOs and RFCs provided information, they did not provide on-site representation at EOCs. On other cases where official EOCs were not established, close alliances were formed with the COE, the USGS, and local officials, such as in North Dakota.	7.7 All WSFOs, RFCs and WSOs should provide the highest level of support possible to EOC operations within their service areas during emergency situations. Highly reliable communications between the EOC and the WSFO/WSO/RFC is essential. When feasible, periodic, on-site EOC support should be provided. Such actions would improve coordination and cooperation in addition to increasing NWS visibility.	9-22 to 9-23

Event / Publication	Finding	Recommendation	Page
The Great Flood of 1993	7.9 The Rock Island COE District strongly encouraged cross-training between COE and RFC personnel. Cross-training of NWS and COE personnel would substantially improve intra-agency and interagency operations, not only during flood events when personnel may be shifted from one office to another but also during routine operations	7.9 The COE and the NWS should establish a technical working group consisting of personnel from all appropriate NWS and COE offices to ensure that techniques and procedures are fully understood and that clear points of contacts are established to clarify any potential misunderstandings during flood events. Moreover, the NWS and COE offices should implement a personnel exchange program whereby personnel from the two agencies would work on-site in the other cooperating agency's office either part-time or full-time.	9-23
	8.5 The media and the public do not fully understand hydrologic terminology, procedures, and forecast products.	8.5 The NWS and NOAA Public Affairs, at all levels, should develop a public education program to increase awareness of and understanding about the hydrology program by using brochures, news releases, facts sheets, and other background materials, along with increased interaction with the media.	9-27
Tropical Storm Alberto Heavy Rains and Flooding Georgia, Alabama, Florida July 1994	2-19 Communities...not as prepared...as they could have been...	2-19, 2-20, 2-21 increase public education	38-39
	2-22 The disaster team felt it was inappropriate for a single NWS office to be expected to respond to an event that covered multiple office and to FEMA's national-level press and Federal coordination briefings. In addition, there was an imbalance in the media contacts and interest with continued potential from weather hazards.	2-22 The NWS should establish a national media unit to provide beginning-to-end coverage of storm events that have national impact of interest...	39
	RFCs and WFOs Insufficient Staffing Issues	3-1, 3-2, 3-3, 3-5, 3-6, 3-7 ...need staff to cover operations	41-44
	3-9 One-on-one phone contacts between the NWS and all types of users are frequently associated with the user's satisfaction with the service provided the NWS. However, the number of individual phone calls which can and should be made is limited...	3-9 The NWS must be more sophisticated in its use of communications...	45-46

Event / Publication	Finding	Recommendation	Page
Northeast Floods of January 1996	1.6 There has been insufficient training on certain aspects of the physics of a snow cover for hydrologists at the RFCs, especially in regard to liquid water retention in the pack and energy exchange at the surface.	1.6 Additional training should be provided to the RFCs on the physics of snow ablation.	1-46
	2.2 Given the uncertainty associated with routine QPFs, updates are needed whenever an earlier forecast is underway or overestimating basin average precipitation. Coordination is required between RFC and the Weather Forecast Offices (WFO) for updating river forecasts when needed.	2.2 Offices need closer coordination in issuing updated or amended routine QPF products. The HAS function can serve as a catalyst in coordinating updates between the RFC and WFO.	2-4
	NWSOs and NWSFOs require additional hydrologic information.	RFCs, in cooperation with NWSOs and NWSFOs, should provide, as appropriate, more hydrologic information (e.g. complete hydrographs, flow, etc). Improved communications (including graphical) systems must be developed in order to provide additional hydrologic information.	2-15
	2.8 Although most offices correctly issued many flood and flash floods watches, warnings, and advisories, there is still some confusion as to what information the products should contain, how to incorporate this information in short-term forecasts, and what information should be contained in Flood/Flash Flood Statements versus the short-term forecasts.	2.8 Many new AFOS headers are being added for specialized products. WSH should look for ways to eliminate some product headers and provide the user with fewer products that give all necessary information instead of issuing many products for specialized situations.	2-18
	5.2 During this event, there was intense demand for the hydrologic expertise of the SH not only in the office but also on the telephone.	5.2 Whenever possible during widespread and high-profile events such as the Northeast Floods of January 1996, each office should designate at least one member of the management team as the main point of contact to the media and emergency management community. Also, hydrometeorology cross training will help ease the demand on the SH and spread hydrologic expertise throughout the office staff.	5-3
	5.7 Many media do not understand hydrologic forecast techniques and the role of the RFC in the NWS infrastructure	5.7 NWS offices should work with state and local media outlets to educate them on the hydrologic/meteorological process. Media representatives are interested in participating in workshops...AMS...ASCE...	5-5

Event / Publication	Finding	Recommendation	Page
Hurricane Fran August-September 1996	4. Currently in Eastern region, NWSFOs are responsible for the QPF along with their long-fused watches, while HSA support is provided by both the NWSFO and NWSO. This split responsibility is awkward and cumbersome for NWSOs that have HSA responsibilities serviced by more than one NWSFO.	4. Transfer QPF and HSA responsibility to NWSOs concurrently.	Executive Summary, Page XII
	6. ...there is a lack of real-time observations along the most critical east-facing beaches...	6. Efforts to properly equip coastal areas with real-time ocean level observation for both land and marine areas, should be intensified.	XII
Disastrous Floods from the Severe Winter Storms in California, Nevada, Washington, Oregon, and Idaho December 1996-January 1997	NWSFO Boise forecasters indicated that coordination calls were often very time-consuming. Most of the forecasters surveyed did not use the "BLAST-UP" system and disliked multiple-office conference calls, feelings that input was not as candid as person-to-person calls.	Although coordination is vital to improve the quality of NWS public products, procedures should be reviewed to streamline the time requirements. It is recommended that a routine conference call be evaluated in an effort to streamline office coordination. Managers and forecasters should promote candid, yet tactful, discussion between forecasters on these conference calls.	13
	John Cline, Director of the BDS, was seriously concerned with the decentralization of responsibility resulting from the NWS modernization. His concern centered on two issues: (1) coordination, and (2) the future ability of the NWS to honor their Memorandum of Understanding (MOU) and dedicate a person to staff the Emergency Operations Center (EOC). His group does not have the time to deal with two, three, or even four individual NWS offices in order to receive weather support during an emergency. Additionally, Mr. Cline expressed concern that during Stage II staffing, the relationship with WSFO Boise will be degraded due to reduced staffing.	The NWS should identify the one office in each state to be responsible for briefing state emergency officials. This designated "state office" should be responsible for acquiring the guidance, forecasts, and briefings provided by appropriate NWS offices. The Meteorologist-in-Charge (MIC) and staff at Boise should do a post assessment to determine if tools could help reduce the requirement of dedicated human staffing by the NWS at the Idaho BDS EOC during the event. The Emergency Managers Weather Information Network, the Boise Internet homepage, and the NOAA Weather Radio should be available to the EOC and could provide a means of "self-brief" by state officials.	13

Event / Publication	Finding	Recommendation	Page
Disastrous Floods from the Severe Winter Storms in California, Nevada, Washington, Oregon, and Idaho December 1996-January 1997	The extra hydrology and EOC staffing by NWSFO Boise stretched the staff resources of the office. However, no Hydrometeorological Technicians (HMTs) were called in to work extra shifts during the event, and overall there appears to be reluctance by NWSFO Boise to integrate the HMT staff into the hydrology program.	The hydrology program is a vital function that is the responsibility of every program of the office. The MIC, SOO, and SOO should work with the operational staff to ensure that everyone is fully aware of the program, fully trained, and has the ability to handle critical flood-related duties.	13-14
	The NWSFO Boise WCM has hosted several media workshops. The unanimous opinion of the local media and the Boise office is that these workshops are very valuable for improving the government-private meteorologist partnership.	All NWS offices should investigate similar workshops to train and meet the local media.	16
	A three-way conference call between NWSFO Boise, NWSO Missoula, and NWSFO Spokane reve4aled that these offices worked well together during this event.	An employee exchange program between coordinating offices should be considered. This will allow the opportunity to understand other office's operations and improve conditions.	16
	EMs from Washington and Payette Counties, where the majority of the flooding occurred, were interviewed. The Washington County EM was very aware of the services NWSFO Boise provided and worked very closely with the Boise staff. On the other hand, the Payette County EM was unaware of the services provided by the NWS. This EM had been on the job less than a year and had no telephone numbers for the NWS office. He was unaware the NWS office was staffed 24 hours a day. This individual did not attend the training sessions for EMS held by the NWS in September 1996. Furthermore, the BDS AREA Field Officer never informed the NWS that Payatte County had a new EM.	The survey team recognizes the difficulty involved in coordinating with some local emergency officials, particularly those who may not recognize the importance of the NWS support until after disaster strikes. Nevertheless, the NWS must ensure that a minimum level of contact is maintained with these officials on a routine basis.	16
	NWSFO Boise and the Idaho BDS established an MOU in 1996 to promote interaction between the two agencies during a weather disaster. During the height of this event, a member of the NWSFO Boise staff provided in-person support to the BDS. The BDS officials expressed their gratitude for the job well done by the NWSFO Boise staff.	All WR field offices should ensure that state and emergency management agencies are aware of the services the NWS can provide. Operating procedures should be established at NWSFO Boise regarding the placement of "on-site" representatives to avoid staffing problems at the NWS office.	16

Event / Publication	Finding	Recommendation	Page
Disastrous Floods from the Severe Winter Storms in California, Nevada, Washington, Oregon, and Idaho December 1996-January 1997	At times, NWSO Eureka staff was confused on which product header to use in a given situation. Also, there was some confusion over which office had responsibility for watches under various situations.	The WR/HSD should review hydrologic products, streamline where possible, and issue clear guidance to field offices on the use of each product and which office(s) have responsibility for issuance of each product type(s). SHs should provide training on products and responsibilities so that all staff members are familiar with hydrology product usage and responsibilities for watch products.	52-53
	NWSO Sacramento issued Flash Flood Watches during this event for potential levee breaches in their HSA...the staff at NWSO Sacramento did not have an "adequate comfort level" on whose office the watch responsibility fell for this situation as described in the WR Regional Operations Manual Letters (ROMLs).	The MSD and HSD in WRH must review the ROMLs on watch dissemination and ensure that all field offices are clear on which office the watch responsibility falls, especially for situation such as potential levee failures.	58
	At times, the NWSO Sacramento staff was confused on which product header to use in a given situation.	The HSD should review hydrologic products, streamline where possible, and issue clear guidance to field offices on the use of each product. SHs should provide training on products so that staff members are familiar with hydrology product usage.	58-59
	An NWSFO Monterey employee was placed in the San Francisco County OES and then to the Region II OES office. This paid dividends in NWS relations with these agencies and provided the opportunity for increased attention for the NWS. These benefits were maximized by having the individual at OES regional office. Many state agencies have expressed the desire for a single point of contact with the NWS. An individual placed at a regional or state office becomes this point of contact be default.	Plans need to be developed and adopted in each state establishing procedures for having a single point of contact between the NWS and state agencies. These plans should include instructions to ensure that adequate coordination occurs between all affected NWS offices and the pint of contact. These plans should be part of the SDM at every office with responsibility within a given sate.	73-74
	The HMTs (NWSFO Reno) contributed greatly to the successful operations during the event. However, they had only limited involvement in actual hydrology operations. The HMTs seemed comfortable with retrieving data from the HYDROMET computer but often would pass along requests for data or river forecast information to the SH or the hydro focal point.	The MIC, SOO, SH, and DAPM need to ensure that all HMTs are fully trained in the flood-related operations at NWSFO Reno, including the use of HYDROMET 4.0 software and the composition of flood products.	82

Event / Publication	Finding	Recommendation	Page
Disastrous Floods from the Severe Winter Storms in California, Nevada, Washington, Oregon, and Idaho December 1996-January 1997	One of the media interviewed revealed that if SH Gary Barbato or assistant Steve Goldstein was not the person he was coordinating with, then the services were much slower. The staff appears to have received hydrologic training, but their proficiency was not sharp as the SH or focal point.	The SH and focal point at NWSFO Reno should continue their fine preparedness activities, working to ensure everyone can retrieve the information requested by customers in an expedient manner.	85
Red River of the North 1997 Floods	12a. NWS products and discussions by NWS staff generally included qualifications intended to convey the uncertainty inherent in NWS outlooks and forecasts. Nevertheless, many users developed a false sense of precision in NWS products.	12. NWS RFCs and offices with hydro responsibilities should review Service Assessment as regards for misunderstandings the precision in NWS products. 12b. NCRFC should investigate estimating explicit exceedance probabilities for its current outlook products...	27
	16. ...desirability to providing NWS staff support for city, county and state EOCs.	16. NWS needs to evaluate...what level of staffing support, if any, can be provided	31
	19. NCRFC HIC and FGF MIC spent many hours providing interviews and other media responses, but they did not have a clear agreement on how they would manage media inquiries. While NWS Public Affairs Officers provided guidance and assistance during the flood event, there was no detailed media plan in place to help guide the MIC and HIC.	19a. PA officers in each NWS region should coordinate flood media plans between NWS river forecast centers and forecast offices. 19b. ...PA develop in each NWS region should develop and conduct media training for each NWS field offices	
Ohio River Valley Flood of 1997	B-1 During the flooding, NWSFO Louisville was involved with multiple severe weather threats as well as the flood threat. All fatalities in the Louisville service area, however, were flood related.	B-1 NWS Louisville should increase the visibility of dangers associated with flooding in their weather education programs, and to the extent possible, increase their outreach efforts on flood preparation.	1
	D-3 There is a high turnover rate at local (county) offices of emergency management. These people play a critical role in disseminating important weather warnings and information in their communities.	D-3 The local NWS should be more active in working with the state and county EMA officials in Kentucky and help plan and conduct periodic training workshops.	2

Event / Publication	Finding	Recommendation	Page
Hurricane Floyd Floods of September 1999	1. The USGS is the agency responsible for maintaining the national stream gag network. The Geostationary Operational Environmental Satellite (GOES) transmission schedule of stream gage data during Hurricane Floyd was every 4 hours. This hindered RFC forecasters' ability to provide timely and accurate river forecasts.	1. Regions should instruct field offices to contact the USGS with their requests for hourly GOES data collection and distribution.	23
	2. Coastal WFOs received real-time Sea, Lake, and Overland Surge from Hurricanes (SLOSH) forecasts from TPC during Hurricane Floyd. These products are not routinely provided during hurricanes. WFOs indicated these forecasts allowed them to provide more specific storm surge forecasts to their customers, and requested real-time SLOSH output during hurricanes.	2. Provide real-time SLOSH outputs to WFOs when a hurricane is within 12 hours of landfall.	23
	3. RFCs provide Flash Flood Guidance (FFG) to WFOs on the amount of rainfall needed to cause flash flooding. WFO Wakefield is served by MARFC and SERFC. MARFC, serving the northern portion of the warning area, provided lower values than the SERFC. It was difficult for Wakefield forecasters to determine which guidance to use.	3. Ensure Flash Flood Guidance is consistent across RFC boundaries.	23
	4. Several WFOs requested SERFC and NERFC issue river forecasts containing river stage every 6 hours instead of forecasts containing river stage every 24 hours. The SERFC and MARFC now issue forecasts with river stage every 6 hours.	4a. MARFC should issue river forecasts containing river stage every 6 hours. 4b. With input from partners, customers, and associated WFOs, the remaining ten RFCs determine if river forecasts should contain river stage information every 6 hours.	24
	5. SERFC provided flood potential graphics on their Internet Web site. Graphics depicted the threat of "widespread and major flooding" days in advance of heavy rains. These products were well received by customers, especially FEMA.	5. Based on customer feedback, RFCs determine whether similar flood potential graphics should be provided.	24

Event / Publication	Finding	Recommendation	Page
Hurricane Floyd Floods of September 1999	6. WFOs issue a Flood Warning (FLW) when a river is forecast to reach or exceed flood stage. A Flood Statement (FLS) is used to update a river forecast when a river is in flood. Flood Statements do not raise public awareness as do Flood Warnings but may be the only place where an update to major or record flooding is mentioned.	6. Change policy to require WFOs to issue a Flood Warning rather than a Flood Statement.	24
	7. Precipitation estimates from WFO Sterling, Virginia, WSR-88D significantly underestimated observed rainfall during Floyd. This problem with underestimating rainfall has previously been documented	7. Fix the Sterling WSR-88D precipitation estimation problem.	25
	8. WFO Wakefield, Virginia, collected hourly river stage observations for Emporia, Virginia. When WFO Sterling, Virginia, assummed backup responsibility for Wakefield, observations were collected every 6 hours. Sterling was adhering to the Eastern Region policy that the servicing RFC, in this case SERFC, should provide data collection druing backup. SERFC, however, was adhering to the Southern Region ploicy of data collection being provided by the WFO with backup responsibility.	8. Make backup policy for collecting river stage observations consistent nationwide.	25
Evaluation of Southern Region's River Forecast Center 24x7 Operational Test		Investigate off hour RFC contact procedures for WFOs and external partners to see if they can be optimized.	13
		Identify specific RFC personnel to monitor hydrologic conditions when the RFC is not staffed.	13
		Establish routine WFO coordination procedures for RFC extended staffing decisions.	13
		Advise external partners when RFCs extend their operational staffing.	13
		Establish consistent products and product formats.	13
		Provide graphical Internet products.	13
		Provide one-stop-shopping for hydrologic products on the Internet.	13
Event / Publication	Finding	Recommendation	Page

Evaluation of Southern Region's River Forecast Center 24x7 Operational Test		Provide more timely updates during severe floods.	13
		Include more flood potential information in hazardous weather outlooks.	13
		Reduce the number of hydrologic product types.	13
		Clarify flood product terminology.	13
		Provide shorter time steps for fast responding streams.	13
		Improve low flow forecast information for navigable rivers.	13
		Include uncertainty in river forecasts.	13
		Provide more timely access to all archived flood event data after an event. (Involves several agencies, not an RFC function).	13
		Issue routine morning hydrologic forecasts earlier.	14
		Establish consistent update frequencies for flash flood guidance.	14
		Clarify the roles of WFOs and RFCs regarding interaction with the media and emergency management.	14
		Conduct more frequent meetings with partners to assess their needs.	14
		Educate our partners on how to be use our services.	14
		Increase site survey travel for model calibrations.	14
		Calibrate models using observed instantaneous discharge rather than mean daily flows.	14
		Modernize the hydrologic models through distributed modeling techniques.	14
		Enhance flash flood program through improved science.	14

Event / Publication	Finding	Recommendation	Page
Evaluation of Southern Region's River Forecast Center 24x7 Operational Test		Put more hydrologic expertise into the Flash Flood Monitoring and Prediction System	14
		Increase availability of timely stream gage data.	14
		Review, update, and enhance river stage history data.	14
		Modernize the Cooperative Observer Program and provide customers and partners with improved access to near real-time and historical records.	14
Tropical Storm Allison, Heavy Rains and Floods, Texas and Lousiana, June 2001	1. Forecasts provided to be difficult for some small rivers/bayous that rose rapidly to record levels. Forecasts for Buffalo Bayou at Sheperd Drive in Houston underforecast the river stage 6 to 12 feet with little or no lead time. Also, the forecasts for the West Fork of the San Jacinto River near Conroe were not accurate. Both software and procedural problems have been identified by the WGRFC and the NWS Office of Hydrologic Development as contributing to these inaccuracies.	1a. The WGRFC , with the assistance of the NWS Office of Hydrologic Developement, should make the necessary software corrections and implement procedural changes needed for small basins that respond rapidly during heavy rainfall. RFCs should be tasked with changing procedures where inadequate. 1b. Regions should evaluate RFC procedures for small basins that respond rapidly during heavy rainfall. RFCs should be tasked with changing procedures where inadequate.	29
	2. Because of the small size of the bayous in the Houston area, most are not included in the WGRFC forecast system. Harris County has initiated a project to develop new forecast tools for these small basins and has invited NWS participation in this effort. The NWS Advanced Weather Interactive Processing System (AWIPS) Release 5.1.2 includes a site-specific hydrologic model which can be used for small gaged basins.	2a. The WFO Houston/Galveston MIC and the WGRFC HIC should meet with the appropriate Harris County officials to determine the NWS role in the project. Once the NWS role is determined, progress will be tracked through the follow-up service assessment reporting process. 2b. Once the AWIPS site-specific hydrologic model is deployed in Build 5.1.2, WFO Houston/Galveston should determine what contribution this model would make to local flood warning operations.	30

Event / Publication	Finding	Recommendation	Page
Tropical Storm Allison, Heavy Rains and Floods, Texas and Lousiana, June 2001	3. The WGRFC generates Mean Areal Precipitation (MAP) averages from radar rainfall estimates and observed rainfall measurements. Currently, coverage of this product does not include the Houston metropolitan area. MAP estimates would have been useful for assessing the flood risk and supplementing the analysis where gages exist.	3a. The WGRFC should extend the MAP coverage in their regions. RFCs should be tasked with extending MAP coverage where inadequate. 3b. Regions should evaluate MAP coverage in their regions. RFCs should be tasked with extending MAP coverage where inadequate.	30
	4. On a few occasions, the interval was excessive between LMRFC's issuance of river forecasts and WFO New Orleans/Baton Rouge's issuance of flood warnings and statements. At an emergency management meeting sponsored by the Amite River Basin Commission in July, there was strong customer support for more rapid dissemination of river forecasts and warnings. In response, the WFO New Orleans/Batton Rouge MIC and the LMRFC HIC have identified procedural changes and training requirements that will address this need and reduce lag time between the LMRFC and WFO issuances.	4. The WFO New Orleans/Baton Rouge MIC, with the assistance of the LMRFC HIC, should develop and implement a plan to change WFO procedures and provide training to staff to ensure rapid dissemination of river forecasts and river flood warnings.	30
	5. Both Harris County OEM and the Harris County Flood Control District expressed a strong need for river forecasts to be issued in reference to Mean Sea Level (MSL).	5. WFO Houston/Galveston should provide river stages in MSL in river flood warnings and statements.	30

Appendix D

Review of External NRC Assessment

Assessment of Hydrologic and Hydrometeorological Operations and Services
National Research Council
December 4, 1996

Page	Conclusion	Recommendation
2	Weather Forecast Office Hydrologic Forecasting System	3-14/Recommendation - The NWS should reevaluate the staffing needs of WFOs with regard to their hydrologic responsibilities. The number of service hydrologists should be increased so that each WFO has a program leader for WFO hydrologic Operations, at least for the first year or two following implementation of AWIPS at each field office.. A related recommendation is provided in the Qualifications section of this summary.
4	Misunderstandings about the roles and responsibilities of personnel within these operational elements of the NWS - particularly with respect to hydrometeorological duties - need to be resolved at all levels of the organization.	4-1/Recommendation - The NWS must communicate the objectives of the hydrologic and hydrometeorological aspects of the modernization program and progress that has been made in the program more effectively to...users of its services. **NOAA RESPONSE to National Research Council - Pg 26** The NWS concurs with the recommendation. The recently issued correspondence course - *Operations of the NWS Hydrologic Services Program* contains a detailed description of the objectives of the hydrologic and hydrometeorological aspects of the modernization program. All Hydrologic and Meteorologic Interns are required to take this course, and many individuals above the intern level are also electing to take the course because they realize the need to understand these objectives. Continued feedback from groups such as the Service Hydrologist Working Group and the RFC DOHs (periodic meetings are held) will occur...we are encouraged by recent reports that integration of hydrologic operations into the WFO is progressing at a strong pace, even though AWIPS is not yet in place at most WFOs

Page	Conclusion	Recommendation
36	The committee agrees with concerns expressed at field offices that some procedures and techniques used in these activities (Test and risk-reduction activities) are tailored and modified for specific geographic areas and need to be tested for the full range of adverse weather experienced in other areas of the United States.	4-7/Recommendation - Updated information on the NWS hydrology operational test and evaluation activities should be provided to field offices on a routine basis, both to keep employees informed and to encourage broader participation in development and test efforts. **NOAA Response to National Research Council - Pg 36** THE HRL home page is utilized to document planned WHFS modifications and improvements arising from the OT&E.
37-38	The committee concludes that NWS forecasters with a degree or extensive formal education in meteorology but no comparable training in hydrology usually are not qualified for hydrologist positions. A more substantial educational background in hydrology is necessary for personnel working in such positions.	4-11 The NWS should review and, if warranted, modify its qualification standards for hydrology positions. The NWS should require a degree or extensive formal education in hydrology for positions that involve a hydrology emphasis...A more substantial educational background in hydrology is necessary for personnel working in such positions. **NOAA Response to National Research Council - Pg 31-32** "...The NWS will utilize several approaches to increase the hydrologic knowledge levels of those in hydrology of hydrology-emphasis positions. These are outlined Hydrometeorological Services Operations for the 1990's, pages 4-6 and D-1,2.
10, Col 1, Par 2	**This was taken from a paragraph in the document. <u>It is not one of the conclusions.</u>** Collocation of RFCs with WFOs to date has demonstrated that direct personal interaction can enhance office operations. However, even at these collocated offices, potential benefits are not being realized because of limited staffing, minimal amounts of cross-training...	
26	To take optimal advantage of the NWSRFS potential, perhaps the most important need is for advanced training for forecasters in the use of both the calibration features and the interactive capabilities of the system.	3-10/Recommendation - In each RFC the level of expertise in the use of NWSRFS calibration procedures vary widely. Life-cycle support for the NWSRFS software is also necessary. This includes software trouble shooting, interactions with users, and integration of new procedures and technologies into software. Adequate training is clearly an issue

Page	Conclusion	Recommendation
27		3-11/Recommendation - To improve consistency in the use of the NWSRFS among RFCs and within RFCs, systematic oversight and effective training programs should accompany the installation of the NWSRFS in RFCs. Training should be provided for all appropriate RFC staff to ensure sustained proficiency in the calibration, verification, development, and use of the NWSRFS.. **NOAA RESPONSE to National Research Council - Pg 10** - NWSRFS has been in use by most of the RFCs for may years in the mainframe environment. As RFCs acquire workstation equipment, they received support and a site visit with training on the use of the new functions in the workstation version of NWSRFS. The on-site training focused mainly on the use of the Interactive Forecast Program which is the graphical user interface to the forecast component of the Operational Forecast System (OFS) of NWSRFS... Additional training in OFS is usually provided once a year in the form of a workshop... As with all NWSRFS-related workshops, resource limitations prevent us from doing formal training for everyone at all RFCs every year... OH has received many requests from the field to provide workshops on various topics, but the resource comstraints limit the number of workshops...
28	There is a potential danger that WFO forecasters may process RFC guidance products through the WHFS and issue warnings and watch products without adequate time for careful scrutiny of RFC guidance...One essential key to proper use of the WHFS is adequate training for service hydrologists...	3-14/ Recommendation - The NWS should clearly reevaluate the staffing needs of WFOs with regard to their hydrologic responsibilities. The number of service hydrologists should be increased so that each WFO has a program leader for WFO hydrologic operations, at least for the first year or two following implementation of the AWIPS at each field office. **NOAA RESPONSE to National Research Council-Pg 14** Service hydrologists were first created in the mid 1970s shortly after implementation of the WSFO/WFO firld office structure. By the mid 1980s, Hydrologic Service Areas (HSA) responsibilities were assigned to 54 NWS offices (mostly WSFOs, but also a few WSOs and RFCs), with the number of service hydrologist positions NWS [eaking at about 45. NOAA concurs that it would have been desirable to establish service hydrologist positions at all 12- WFOs as part of the modernization and associated restructuring (MAR) of the NWS...

Page	Conclusion	Recommendation
29	The WARF objectives to provide long-lead and probabilistic forecasts of low-flow and flood conditions will be important additions to the suite of products and services produced by the modernized NWS...The main shortcoming of WARF and ESP components of the AHPS is the apparent lack of involvement by the NWS field personnel and user community during program development	3-18/ Recommendation - Field personnel and users of products and services should have greater involvement in the further definition and development of WARFS and other components of the AHPS. **NOAA RESPONSE to National Rersearch Council-Pg16** Recognizing the interest and requirements of NWS hydrologic forecasting clientele, the NWS has implemented and demonstrated the Advanced Hydrologic Prediction System (AHPS) for the Des Moines River Basin in Iowa during March 1997...This included solicitation for involvement of RFC personnel within each of the 13 RFCs... ...Des Moines WFO provided them (customers) a questionnaire and conducted a follow-up meeting, inquiring on their requirement...
30	The NWS can best exploit the opportunity that the modernization affords not only by emphasizing technology but also by capitalizing on the overlapping aspects of hydrologic and meteorological science and technology and by developing new operations to aid the interaction and transfer of information between hydrologists and meteorologists. Emphasis needs to be placed on the tools and scientific principles common to the meteorology and hydrology disciplines in the NWS, while, at the same time, recognizing the distinctive nature and requirements of each.	
	Nevertheless, training and staffing are fundamental issues that are implicit in the modernized operations of a WFO and RFC. Modernized equipment exists, along with new models and algorithms, and new a organizational structure will soon be in place. However, sufficient staff must also be in place who have appropriate training to take advantage of these modernized capabilities.	

Page	Conclusion	Recommendation
30-31	Even with the support of HAS personnel at RFCs and service hydrologists at WFOs, hydrometeorological forecasting at WFOs may at times produce an excessive workload for the planned staffing. Responsibilities and staffing levels may have to be rethought and adjusted over time. Nevertheless, appropriate training will be crucial.	3-19/Recommendation - The NWS should consider the need for more personnel in the hydrometeorological forecasting function. A formal "task analysis" of this function should be considered is difficulties are identified during operational test and evaluation and risk-reduction activities. Nevertheless, adequate training and cross-training is vital for WFO and RFC staff with hydrometeorological forecasting responsibilities. **NOAA RESPONSE to National Research Council-Pg 18** This recommendation falls in a section on WFO/RFC interaction and addresses workload issues at both RFCs and WFOs...
37	During visits to field offices, to committee found several examples of initiatives in which new flash flood forecasting methodologies had been developed that were potentially use ful other offices. Field forecasters who developed these new initiatives had received some help and encouragement from their regional office, but the perception in the field was that they had received little or no support for their efforts from NHSH. The committees perceives that the seemingly lack of support for local initiatives has resulted in part from competition for resources designated for centrally managed research and development activities. Local initiatives can be productive, both in the development of useful technologies and in building moral.	4-9/Recommendation - The NWS should ensure that sufficient technical support and resources are available to support a modest level of local initiatives to develop forecasting techniques and methodologies at field offices.
38	Given the substantial changes in hydrology-related roles and functions, both within and across field offices in the modernized NWS, assignments of sufficient numbers of appropriately qualified personnel to hydrologic duties is essential to the success of modernized operations. The committee concludes that NWS forecasters with a degree or extensive formal education in meteorology but no comparable training in hydrology usually are qualified for hydrologist positions. A more substantial educational background in hydrology is necessary for personnel working in such positions.	4-11/Recommendation - The NWS should review and, if warranted, modify its qualification standards for hydrology positions...

Page	Conclusion	Recommendation
38	Overall, the NWS has done thorough and exemplary job of defining the requirements and planning the staffing needed in the modernized hydrology and hydrometeorology functions of the NWS. The are two exceptions. First, Service hydrologists will manage the hydrology programs at all future WFOs; however; only 80 of the planned 119 WFOs will have a service hydrologist assigned on station. Various workload factors such as frequency of flash floods, proximity to other WFOs, number of RFC service locations, number of communities with flood problems, training of hydrometeorologists, etc were used to determine which WFOs would be assigned a full-time service hydrologist.	4-12/Recommendation - The NWS should continue to review and adjust hydrology staffing to meet specific operational needs as modernization progresses. **NOAA Response to National Research Council - Pg 33** The NWS concurs with the recommendation. Some adjustments have already been made with regard to locations for service hydrologists. If the budgetary process aver allows for addition of a new position, the NWS would certainly find it desirable to add service hydrologists ro selected WFOs.
39-41	After reviewing the training plan and course content in light of operational duties and responsibilities of the hydrologists and hydrometeorologists, and based on the reactions of NWS personnel to their participation in various courses and training programs, the committee concludes that new, specialized hydrology training modules are necessary to prepare forecasters for their new and complex duties and to fulfill the potential of modernization. Although the new WFO Operational Hydrometeorology Forecasting course may be adequate for WFO meteorological forecasters, it does not adequately meet the needs of service hydrologists, who also serve as the scientific liaisons for WFO hydrology	4-13/Recommendation - The NWS should develop new, specialized hydrology training modules for RFC staff and WFO service hydrologists that are compatible with new models and procedures in the interactive hydrologic forecast environment. This training should include new quantitative forecast techniques and the use of distributed observations from a variety of new sensors and sources. **NOAA Response to National Research Council - Pg 33** The NWS concurs with this recommendation. A new course on the WHFS has been designed and will be offered for the first time at the NWSTC in FY 1998...The new correspondence course *Operations of the NWS Hydrologic Services Program* will be a prerequisite for this centralized course and provides a good introduction to the science and operations utilized in a WFO hydrology program. Specialized training material will be developed to supplement the training provided through the WHFS course. The Office of Hydrology's HRL provides several types of workshops for RFC staffs that are dedicated to the new models and procedures used in interactive NWSRFS environment. This is supplemented by documentation available on-line through the Internet.

Appendix E

Operational Staff Web Survey

The following questions were common to both RFC and WFO surveys. Responses are provided side-by-side for direct comparison.

RFC-01 :
In which region do you work?

A. Eastern (33)
B. Central (35)
C. Southern (48)
D. Western (32)
E. Alaska or Pacific (10)

WFO-01 :
In which region do you work?

A. Eastern (125)
B. Central (295)
C. Southern (198)
D. Western (152)
E. Alaska or Pacific (21)

RFC-02 :
What position do you hold?

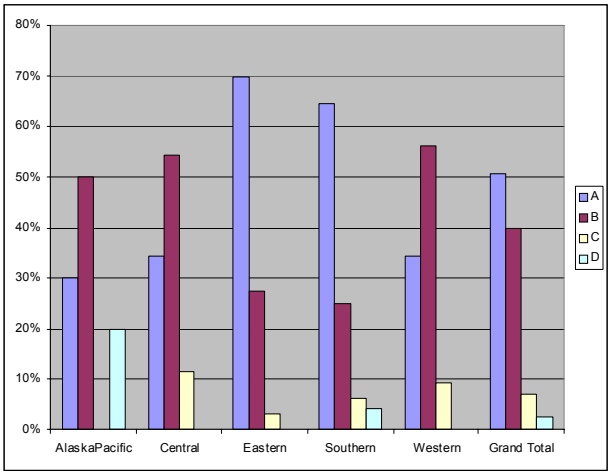
A. Hydrologist-in-Charge (12)
B. DOH (14)
C. Hydrologic Forecaster (102)
D. HAS Forecaster (31)

WFO-02 :
What position do you hold?

A. Meterorologist-in-Charge (65)
B. Science Operations Officer (45)
C. Warning Coordination Meteorologist (47)
D. Service Hydrologist (72)
E. Meteorologist (415)
F. Meteorologist and Hydro Focal Point (33)
G. Hydrometeorological Technician (106)

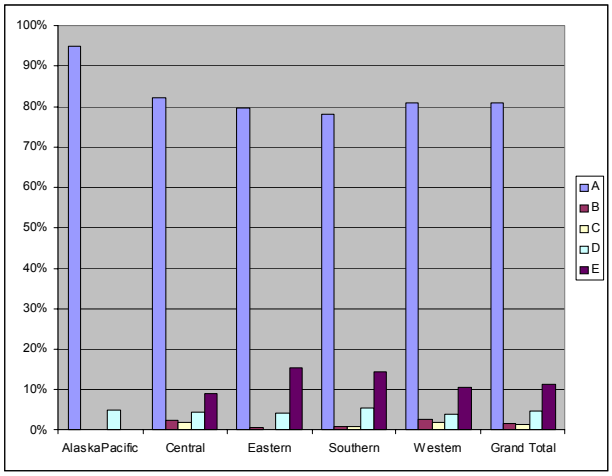
RFC-03 :
What is your educational background?

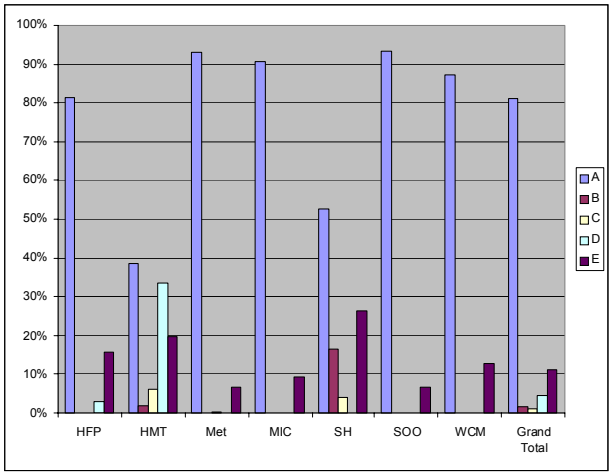
A. Meteorology/Atmospheric Science (80)
B. Hydrology, Civil Engineering or related field (63)
C. Other Physical Science (12)
D. Other (4)



WFO-03 :
What is your educational background?

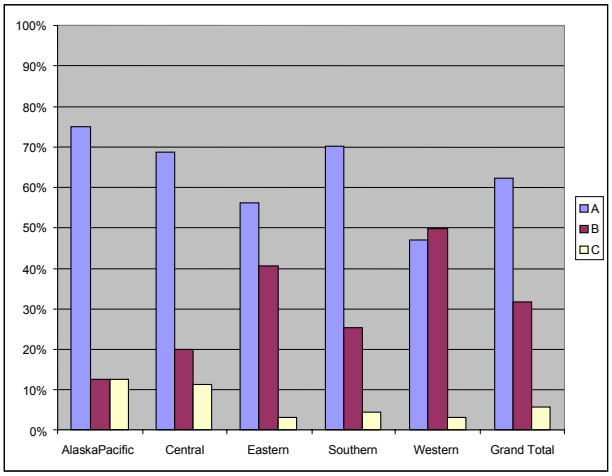
A. Meteorology/Atmospheric Science (631)
B. Hydrology, Civil Engineering or related field (14)
C. Other physical science (11)
D. Other (36)
E. Meteorology and Hydrology (89)





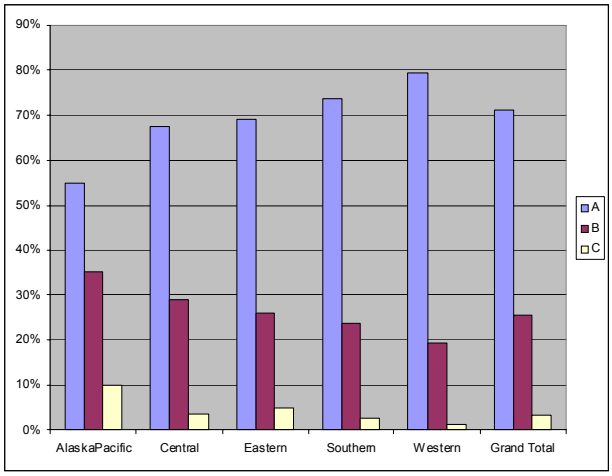
RFC-08 :
How important is a local NWS contact in the delivery of products and services?

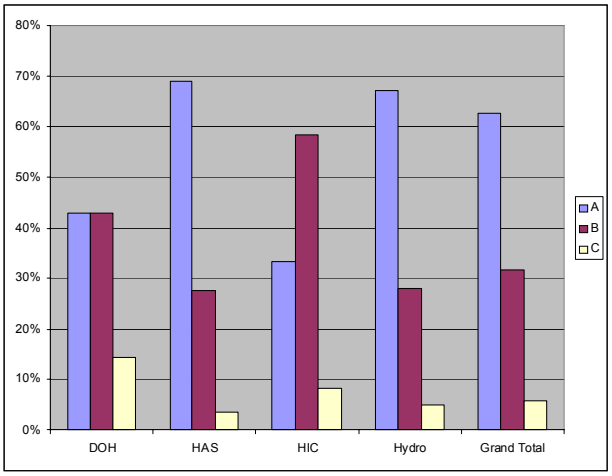
A. Extremely Important (97)
B. Somewhat Important (49)
C. Not Important (9)



WFO-10 :
How important is a local NWS contact in the delivery of hydrologic products and services

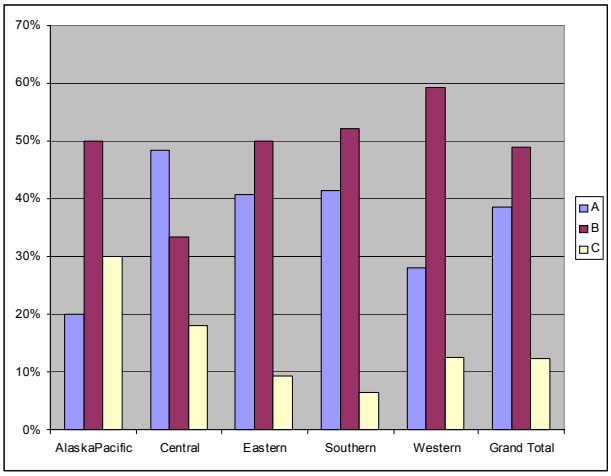
A. Extremely Important (553)
B. Somewhat Important (197)
C. Not important (25)

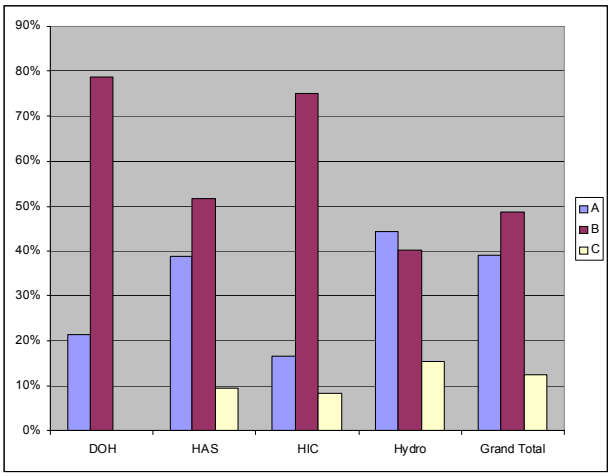




RFC-09 :
How important is a single NWS point of contact for our customers?

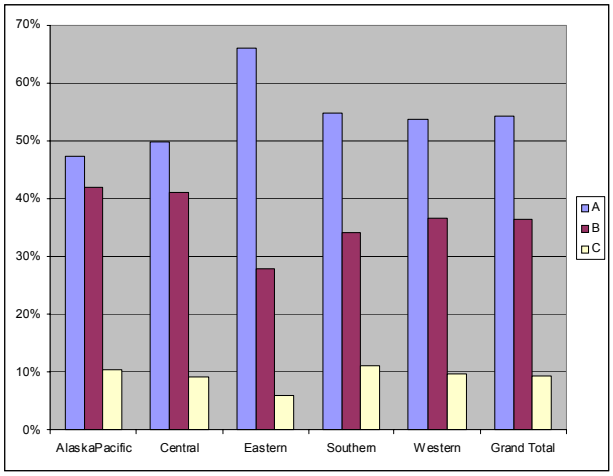
A. Extremely Important (60)
B. Somewhat Important (75)
C. Not Important (19)

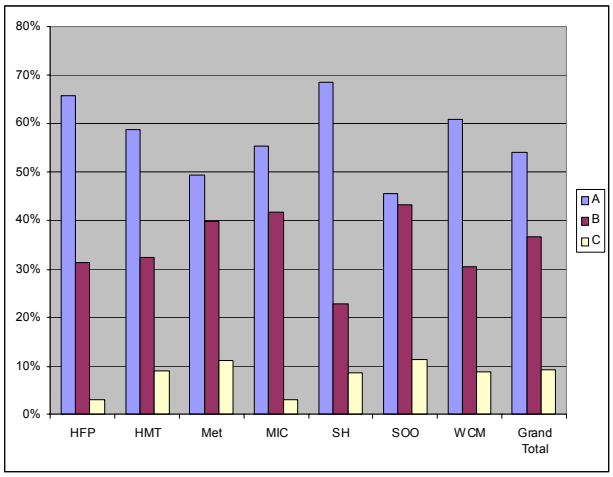




WFO-11 :
How important is a single NWS point of contact for our customers?

A. Extremely Important (417)
B. Somewhat Important (278)
C. Not important (71)



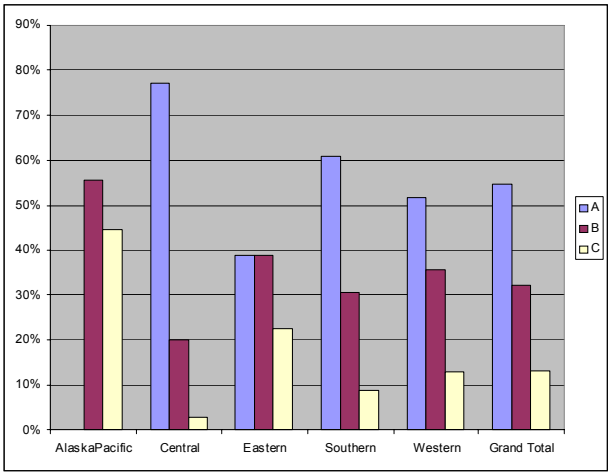


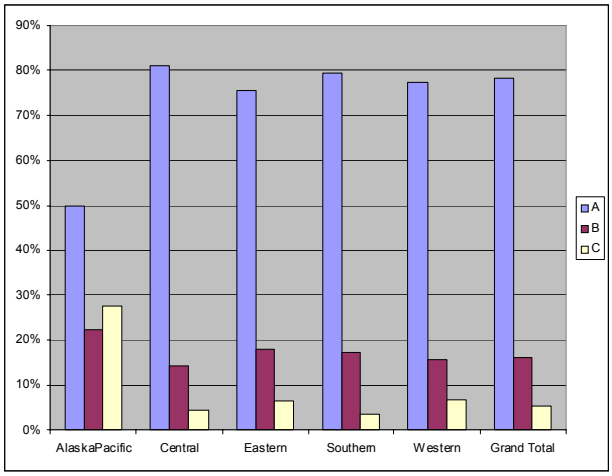
RFC-10 :
What is the impact of having the WFO issue the public hydrologic products?

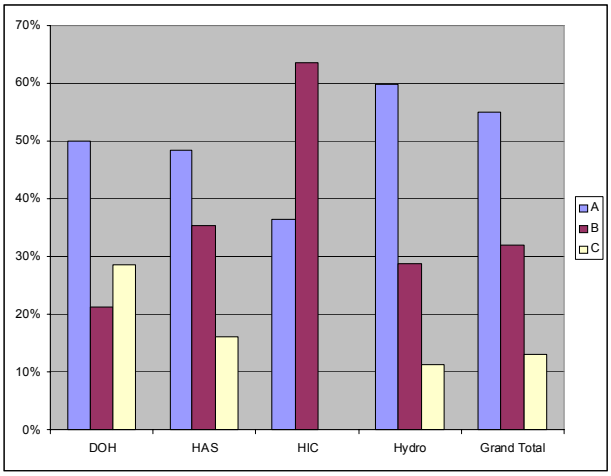
A. Service is improved - Local knowledge and contacts improve the quality of the forecast information that the RFC would be able to provide (84)
B. Neutral - information is passed through with no content gain or loss (49)
C. Service is degraded - without the detailed hydrologic knowledge, information to the public is lost by having the WFO issue the public products (20)

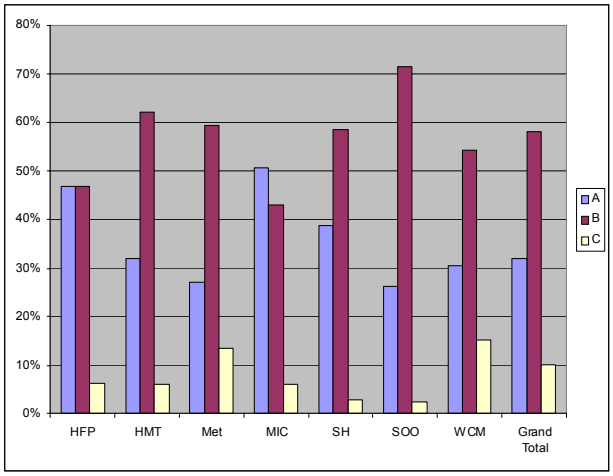
WFO-12 :
What is the impact of having the WFO issue the public hydrologic products?

A. Service is improved - local knowledge and contacts improve the quality of the forecast information that the RFC would be able to provide (609)
B. Neutral - information is passed through with no content gain or loss (125)
C. Service is degraded - without the detailed hydrologic knowledge, information to the public is lost by having the WFO issue the public products (43)



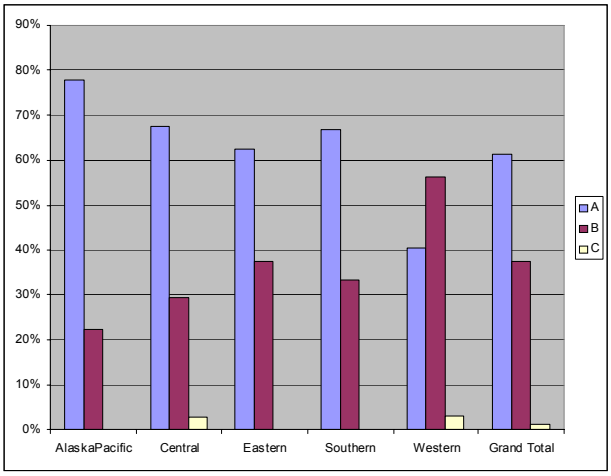






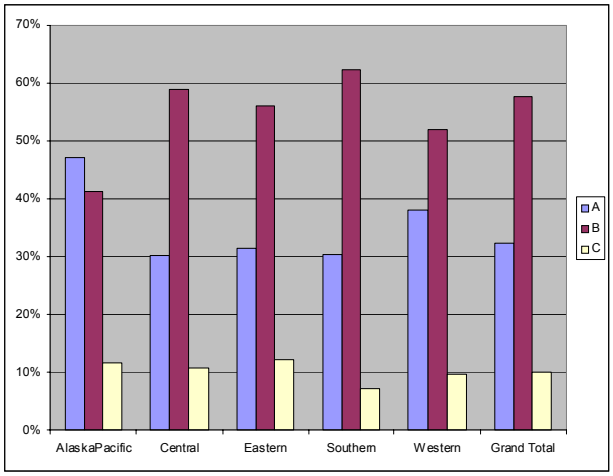
RFC-11 :
Does your office understand the hydrologic needs of WFO customers?

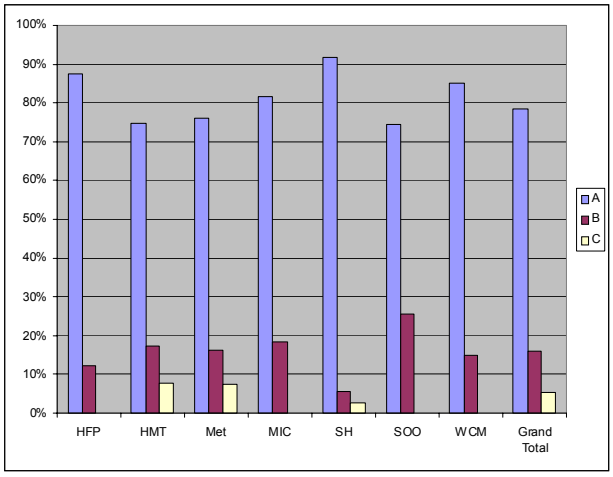
A. Yes (95)
B. Somewhat (59)
C. No (2)



WFO-15 :
Does the RFC understand the needs of your hydrologic customers?

A. Yes (245)
B. Somewhat (435)
C. No (75)



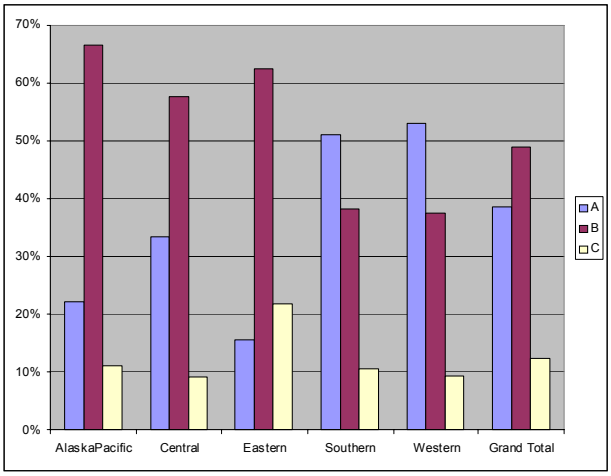


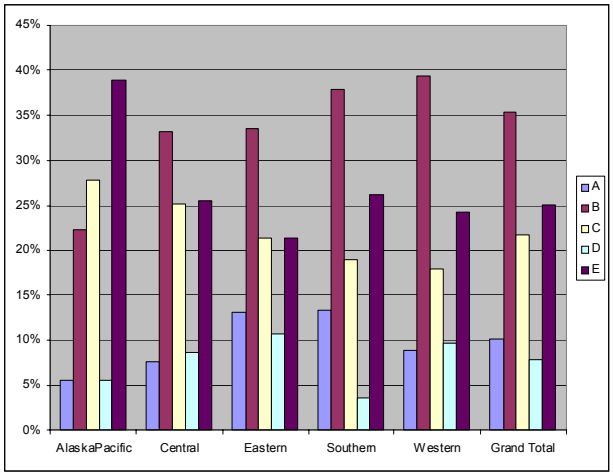
RFC-13 :
Please rate the responsiveness of your RFC to WFO requests for new or expanded services.

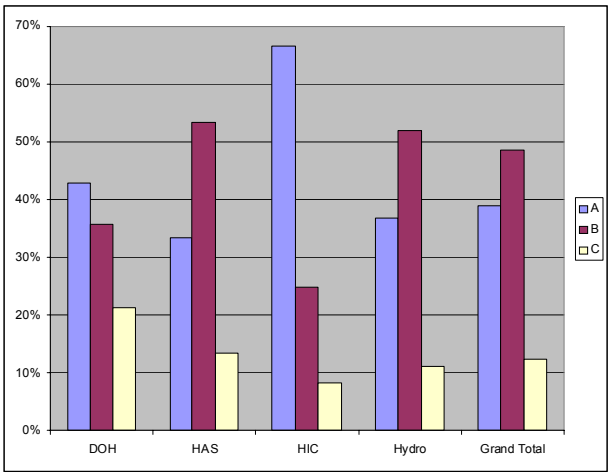
A. Excellent (60)
B. Good (75)
C. Fair (19)
D. Poor (0)

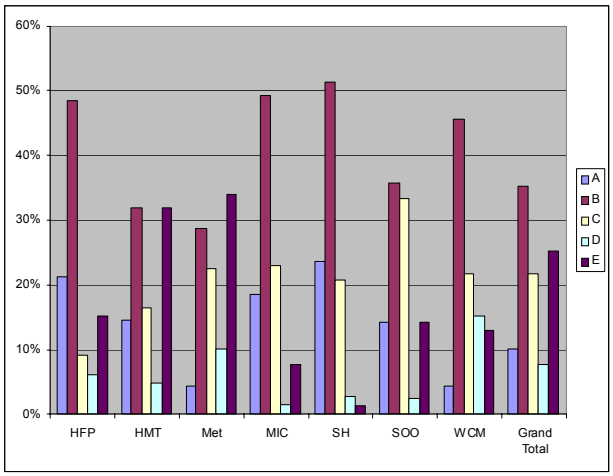
WFO-28 :
Please rate the responsiveness of the RFC to WFO requests for new or expanded services.

A. Excellent (78)
B. Good (272)
C. Fair (168)
D. Poor (60)
E. Unknown (193)







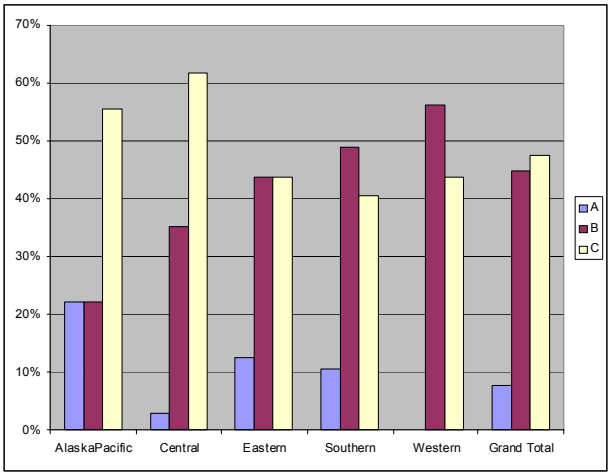


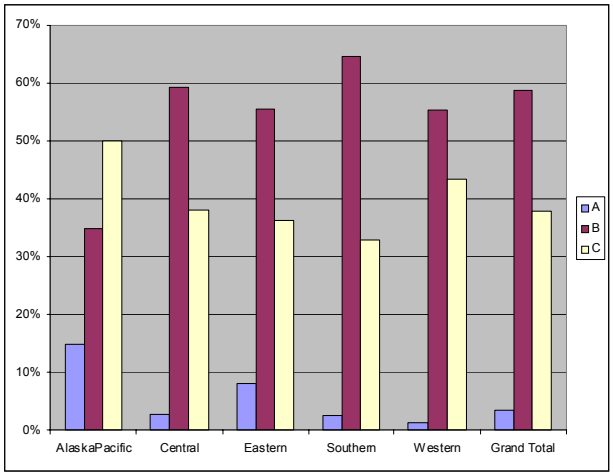
RFC-14 :
What field office should be responsible for the flash flood program?

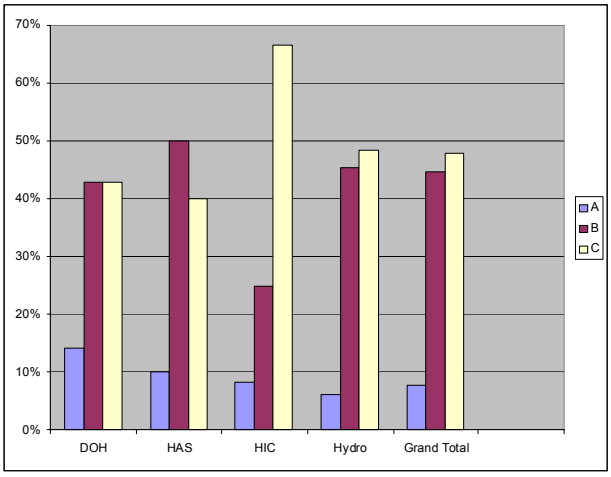
A. RFC (12)
B. WFO (69)
C. Both RFC and WFO (74)

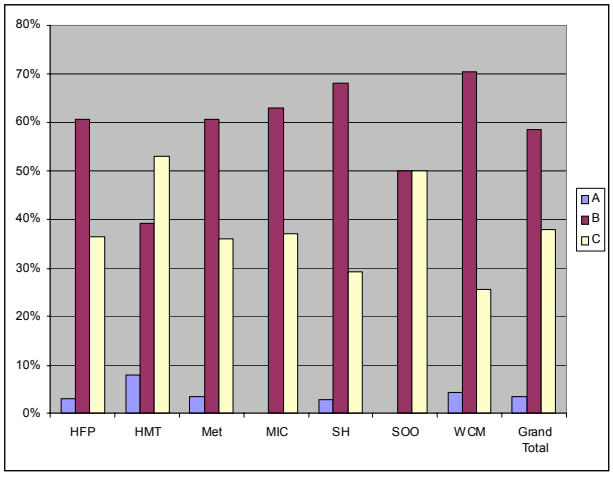
WFO-16 :
What field office should be responsible for the flash flood program?

A. RFC (28)
B. WFO (459)
C. Both RFC and WFO (296)



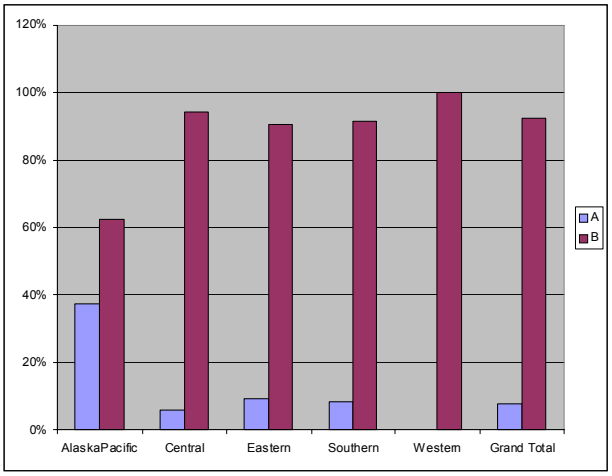






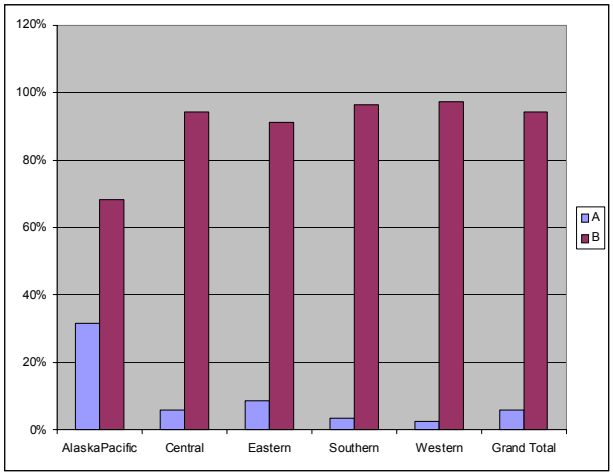
RFC-15 :
What field office should issue public flash flood watches and warnings?

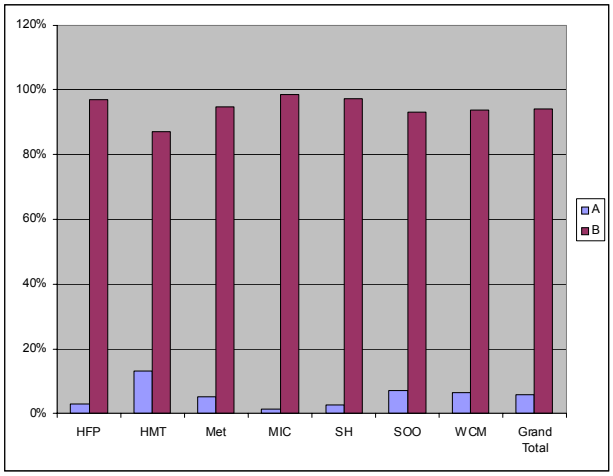
A. RFC (12)
B. WFO (144)



WFO-17 :
What field office should issue public flash flood watches and warnings?

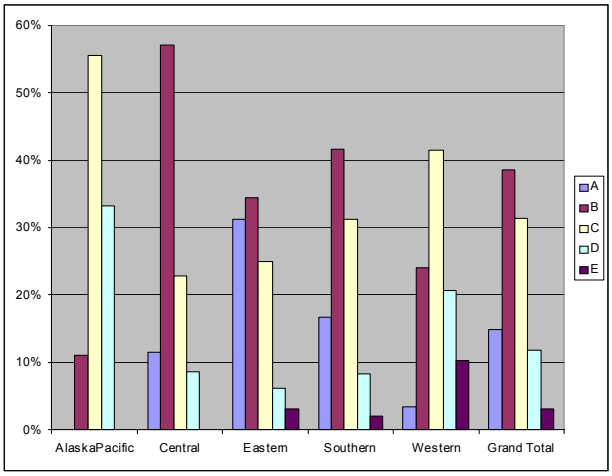
A. RFC (45)
B. WFO (734)





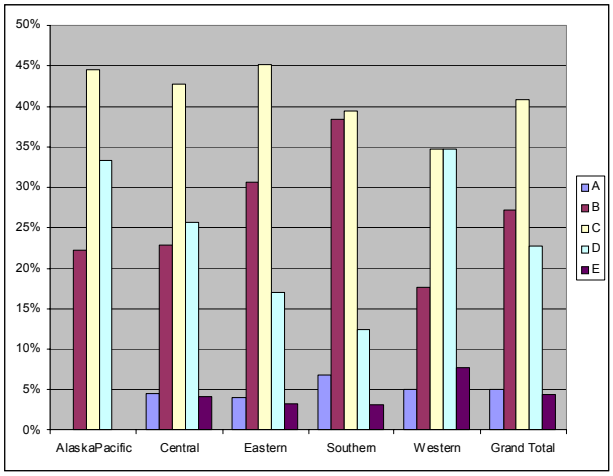
RFC-16 :
Please rate your offices support for the flash flood program.

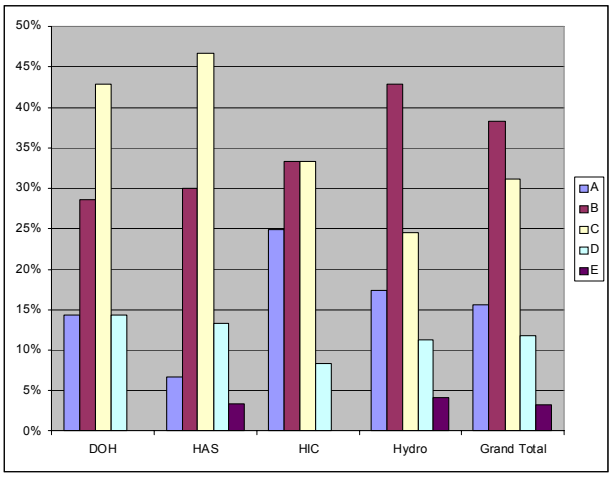
A. Excellent (24)
B. Good (59)
C. Adequate (48)
D. Poor (18)
E. Unnecessary (5)

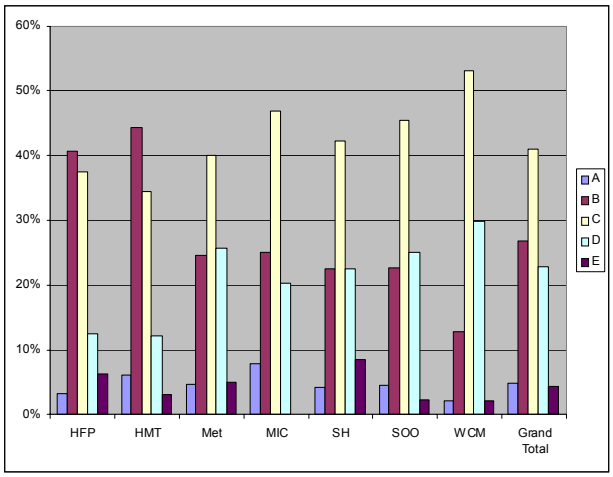


WFO-20 :
Please rate the RFC support of the flash flood program

A. Excellent (38)
B. Good (207)
C. Adequate (312)
D. Poor (174)
E. Unnecessary (34)

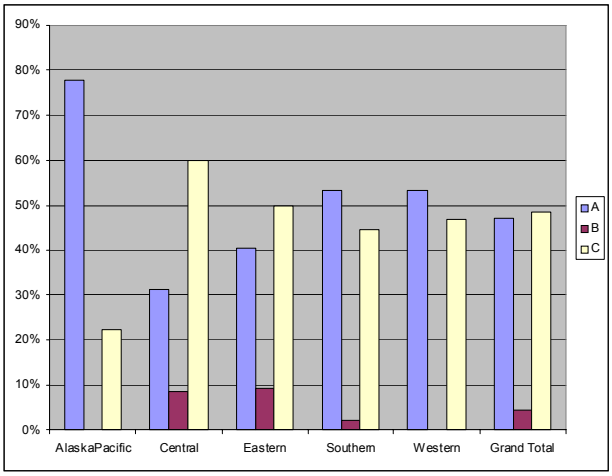






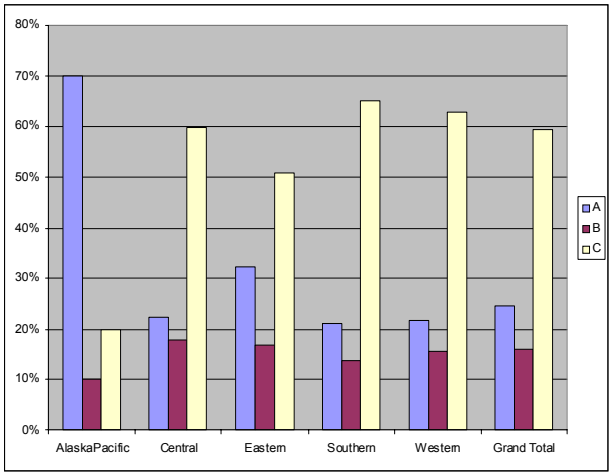
RFC-18 :
What field office should be accountable for the river flood program?

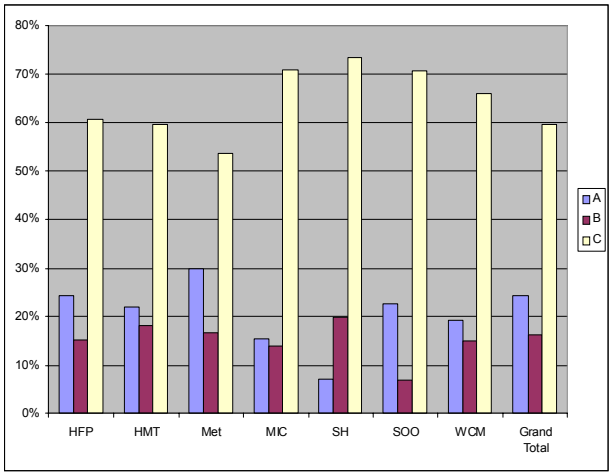
A. RFC (73)
B. WFO (7)
C. Both RFC and WFO (76)



WFO-22 :
What field office should be accountable for the river flood program?

A. RFC (194)
B. WFO (125)
C. Both RFC and WFO (462)



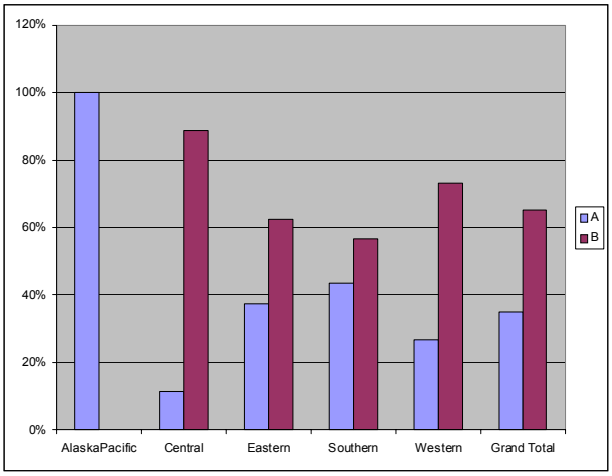


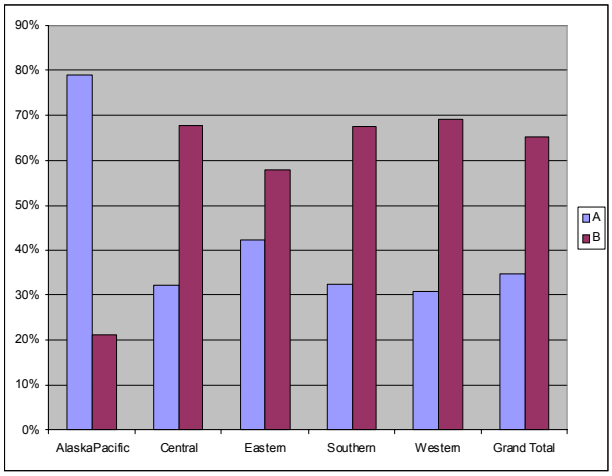
RFC-19 :
What field office should issue public river flood watches and warnings?

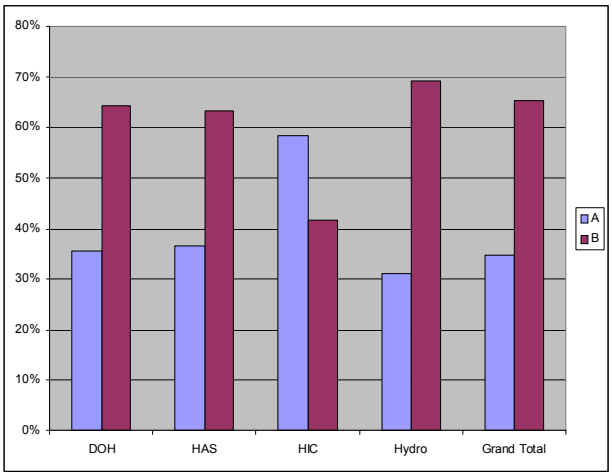
A. RFC (53)
B. WFO (100)

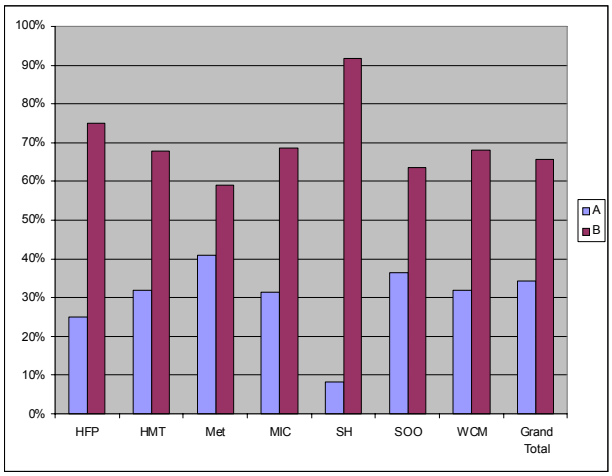
WFO-23 :
What field office should issue public river flood watches and warnings?

A. RFC (270)
B. WFO (506)



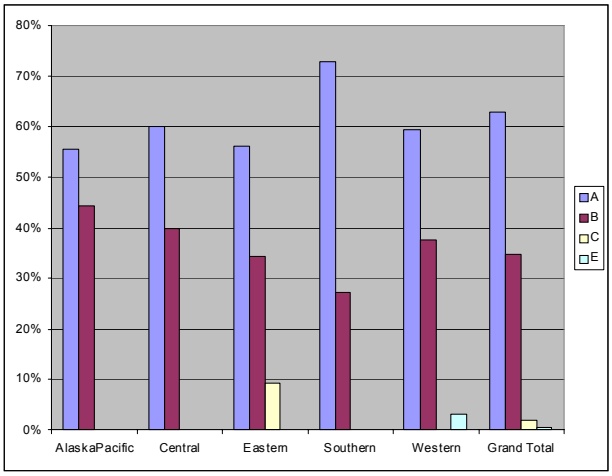






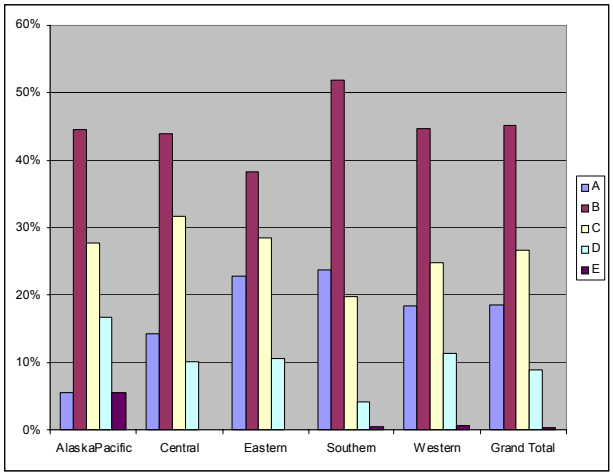
RFC-20 :
Please rate your office support of the river flood program

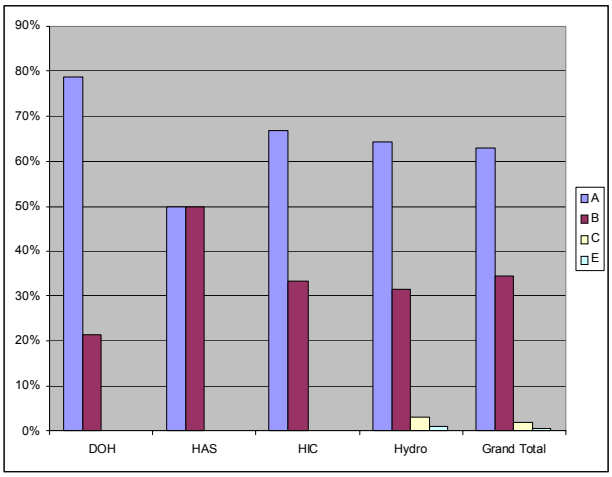
A. Excellent (99)
B. Good (54)
C. Adequate (3)
D. Unnecessary (1)

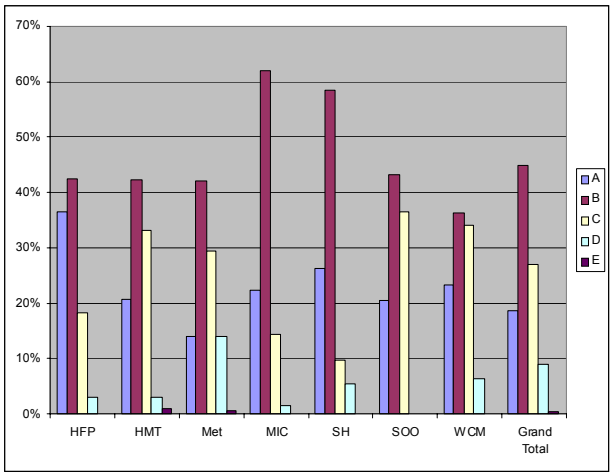


WFO-26 :
Please rate the RFC support of the river flood program.

A. Excellent (144)
B. Good (344)
C. Adequate (204)
D. Poor (69)
E. Unnecessary (3)

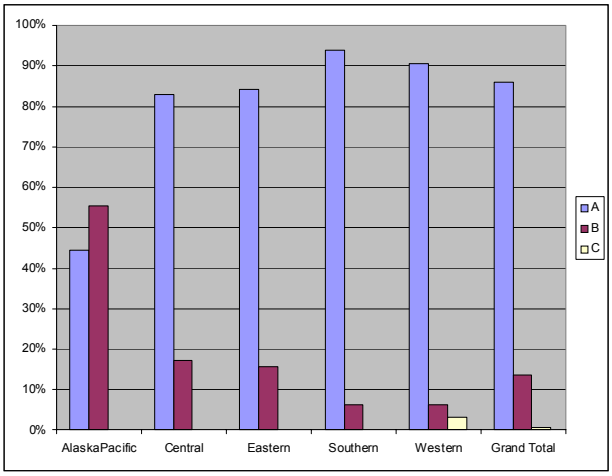






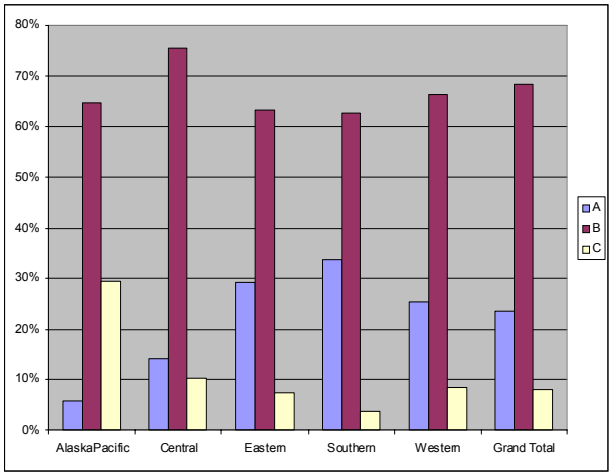
RFC-23 :
Is the RFC available to provide operational support when required?

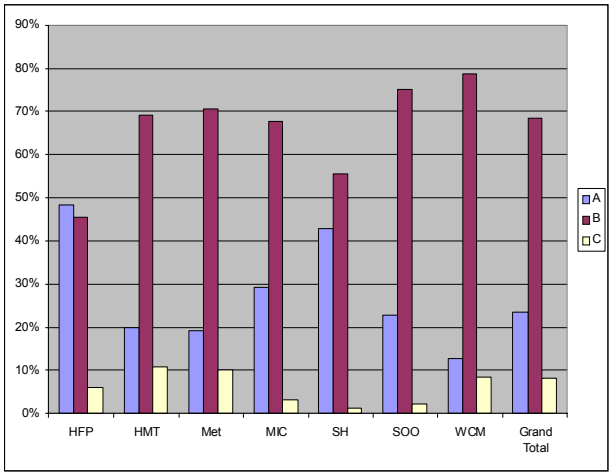
A. Always (135)
B. Most of the time (21)
C. Frequently unavailable (1)



WFO-29 :
Is the RFC available to provide operational support when required?

A. Always (177)
B. Most of the time (518)
C. Frequently unavailable (62)



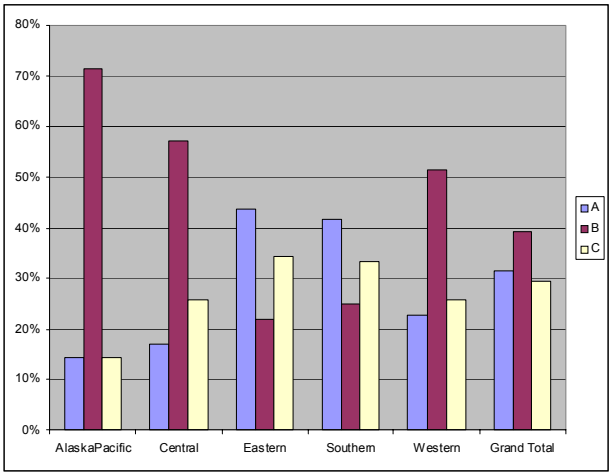


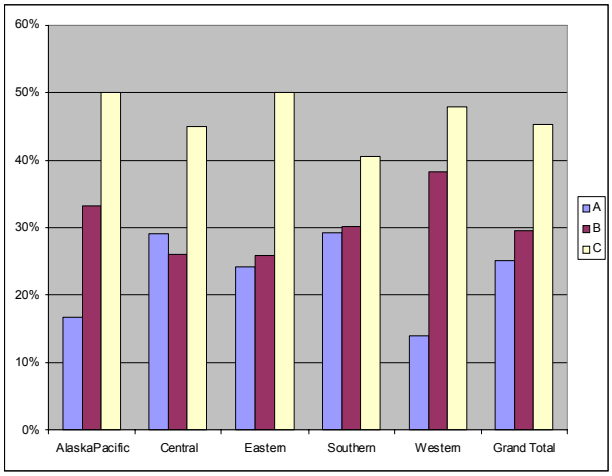
RFC-24 :
Have hydrologic database inconsistencies resulted in coordination or service problems?

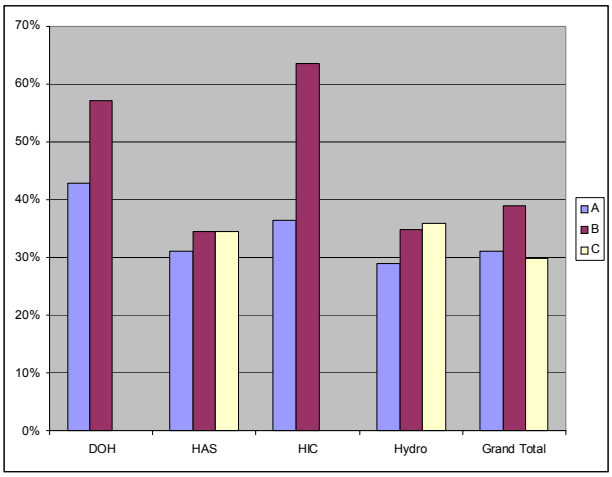
A. Yes (48)
B. No (60)
C. Don't know (46)

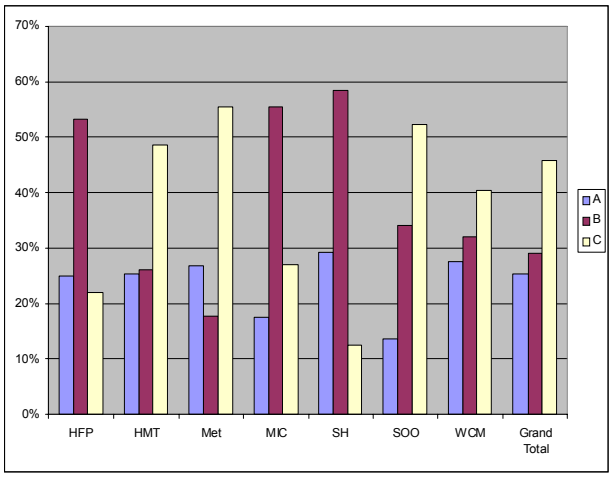
WFO-30 :
Have hydrologic database inconsistencies resulted in coordination or service problems?

A. Yes (195)
B. No (229)
C. Don't know (352)









RFC-24 Text Responses (42)

Almost all acknowledge that some inconsistencies in location and flood stage exist; however, it appears to be rare that a flood statement has been issued with incorrect information

Significant amount of work is necessary to maintain consistency.

inconsistent office identifiers and naming conventions at this time will make it very difficult to merge.

Office has procedure to deliver rating curves routinely to WFO.

Too many places where info is maintained - hydrobase, ofs, local files.

APRFC (?) Has been maintaining master copy and providing updates to WFO; however, this will be stopping shortly due to WFO customization.

WFO-30 Text Responses (143)

None noted (20)

Process is in place to address inconsistencies (4)

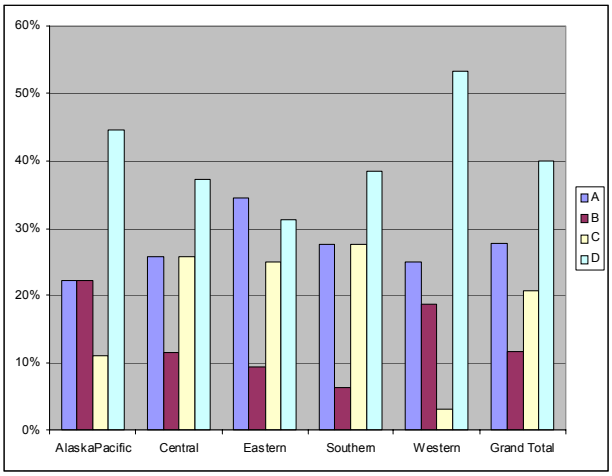
Small problems have been resolved (3)

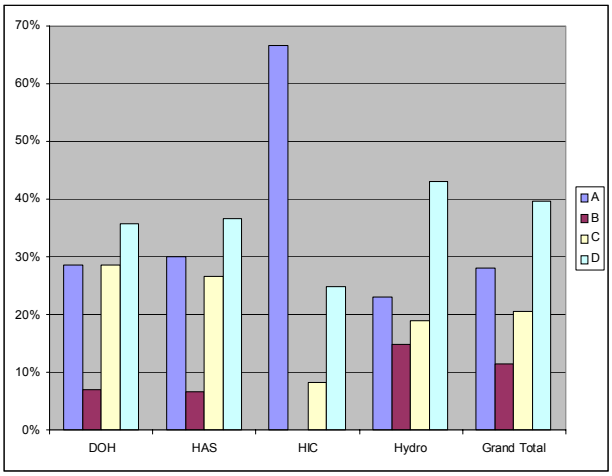
SH has team to maintain (2)

Types of inconsistencies
- bankfull and flood stage definitions
- ASOS/AWOS precip errors
- RFC smooths data during convective precip
- RFC used automated reading rather than observer
- differences in QPF (5)
- WFO forecast point lists (4)
- rating curves
- differences in data sources
- stages and forecasts have been different
- WFO modification to forecast product does not get to RFC
- problems during ice jams

RFC-25 :
What will be the impact of AHPS?

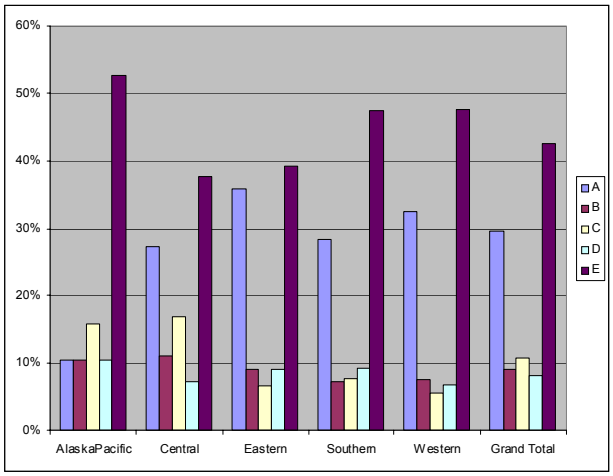
A. Significant improvement (44) This will allow me to provide better products to our customers including the uncertainty information they need
B. No change (18)
C. More difficult (32) I am not sure that I will be able to present this information appropriately to our customers
D. Unsure (62)

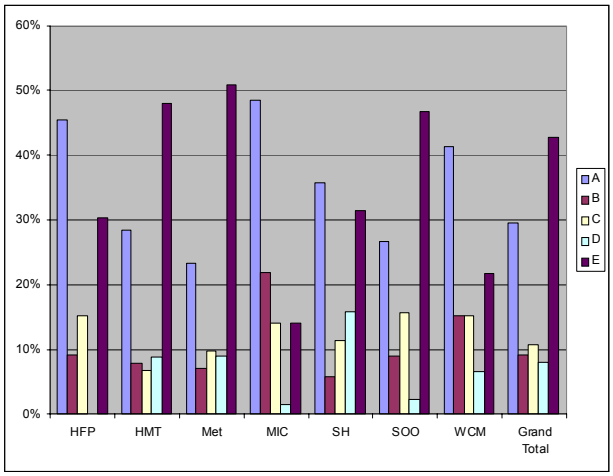




WFO-31 :
What will be the impact of AHPS?

A. Significant Improvement (226) This will provide better products to our customers including the uncertainty information they need
C. No change (84)
D. More difficult (63) I am not sure that I will be able to present this information appropriately to my customers
E. Unsure (327)
** Choice B (70) was a typo on the web survey that was not intended to exist. It appeared on the survey as a continuation of choice A starting with the word customer. Many noted this error but apparently chose this option intending to respond that it would be some improvement, but not significant.





RFC-25 Text Responses (73)

Several major concerns were consistently expressed:

Workload - AHPS is seen as placing a significant new

workload on RFC staff with no additional resources to address. Workload is both in the front-end of model development and calibration, computer processing time taking away from ability to perform other work, as well as forecaster time in producing products

Customer Needs - there is a strong sense that there has not been a clear customer call for many of the products that are being produced, or that they are meeting the needs of a small segment of our user base. There is a great deal of concern that the probabilistic products are going to cause more confusion for many of our users than they will solve problems

Short term forecasts - Many expressed a belief that the user is far more interested in getting a good short term forecast, probabilistic or deterministic rather than longer term forecasts

Flood Inundation - Many saw flood inundation mapping as significant progress and probably the best part about AHPS. However, even more expressed concern that from a FLDWAV or map availability, or maintenance standpoint it could not be properly done

Science concerns - Technology is beginning to allow us to perform a lot of tasks and generate a lot of pretty products; however is the science running behind the technology the appropriate science for the job. More and new products does not necessarily equate to better products

WFO-31 Text Responses (233)

Major comments:
Need to provide training both to NWS and external users (15)
Make sure the software works properly (not IFPS etc) (11)
Never heard of it or don't know enough about it (11) Many others said it was too soon to make any judgement regarding AHPS until it was available locally.
Flood mapping is viewed as important (10) if it can actually be done in an accurate manner.
Need to focus more on quality of our existing forecasts (8)
We lack credibility if our existing forecasts are not accurate
Success of AHPS will largely depend on accuaracy of products
Will it work for small streams (5)
Will it work in the western US (2)
Leave it to the RFCs - the WFOs are already overwhelmed (6)
Are the goals of the program bigger than what it can actually deliver? (4)

Comments on user reaction
A lot of speculation on what users want, need, and can understand
Those who have actually gotten feedback from users have generally been positive
Interent accesssibility is positive

Other comments
Does this make the WFO superfluous in the hydro program?
Need to keep traditional products.
Allow WFO early access to products before putting on web.
Could be degradation of service.

Misunderstandings
It is clear a lot do not understand what AHPS is, such as:
This is a good first step toward enabling the local experts to fix notoriously bad RFC forecasts

The time could be spent on improvements to basin calibration and modeling

Topographic maps are ...at intervals of 20 to 100 feet ...How can we map flood outlines with these maps?

AHPS was described to me by a high ranking CRH member as only being a means to pump funding into the RFCs so they could update model information.

AHPS just seems like a web version of what we already have in AWIPS.

If AHPS is to replace outdated and no longer supported Hydromet, ...

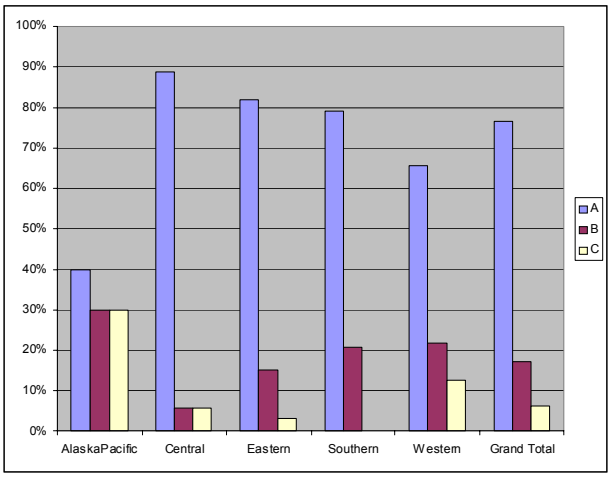
The following questions and responses were unique to the RFC Staff Survey

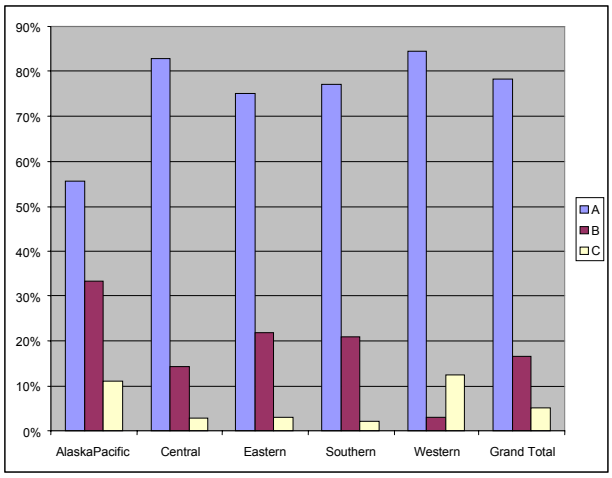
RFC-04 :
Do you perform hydrologic forecast functions at your office?

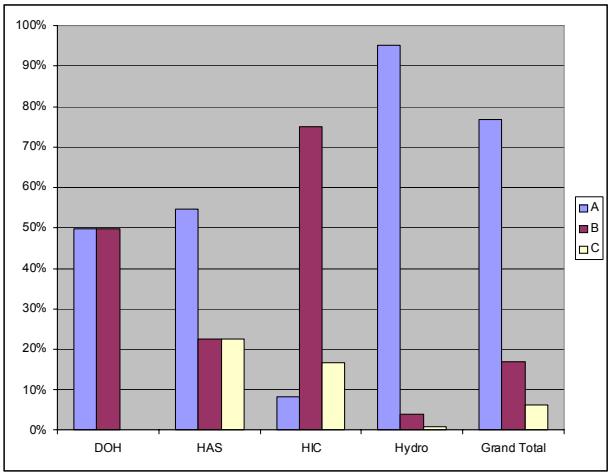
A. Routinely (122)
B. Occasionally (27)
C. Never (10)

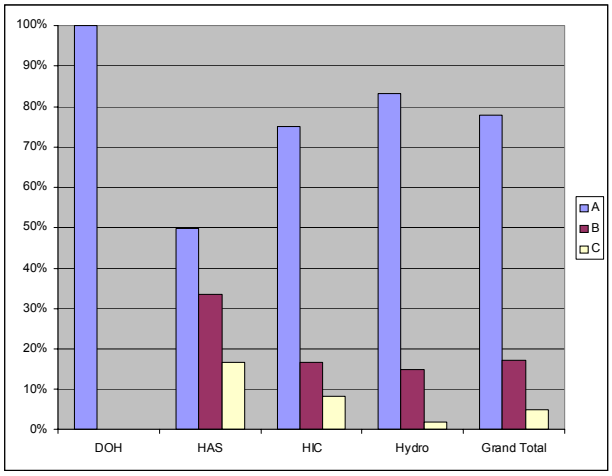
RFC-05 :
Do you feel adequately trained to perform the hydrologic function?

A. Yes (122)
B. Somewhat (27)
C. No (8)









RFC-05 Text Responses (41)

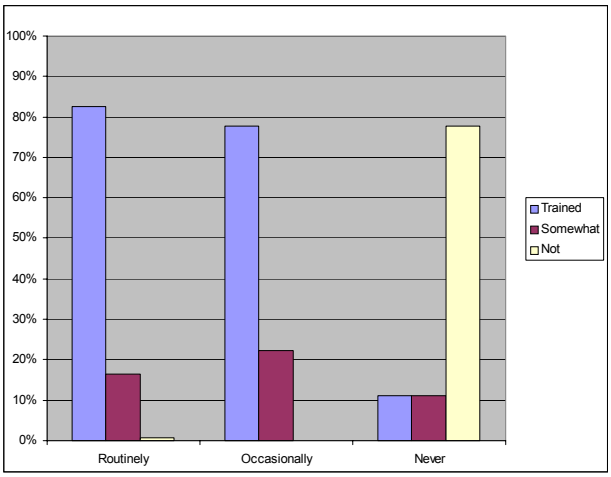
Experience is the key trainer for RFC forecasters

Training on GUIs is adequate; however better training is needed in the behind the scenes applications that are critical to the operations. Also, better training in the science aspects - snow model operations, appropriate use of MODs

Need for Basic OFS training early in RFC career for all. In general better training and mentoring for new hires is needed

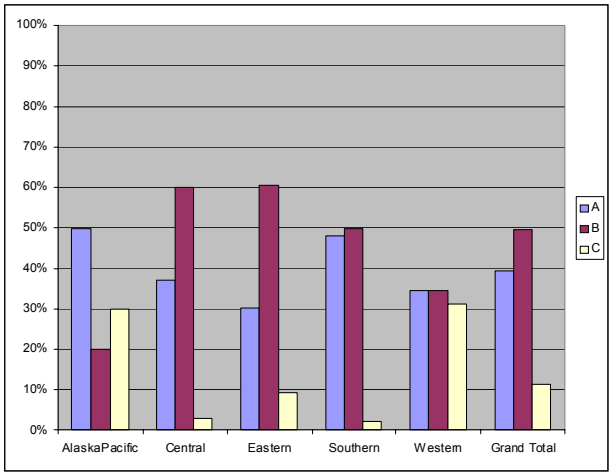
"... The flood forecasting being done from small cubicles inhibits hydrologists with many years of experience from sharing their knowledge with less experienced hydrologists. It also inhibits operations by making it difficult for hydrologists that work the mainstem and tributaries to communicate essential information and insight."

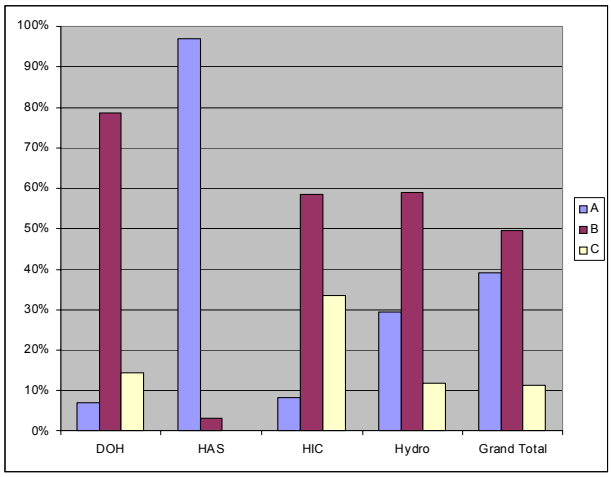
Comparing the responses to questions RFC-04 and RFC-05 yields the following comparing the training level compared to the frequency which the RFC hydrologic function is performed.



RFC-06 :
Do you perform HAS forecast functions at your office?

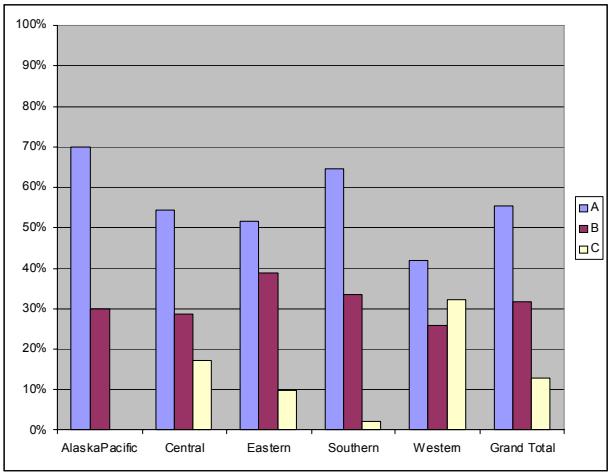
A. Routinely (62)
B. Occasionally (79)
C. Never (18)





RFC-07 :
Do you feel adequately trained to perform the HAS function?

A. Yes (86)
B. Somewhat (50)
C. No (20)



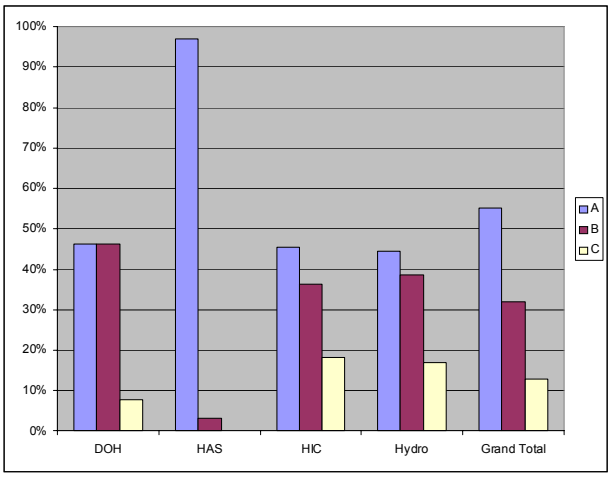
RFC-07 Text Responses (39)

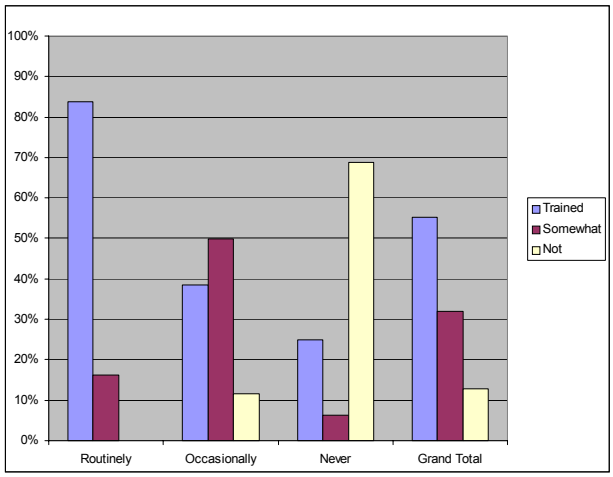
Civil Engineers working the HAS shift - do not have the detailed met training to develop QPF although they can run the basic shift operations and can generally get HPC QPF into model although not value added

Lack of frequency of HAS shifts may limit ability to gain expertise

Wide variety of training experience - no met training, COMET hydromet et al, qualified met

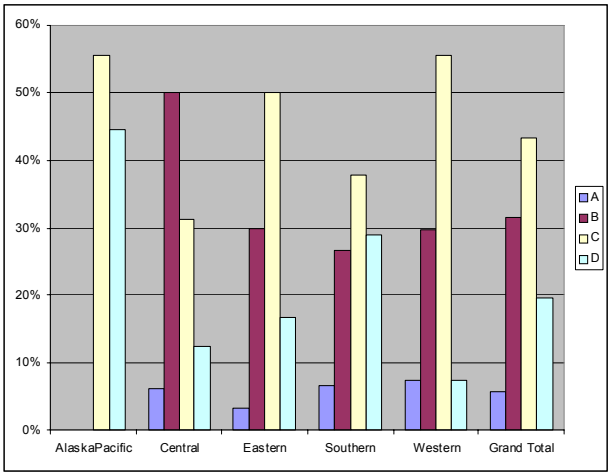
Comparing the responses in RFC-06 and RFC-07 yields the following chart showing the level of training in the HAS function compared to the frequency in which the HAS function is performed:

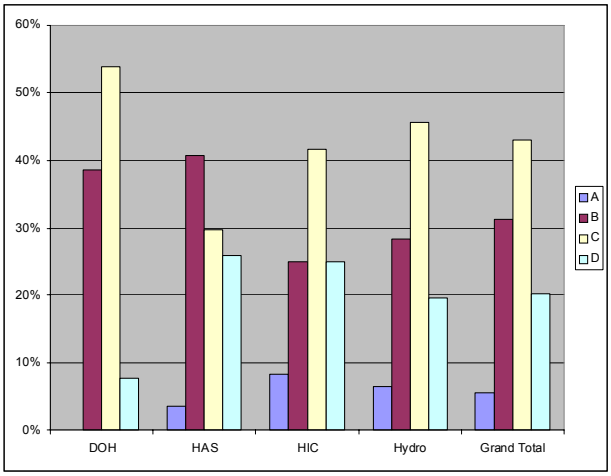




RFC-12 :
Please rate the WFO accomplishments in hydrologic outreach during the past 12 months

A. Excellent (8)
B. Good (45)
C. Adequate (62)
D. Poor (29)





RFC-17 :
How can your office improve support for the flash flood program?

Implementation of gridded FFG appears to be a big issue. However, there is a lot of concern regarding the status of thresh-R

Wide diversity: issue all products from RFC to there is nothing RFC can do to support FF program

Coordination and cross-training opportunities with the WFOs is important

Definition of flash flood is not consistently applied. Some offices are still verifying on basement flooding

Data network, both precip and streamflow, hampers ability to monitor effectively

Requires additional staffing to monitor the small scale

FFG is often a black box - more training is necessary

Improved site specific models

Need to have a program to better identify flood prone areas

RFC-21 :
How can your office improve support for the river flood program?

Data networks - there is a insufficient real time precip data and constant threatened cuts to the stream gaging network make it very difficult to issue adequate forecasts

Model development - This includes both continued calibration efforts of existing models as well as improvements to the forecast models that are availalble. Moving towards distributed modeling is seen as a potential improvement but it requires reliable precip data sources on the model grid which does not currently exist. There is also a signiificant need to moving to less than 6 hour modeling time steps

WFO Outreach - A better job could be done in orienting WFO staff to RFC operations and products. This may include training in some basic hydrologic science

Improved customer relations - we need to better understand the needs of the NWS customers of our products. We need to understand who are customers are.

Public Product - 7 people indicated that public product issuance should be done from the RFC feeling that the WFO has two problems: (1) little or no added value (2) delays in product issuance. However, 2 specifically felt that this should not be done as it would distract from the other important missions of the RFC including development time

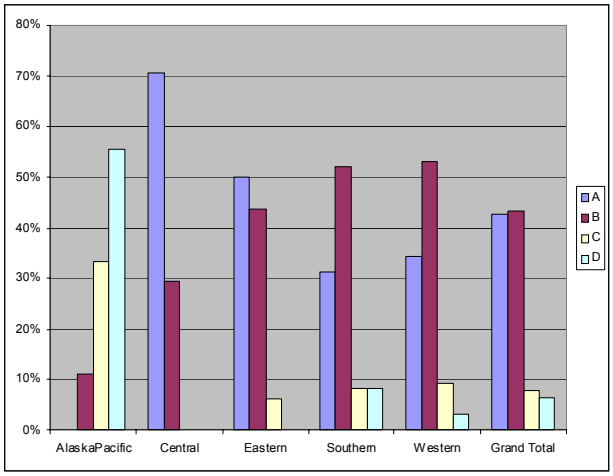
Time and Staffing - we never have enough

A WCM position at the RFC for outreach

If the RFCs take over public product, have fewer but larger RFCs

RFC-22 :
What role does your office typically play during river flooding episodes?

A. Issue guidance and let the WFOs decide what watches and warnings to issue (67)
B. Issue guidance and assist the WFOs in deciding what watches and warnings should be issued (67)
C. Specify for WFOs what watches and warnings should be issued (12)
D. Draft watches and warnings for WFO issuance (10)



RFC-26 :
Please provide any additional comments regarding the roles and responsibilities of the RFCs and WFOs in the provision of flash flood and river forecast and warning service?
(53 Responses)

RFCs should at least issue discussion on forecast if not public product

General consensus that flash flood program remain in WFO; less consensus on river watch warning program

Need more WFO accountability for hydro program (*)

Hydro Program Organization

Regional differences

National Center merging OHD and RFCs (not in DC)

Combine similar RFCs

HL retention continues to be a significant problem
Remove hydro program from NWS and form separate NOAA office

Flash flooding is not well defined program

RFC provide better support and training to WFO

SH improves hydrologic function; when not available the program suffers (*)
Lead forecasters need better training

Allow SH more focus on hydro

Better exchange visits between WFO and RFC

GS12 computer specialist under HIC instead of ESA

WCM function in RFC (*)

RFC needs to be aggressive in outreach at state and regional levels

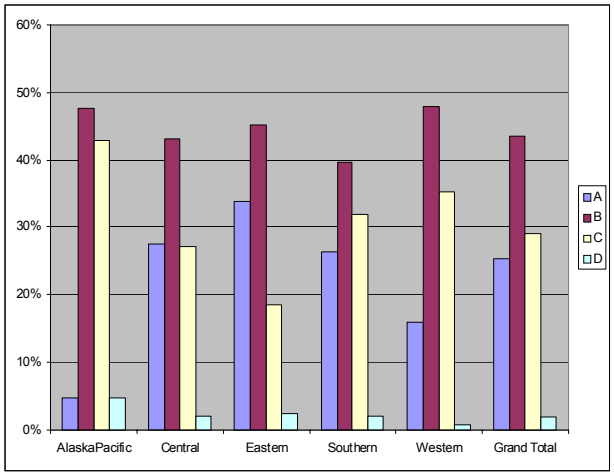
The following questions and responses were unique to the WFO Staff Survey

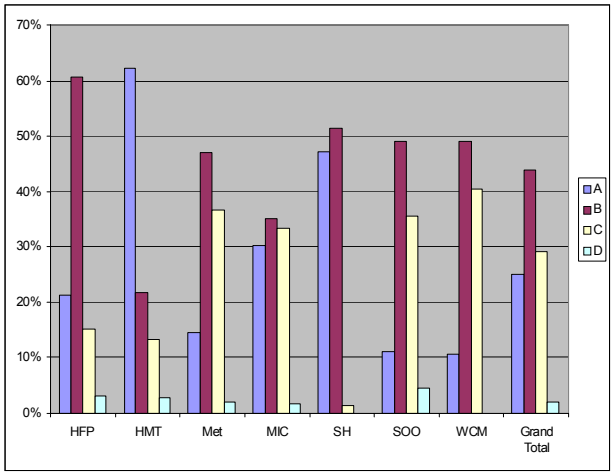
WFO-04 :
My office has an on-station.

A. Service Hydrologist (584)
B. Hydro Focal Point (201)

WFO-05 :
How often do you perform hydrologic functions at your office, including issuing routine daily statements, large or small stream flood warnings and statements?

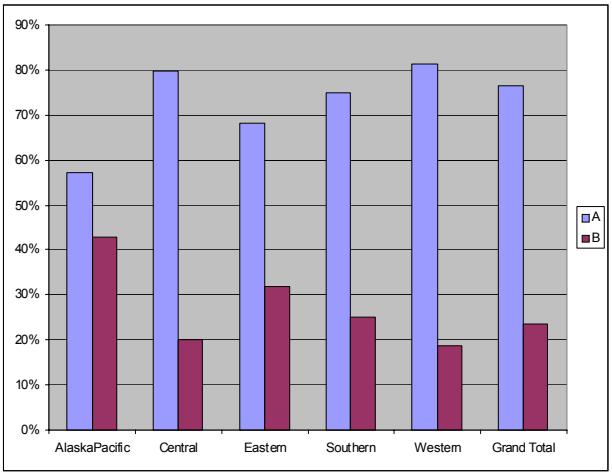
A. Routinely, almost every operational shift (200)
B. Occasionally (344)
C. Rarely (228)
D. Never (15)

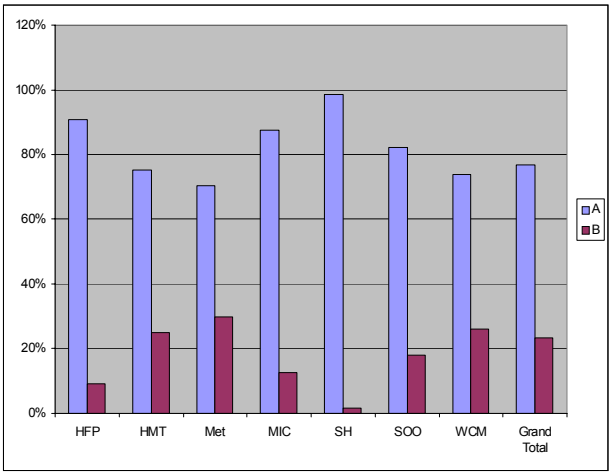




WFO-06 : Do you feel adequately trained to perform the hydrologic function?

A. Yes (599)
B. No (184)





WFO-06 Text Comments (280)

SH feel adequately trained

Wide disparity in responses

Equal number of responses indicating adequately trained and training was non-existent

Training needs to be looked at in context of roles individuals are playing - this varies by WFO

Some HMTs indicate they perform most of the functions but are denied NWSTC training

Forecasters indicate that HMTs are not trained because the forecasters perform the function

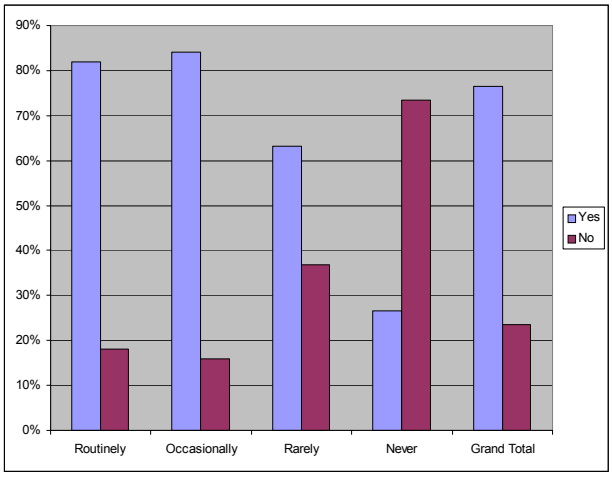
Infrequent flooding, particularly in the west, make it difficult to keep up with software changes

Dam Break training needs to be enhanced

Frequent software changes to WHFS may be either welcomed or viewed as confusing

Level of comfort is a function of SH enthusiasm, ability to train, and time available to develop training program

Comparing the responses to WFO-05 and WFO-06 yields the following chart that compares the level of training compared to the frequency in which the WFO hydrology function is performed:

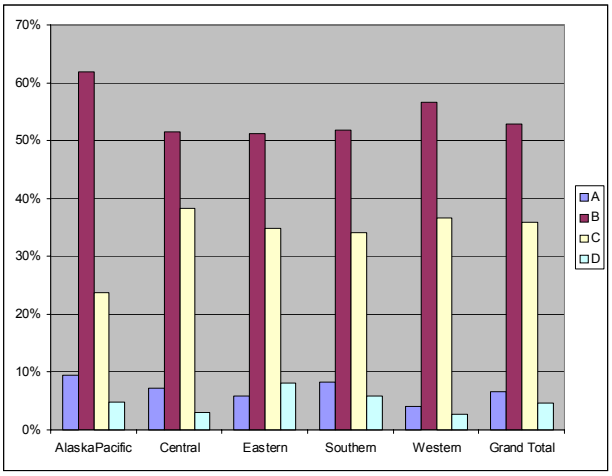


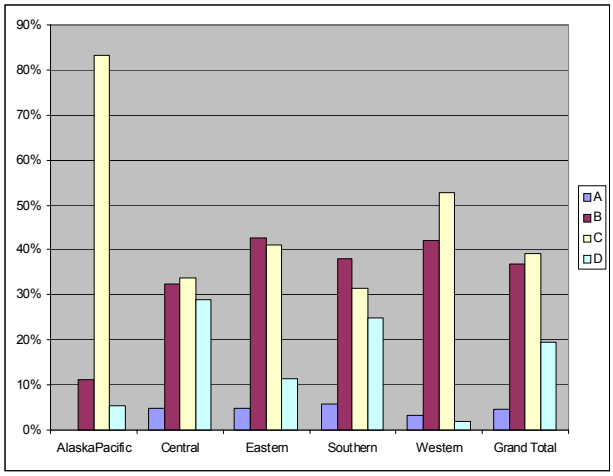
WFO-07 :
Which statement best describes your approach in performing hydrologic functions?

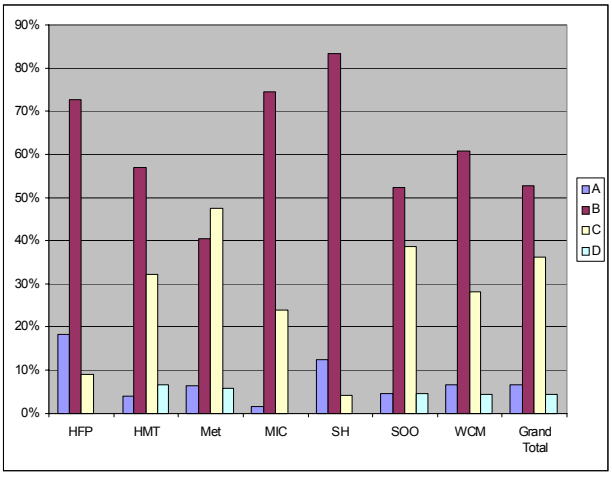
A. I would consider applying for a job at an RFC or OHD in the future (52)
B. I enjoy performing the WFO hydrologic functions (411)
C. It is part of the job, thus, I just do the tasks (281)
D. I believe these functions are unnecessary at WFOs and another office should be doing this work. (35)

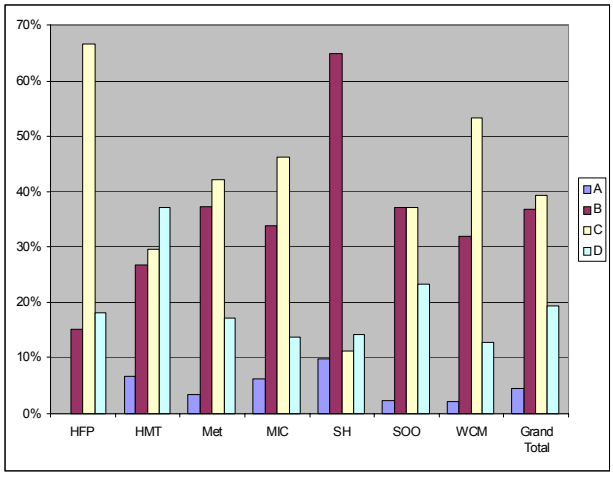
WFO-08 :
When flooding is occurring within your HSA, who usually completes most of the workload regarding flood warnings?

A. Service Hydrologist prepares nearly all warnings and statements for the duration of the event (36)
B. Service Hydrologist prepares warnings and statements when available and may work some extra shifts; otherwise handled by forecasters or HMTs (288)
C. Flood warnings and statements are routinely prepared by the meteorological forecasters. (306)
D. Flood warnings and statements are routinely prepared by the HMT staff (153)







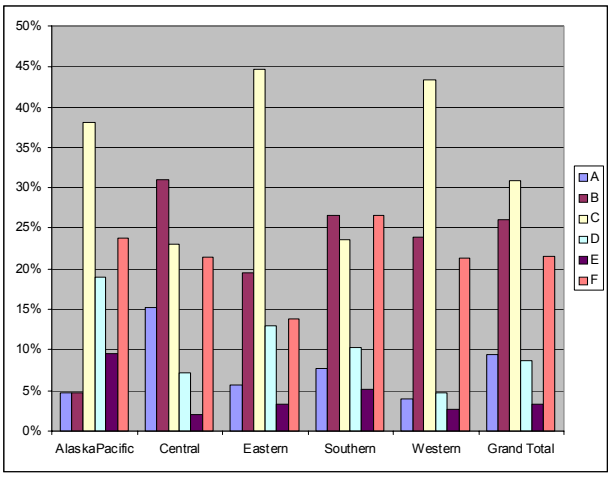


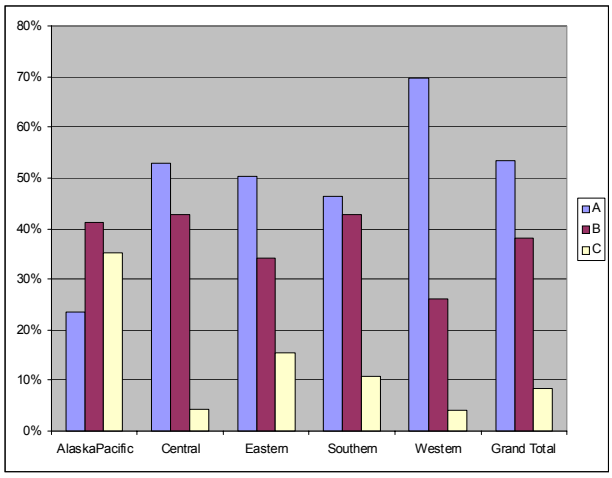
WFO-09 :
What percent of time is the service hydrologist performing operational met or HMT functions?

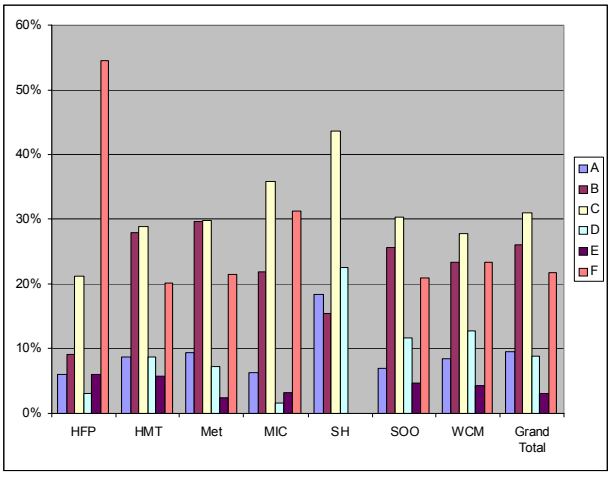
A. None (75)
B. < 10 percent (204)
C. 10-25% (242)
D. 25% - 50% (68)
E. more than 50% (26)
F. No Service Hydrologist (169)

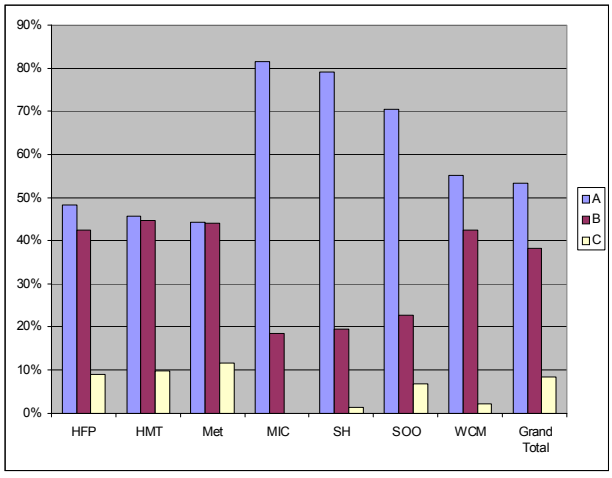
WFO-13 :
How is hydrologic service outreach approached in your office?

A. Enthusiastically. We believe we are accountable for hydrologic outreach in our HAS. (410)
B. We perform limited hydrologic outreach. (293)
C. Hydrologic outreach is unusual in our office. (65)



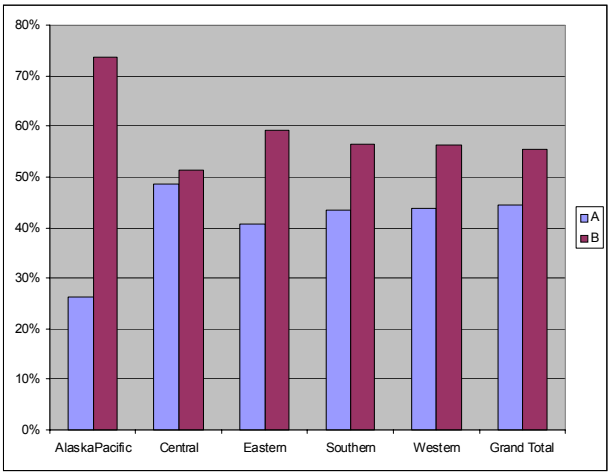






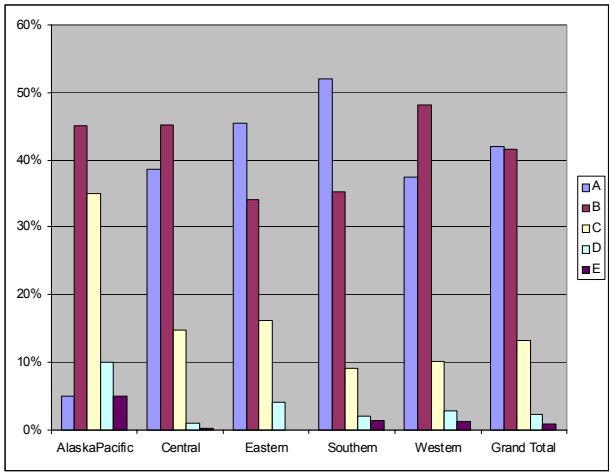
WFO-14 :
Were you directly involved in hydrologic outreach during the past 12 months?

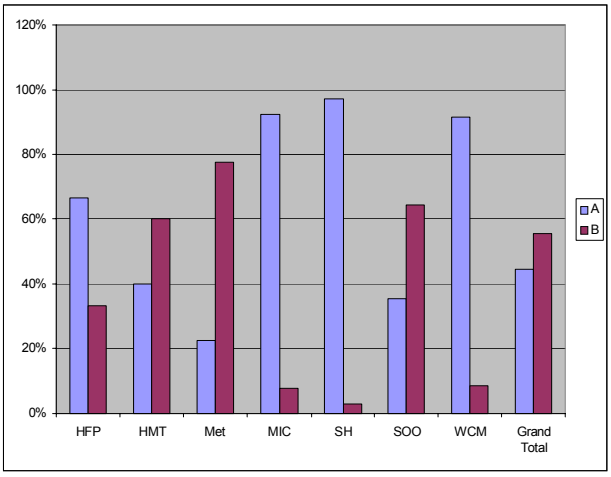
A. Yes (350)
B. No (437)

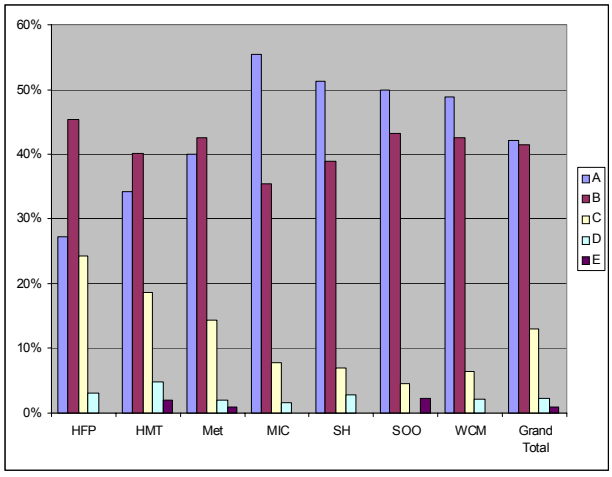


WFO-18 :
Please rate your offices support for the flash flood program

A. Excellent (328)
B. Good (324)
C. Adequate (103)
D. Poor (18)
E. Unnecessary (7)







WFO-19 :

How can your office improve support for the flash flood program? (402 responses)

Training Issues
More training in a variety of forms is needed (34)
VISIT teletraining, WES cases
Drills need SOO involvement
NOTE: concern about time issues
Local studies need to be performed to assess: (22)
Climatology
flood prone areas
GIS tools
Provide additional training to existing spotter network and actively seek reports (16)
Field visits by staff (3)

Science and Technology
Implementation of AMBER, FFMP, and Site Specific (28)
Need maps/atlases/GIS type info readily available (7)
Set up audible alarms of potential troublespots
Local mesoscale and hydro models linked (4)
Tools to help visualize terrain (2)
More workstations required to monitor severe and heavy precip

Operations Issues
Rain gage network needs to be expanded (25)
Rain gage network, particularly IFLOWS, needs to be better maintained (6)
Better outreach and coordination to local officials and media (24)
Need to pay attention to heavy precip and give it the same priority as severe (15)
Need a service hydrologist (6)
Don't wait for reports of flooding before issuing products (2)

Other comments
Need guidance on urban flooding vs FFW
Exchange visits with RFC
Do we need an RFC in Central Region?
Having another office issue watch might heighten awareness
No RFC in Hawaii
Need clear concise E22
Support cloud seeding
Combined Severe Thunderstorm and Flash Flood Warning
Allow deviation from RFC guidance
Need an 88D in northeast Wyoming
Get rid of urban advisories

WFO-21 :

How can the RFC improve support for the flash flood program? (444 responses)

Status Quo?
No changes necessary (24), What support? (10)

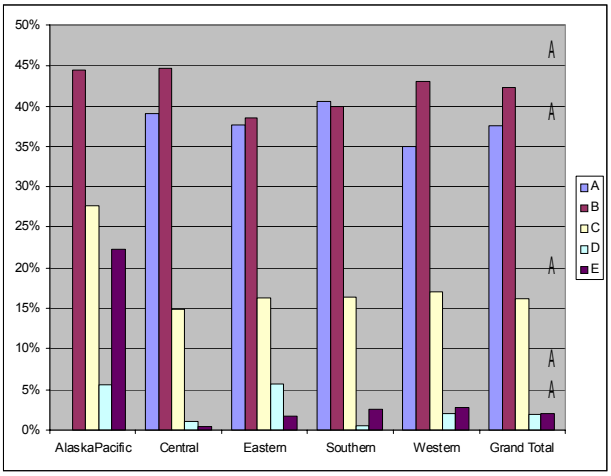
Staffing
Better 24 hour availability for flash flood support (25)
RFCs take full responsibility (4)
RFC should not take full responsibility (8)
Service Hydrologist at every WFO (3)
Move FTEs out of RFC (2)
Move SH to RFC and have RFC 24 hour (1)

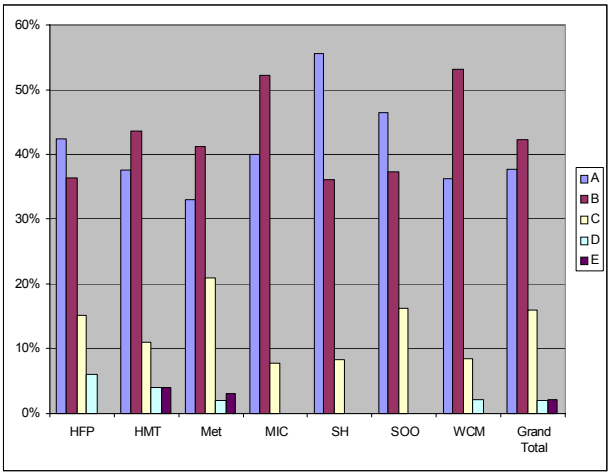
Products and Services
Improve FFG (143)
Issue FFG 2 or more times per day(25)
Provide FFG where not currently available (17)
Coordinate FFG across RFC boundaries (24)
Consistency on zone or county guidance (5)
Gridded FFG (5),Verify FFG (7)
Training on FFG (3)
Better definition of Flash Flood (3)
Update QPF/QPE more frequently (5)
Improve quality of QPF/QPE (11)
Provide automated StageIII when RFC closed (2)
Provide Precip data to support AMBER (2)
Develop models with short time steps and add more Forecast points(17)
Provide site specific model to wfo (15)
RFC should issue flood watches like SPC (2) - NOT Issue flood watch (7)
Provide training to WFOs on identify flood prone areas, Ice jam, outreach (8)

RFC Behaviors
Monitor events better and corrdinate with WFO (60)
RFC needs better basin understanding (18)
Understand needs of WFO (8)
Provide info to WFOs more quickly (9)
RFCs need to demonstrate concern for flash flooding (10)
Flash flood focal point to work with WFOs (2)

WFO-24 :
Please rate your office support of the river flood program

A. Excellent (290)
B. Good (326)
C. Adequate (125)
D. Poor (15)
E. Unnecessary (16)





WFO-25 :
How can your office improve support for the river flood program? (355 responses)

Improve training for forecasters and HMTs (48)

Increase number of gaging sites and forecast points (35)

Improve communications between RFC and WFO in particular more visits between the two offices (31)

Increase outreach with customers and partners (28)

Need a full time service hydrologist, not focal point (25)

Sr Service Hydrologist role not functioning as it should. They are not providing needed support to focal point and in some cases they had never been visited by the SH (3)

Need more time for SH / HFP functions

More support (time and funds) for field work (20)

All river functions should be at RFCs (12)

Give WFO more latitude in revising forecasts (5)

Give WFO the models

Implement Site specific (14)

WFO-27 :
How can the RFC improve support for the river flood program? (383 responses)

Products
Products need to be quality controlled a lot better.
Frequent complaints about forecasts being in error before they are even issued (22)
Product verification needs to take place (9)
More frequent updates particularly during flooding (9) especially need a quicker turn around time from data receipt to product (4)
Provide hydro forecast discussion product (2)
Provide forecasts with and without QPF (9)
Be willing to deviate from model guidance (7)
RFC needs to be proactive and not wait for request for forecast (12)
More forecast locations (5)
Ability to make several scenario or contingency runs as the event is in progress (4)
Provide daily forecast for all locations (9)
Graphical QPF and stage products (3)
RVF should be guidance not gospel (5)

Coordination
Better real time coordination with WFO to discuss conditons (22)
More outreach to WFO for training and listening (16)
Increase knowledge of HSA basins (14)
Field trips, possibly including WFO staff (7)
More willingness to rerun (7)
Listen to the WFO and be responsiveness (15) and don't give them an attitude (2)
Better monitoring of weather conditons (5)
Better communication skills (5)
Awareness of situational impacts (5) including media times (2)
Be willing to answer phones and talk to public (4)
Identify self when answering phones
WCM position

Science
Continue working on science improvements and calibration (14)
Improve snow model (2)
Develop ice jam model
Implement AHPS probabilistic forecasts (7)
6 hour time step is a problem
Use more QPF in models (4)

Other
RFC do not have to deal with the public complaints about their forecasts (8) and they do not care
24 hour staffing (11); increased staffing during flooding or potential flooding (4)
Keep up the good work (12)
Take over entire program (12)
Give entire program to WFOs (3)

WFO-32 :
Additional comments (304 responses)

Most of the comments were a re-statement of things earlier mentioned in the survey. A lot of emphasis on communication and coordination. Customers are served best when a strong working relationship exists between WFO and RFC.

Many comments on the accountability of WFO for river forecasts that they did not produce and do not have the flexibility to change

Training deficiencies were also noted

Many mentioned that they feel the current system may not be perfect but it is working fairly well. They don't want to abandon the WFO hydro program at a time they are getting the tools to do the job.

Almost all felt that especially the flash flood program needs to remain at WFO. Less certain about river flood although they tended to favor that

Other comments

RFCs need to provide better info on when products will be issued particularly during flood situation

RFCs need to do a better job communicating advances and limitations

WFO should be more accountable for hydro program. They should be able to do a better job, but don't because hydro program is not taken seriously

Build WHFS into GIS system and have RFCs also prepare GIS maps usable by WFOs

RFC forecasters should be included in all flash flood coordination calls

Several noted improved relations with RFC in past several years

Overlapping roles for QPF with the advent of IFPS needs to be looked at

Several mentioned attitude problems with RFCs - viewed as elitist and not wanting to support WFO
The organization of the RFCs is based on technological demands of the 1960s. RFCs should be creating their own local models and providing more innovative support to WFOs

Consolidating SH at RFC should be explored and possibly prototyped

Need 2-way communication to provide RFC reasoning/certainty

Method of assessing RFC effectiveness needs to be established

RFC ability to support a dam break, especially after hours

Those offices supported by multiple RFCs often noted differences in services, procedures, and attitudes

Appendix F

A Brief History of the Hydrologic Services Program Since 1945

In 1945, several hundred Weather Bureau Offices existed across the Nation, but only 85 were assigned "River District Offices" (RDO) functions. RDO functions were an addition to the weather-related responsibilities of these selected offices. A typical RDO area was defined by river basin boundaries and was significantly different from the area for the office's weather responsibilities. Only about 20 percent of the RDOs had a full-time "river expert" on staff. Floods were only occasional events in any one district, but very demanding of staff time when they occurred. The time consuming manual computations required to derive river forecasts, issue flood warnings, and provide other hydrologic services tended to suffer at the expense of other office activities for which there were more frequent and routine demands. The benefits of establishing separate River Forecast Centers (RFC), staffed by hydrologists, for the routine forecasting of streams and development of hydrologic forecast procedures to support these operations was recognized. Plans were formulated to create centers to perform these functions. The forecasts produced by RFCs would be transmitted to RDOs for dissemination to the public.

Figure 1 shows the areas of responsibility for the 13 RFCs that were eventually established to cover the entire U.S. As shown in the table at the bottom of this figure, it took 33 years to achieve complete coverage of the Nation by RFCs[1]. It is notable that formation of each center occurred through the political efforts of interest groups and local, state, and congressional delegations, often in response to one or more major flood events. Also, formation and locations for most RFCs was strongly influenced by activities of the U.S. Army Corps of Engineers. The Corps had begun producing its own forecasts for some rivers and releasing them to the public, and the NWS knew it needed to do a better job at river forecasting to support its cooperators and convince them that duplicate efforts weren't necessary. Many NWS RFCs were located in the same locations as Corps district offices, and the two agencies developed close working relationships. Even though RFC formation was closely linked to politics, an examination of the 13 areas of responsibility reveals, on the whole, a geographically sound subdivision of the nation according to major river basins and/or climatological regions.

The 1950's were characterized by slow but steady improvement of hydrologic procedures and techniques. River forecasts and warnings had improved to the point where the failure of the public to heed flood warnings was already being noted as an increasing problem. However, hydrologic modeling was beginning to lag behind atmospheric modeling in terms of scientific sophistication. The rather easy-to-understand unit hydrograph approach developed in the 1930's had become the

[1] Actually the AKRFC didn't assume responsibility for Hawaii until 1996, making the true length of time for national coverage 50 years.

River Forecast Center	Year Formed[1]	Circumstances Leading To Formation
Ohio (OHRFC)	1946	Ohio R. floods of January-February 1937, decision to focus hydrologic forecast expertise in a regional center
Missouri Basin (MBRFC)	1946	Several major floods, decision to focus hydrologic forecast expertise in a regional center
North Central (NCRFC)	1947, 1979[2]	Major floods in North Dakota and western Minnesota in the late 1970's (for current RFC formed in 1979)
Arkansas-Red (ABRFC)	1947	Record floods of March-April 1945 in the Arkansas and Red River basins
Middle Atlantic (MARFC)	1948	Record floods of 1936 in the Susquehanna basin, upgrade of the old Federal/State of PA river forecast center
Northwest (NWRFC)	1948	Record flood of May-June 1948, record floods of November 1949 in NW Washington
Southeast (SERFC)	1955	Efforts to establish a coordinated river forecast operation for the southeast states.
Northeast (NERFC)	1955	Efforts of congressional delegations in several New England states
West Gulf (WGRFC)	1961	Floods of April-May 1957 in southwestern U.S., findings of Senate report of November 1959 on river forecasting
California-Nevada (CNRFC)	1963	Series of floods in 1950's and early 1960's in Northern and Central California, construction of State Water Project
Colorado Basin (CBRFC)	1969	Efforts to upgrade water supply forecasting activities to full river forecasting operations
Alaska-Pacific (APRFC)	1971	Recommendation in disaster survey report on the August 1967 floods on the Tanana and Chena Rivers
Lower Mississippi (LMRFC)	1971	Efforts to complete national RFC coverage for an economically important portion of the basin

[1] Many RFCs had earlier predecessors with various types of hydrologic forecasting responsibilities (e.g., water supply)
[2] St Louis RFC was consolidated with the Kansas City RFC in 1966 and reformed as the NCRFC in 1979

Figure 1. RFC areas of responsibility and brief history of RFC formation.

foundation of NWS hydrologic modeling. Meanwhile, atmospheric models were increasingly based on the principles of thermodynamics and theoretical equations of fluid motion. This divergence is largely attributable to the relative ease at which the equations of motion can be solved above the atmospheric boundary layer as opposed to the extreme difficulty in modeling physical processes associated with water movement on and below the ground surface in a variety of hydro-climatic regions. However atmospheric modeling clearly received the lion's share of Weather Bureau resources in terms of research staffing and computers.

The computer age didn't begin for NWS hydrology until the 1960's, and the first computerized hydrologic models simply represented automated versions of the forecast procedures developed over the previous decades. In 1961, the West Gulf RFC received an IBM 1620, which allowed hydrologic forecast procedures to be computerized for the first time. Even though this computer-card fed system was primitive by today's standards, its use allowed forecasts to be issued hours earlier than was previously possible. The hydrologic modeling programs developed at RFC Fort Worth spread quickly to the other RFCs. This illustrates a programmatic complication still existing today. RFCs were evolving into substantially independent entities in an environment with minimal centralized support, relying on locally-developed procedures and customized adaptations of the work done by other RFCs for much of their forecasting technology.

During the mid 1960's, headquarters support for the Hydrologic Services Program was reorganized in an effort to improve management. In 1964, the Hydrologic Services Division became the Office of Hydrology, with broad responsibility to support the hydrologic forecast and warning efforts of Weather Bureau field offices.

In the early 1970's, an NWS flash flood program was established in response to a recommendation in the disaster survey report on the July 4-5, 1969 floods in the Akron, OH area. The NWS approach to addressing flash flooding illustrates another programmatic complication which still influences present operations. Short-fused flooding had been largely ignored by the RFCs, since they were still well-entrenched in lumped, unit hydrograph based modeling systems which didn't lend themselves to smaller basins. Also, they were not staffed to handle events which could essentially occur at any time of the day. Furthermore, flash flood forecasting technology required a real-time data network which didn't exist in most areas. Instead of developing the required small basin hydrologic modeling technology, implementing nation-wide networks, and investing in the computer resources needed to provide on-site flash flood forecasting capabilities, the NWS opted for a simplified approach based on county-wide warnings. This provided an easy way for local weather offices to issue flash flood watches and warnings for areas when sudden flooding was occurring and it was impractical to pinpoint individual threatened locations.

Towards the end of the 1970's, floods in Rapid City, SD (1972), Big Thompson Canyon, CO (1976), Johnstown, PA (1977), and other locations prompted efforts to establish real-time data networks which would allow more site-specific warnings to be produced for short-fused flood events. The ALERT technology was developed to provide real-time data for California river systems, since national networks didn't provide adequate coverage or timeliness. IFLOWS was developed to provide real-time data for flood-prone areas in the Appalachian region. However, these networks only served small areas and left most of the nation uncovered.

During the early 1970's, the Office of Hydrology developed an operational forecast system which eventually evolved into the NWS River Forecast System (NWSRFS) by the middle and late 1970's. By Version 5 of this system, several models developed by individual RFCs were incorporated. During the 1970's and 1980's, NWSRFS was executed on mainframe computers at the World Weather Building. However, the buy-in to NWSRFS was slow and most RFCs relied heavily on their own modeling systems

In January 1971, the Weather Bureau officially became the NWS and the Weather Service Forecast Office (WSFO)/Weather Service Office (WSO) structure and the associated "area management" concept were implemented. In this structure, WSFOs were responsible for forecasts and watches for state areas, multi-state areas, or portions of states and WSOs within the WSFO areas produced local adaptations of WSFO forecasts and warnings for county areas. After implementation of WSFOs and WSOs, the NWS continued to provide hydrologic services through the RDO structure for a few more years. However, as the number of WSFOs increased from 38 to 52 between 1971 and 1974, the number of RDOs decreased from 83 to 69, as many were consolidated and their boundaries were revised to more closely coincide with state and WSFO areas. In 1974, efforts were increased to hire a hydrologist for each WSFO to manage their hydrologic programs. These individuals came to be known as Service Hydrologists. In the 1975-1976 period, public hydrologic services were phased out of RDOs and given to WSFOs and WSOs with assigned HSA responsibility. By 1985, there were 54 HSAs – most of which were assigned to WSFOs, but a few of which were assigned to WSOs and RFCs. Most HSA offices had a Service Hydrologist.

The 1980's was a somewhat frustrating period for field offices, because public demands for improved weather and hydrologic services seemed to continually increase under the assumption that the NWS must be keeping up with all of the new computer technologies and capabilities. In reality, few if any major National upgrades to hardware or scientific capabilities were implemented at NWS field offices during this period, and stream and precipitation networks were actually being cut back in many areas due to budget problems. For a few field offices, pressures from outside the NWS brought about staff augmentations and/or improved computer systems to support hydrologic operations. However, field offices generally made due with locally or regionally acquired microcomputers and late 1970's-era equipment. Fortunately, highly creative NWS personnel made innovative adaptations to these systems to continually increase their usefulness into the 1980's.

Automated real-time networks provided a wealth of new hydrometeorological information for hydrologic operations. Unfortunately, most WSFOs and WSOs did not have access to DCP data, since AFOS was not designed to receive and store such large volumes of digital information. RFCs did have access to these data through their DATACOL systems since they needed it for hydrologic modeling operations.

The 1980's were the first decade in which WSFOs and WSOs operated completely under the Service Hydrologist/HSA structure. No nationally-supported hydrologic forecast system existed at HSA offices during this period, and regional headquarters provided almost all support for HSA operations. On a site-by-site basis, Service Hydrologists developed local procedures for storing hydrologic information and deriving hydrologic forecasts based on RFC guidance. National

support for HSA operations was regarded as a low priority at NWS headquarters, with almost all resources oriented towards RFCs. Ironically, many RFCs continued to operate virtually independent from the national support structure, because headquarters development efforts tended to be divorced from the actual field office requirements. Hydrologic service program support was also weak due to excessive emphasis being placed on international activities with little relationship to field office operations and interagency coordination activities which brought proportionally small benefits to field offices given the staff hours involved.

The NWS modernization and associated restructuring (MAR) of the 1990's brought about major changes to the Hydrologic Services Program which continue to be felt to this day. Modernized technologies were implemented and the WSFO/WSO field office structure was replaced with a single tier Weather Forecast Office (WFO) structure. However, the greatest benefit of the MAR was probably that it forced NWS headquarters to eventually implement a requirements-based approach to hydrologic system development for both WFOs and RFCs.

The NWS MAR forced the hydrologic staffing at WFOs and RFCs to be re-evaluated. It was decided to assign HSA responsibility to each WFO, but conversion to a field office structure where state boundaries were less important necessitated a review of Service Hydrologist distribution. An analysis was conducted to determine WFO areas with the highest hydrologic program requirements. In the final analysis, it was decided to increase the total number of Service Hydrologists from 45 to about 80. The analysis showed that almost all locations with pre-MAR Service Hydrologists would continue to require the position, even though their office may have been moved and their HSA reduced in size. Positions were also assigned to new WFOs serving areas with high user requirements and flood frequency. An equally significant change affecting WFO hydrologic operations was the transfer of responsibility for issuing hydrologic forecasts and warnings to the operational shift Meteorologists. This required a major culture change in the WFOs, since Service Hydrologists had been largely responsible for this function in the past.

For RFCs, it was decided to extend from an operations schedule which covered an average of 10 hours per day to a "nominal 16-hour" schedule. This schedule extension, as well as the establishment of a new Hydrometeorological Analysis and Support (HAS) function, was taken into account in an analysis for new RFC staffing levels. In recognition of the importance of modernized RFC operations and the resulting added workload, total staffing at all RFCs went from 135 to 200 – an increase of about five per office. This was the first time an RFC staff augmentation was achieved independent from outside political efforts.

Appendix G

Team Observations

The following observations were derived from the Team's information collection and assessment activities.

1. NWS is doing a very good job of meeting our customer's and partner's basic hydrologic service needs.

2. Flash flood guidance is currently a weak link in the flash flood program..

3. There are very real, significant, and justifiable differences between the RFCs as a result of variation in hydrologic regime and the specific needs of local customers. Complete standardization is neither feasible nor an effective way to serve NWS customers.

4. RFCs collect, assemble, and develop a wealth of hydrologic observational and forecast data for their areas that is of great value to NWS customers and partners.

5. There is high value associated with elevating the technical credibility of the NWS hydrology program.

6. Current OPM hydrologist (GS-1315) requirements do not meet the NWS needs. The NWS has specific needs that are not addressed in this very generalized series. The continued use of this series, without substantial modification, will limit the ability of the NWS to meet established goals..

7. NWS customers and partners have clearly defined what constitutes enhanced service.

8. There exists a clear need for consistency in products and services from office to office.

9. NWS product categorization (i.e. flash flood vs. river flood) confuses NWS customers and partners.

10. Resources are lacking to develop sub-national hydrologic modeling capabilities needed for forecasts. These local and regional requirements are significant and essential to meet customer requirements.

11. The expectations for RFC operational support are not consistent between WFOs and RFCs.

12. Data resources are often the limiting factor in providing hydrologic service that meets NWS customer and partner requirements.

13. Many WFOs and RFCs are not functioning as a team.

14. Training remains a very important aspect of current and future service delivery capability. It was noted that experience is the best trainer.

15. Hydrologic modeling and forecasting capability will evolve outside of the NWS.

16. Internal and external expectations for RFC products have not been established.

Appendix H

Detailed Supportive Information Associated with Primary and Secondary Findings

Finding 1: The current NWS operational structure is meeting the basic hydrologic service needs of its customers and partners.

Assessment of Customer and Partner Service Requirements.

- The vast majority of customer and partner current needs are being met.
- 40% of interviewed customers/partners indicated the quality of NWS hydrologic products and services is excellent while 60% indicated it is good.
- 33% of interviewed customers/partners indicated the timeliness of NWS hydrologic products and services is excellent while 63% indicated it is good. Only 4% indicated that the timeliness of NWS hydrologic products and services is poor.
- The NWS has many satisfied customers.
- Interviews with several customers revealed an outstanding working relationship with a supporting WFO, RFC, or both..
- 53% of interviewed customers/partners indicated that a local NWS point of contact is very important.

External Assessment (NRC Report).

- Aside from education, training and some staffing issues, the report is generally favorable towards the ability of the NWS to meet customer and partners needs with the current operational structure.

Internal Assessments, Documents, and Disaster Survey Reports.

- Reports do not identify instances where major failures in the operational structure lead to service delivery problems.

Insight from Corporate Experts

- "Most of the options for staffing and responsibilities have been considered at one point or another during the past 20 years."
- "If RFCs were to become responsible for public outreach, a lot of travel time (and money) would be required."
- "RFCs probably cannot integrate both river and flash flood program."
- "If production responsibility for hydrologic information is taken from the WFOs will they remain interested and enthusiastic about hydrologic outreach and customer service?"

Operational Staff Web Survey

- More than 90% of WFO and RFC staff feel that WFOs should continue to issue public flash flood watches and warnings.
- Most WFO and RFC staff feel that WFOs should continue to issue public flood watches and warnings.

- A substantial majority of both WFO and RFC staff feel that a local NWS contact is extremely important in the delivery of products and services.
- Nearly 80% of WFO and more than 50% of RFC staff feel that service is improved when the WFO issues public hydrologic products..

Finding 2: NWS customers and partners have requirements for enhanced hydrologic service.

Assessment of Customer and Partner Service Requirements.

- Increase forecast accuracy and dependability.
- Expand forecast locations.
- Provide routine forecasts earlier in the day.
- Provide routine and consistently available forecast information.
- Provide forecasts for smaller, faster responding watersheds.
- Increase temporal precision.
- Provide forecast uncertainty.
- Where feasible, provide flood inundation mapping.
- Include affects of water management activities in ESP traces.
- Provide forecasts for a spectrum of durations (hours, days, weeks, months).
- Improve QPF and QPE.
- Provide on-line, real-time and historical data access.
- Provide consistency in products and information.
- Improve timeliness of Cooperative Observer Program data collection.
- Increase the density of data collection networks.
- Increase communication and coordination with counties.
- Address intra and inter WFO/RFC partnership inconsistencies.
- Improve public awareness and customer education.
- WFOs require access to hydrologic expertise and hydrologic field support to ensure a successful hydrologic forecast program.
- The NWS needs consistent hydrologic expertise at WFOs.
- The NWS should increase its visibility in hydrology and get more involved with active hydrology groups.
- The NWS should increase its collaborative interest and intergovernmental relationships need to be developed and enhanced.
- Although the external user community perceives the NWS is doing a good job in providing data, forecasts, and information, the gap between services and user requirements is growing.
- NWS customer base is diverse in its need and use of hydrologic data, forecasts and information.

External Assessment (NRC Report).

- The committee concluded that NWS forecasters with a degree or extensive formal education in meteorology but no comparable training in hydrology usually are not qualified

for hydrologist positions. The NWS should review and, if warranted, modify its qualification standards for hydrology positions.

- Field personnel and users of products and services should have a greater involvement in the further definition and development of WARFS and other components of AHPS.

Internal Assessments, Documents, and Disaster Survey Reports.

- The modernized NWS has a critical need for professional personnel trained in both hydrology and meteorology and has developed qualification criteria for these new hydrometeorologists. (The Great Flood of 1993).
- NWS needs consistent hydrologic expertise at WFOs (Northeast Floods of January 1996).
- The hydrologic program at WFOs would benefit from the delivery of more information from the RFCs (Northeast Floods of January 1996).
- RFC forecasts should remain reflective of the current QPF (Northeast Floods of January 1996).
- WFOs and NWS partners need up-to-date river forecasts with more detail than just daily stage values.(Hurricane Floyd Floods of September 1999).
- A need exists for better forecasting capability for small, fast responding watersheds (Tropical Storm Allison, Heavy Rains and Floods, Texas and Louisiana June 2001).
- AHPS products and information will cover future hydrologic events ranging from minutes out to months. These new services will enable partners and customers to make more informed decisions and better manage risks. Incorporated into products will be applicable data from the historical record, current observations, forecast point descriptions, maps, geographic information, and other data which will enhance partner and customer understanding of the likelihood and impact of potential and forecasted hydrologic events (AHPS Concept of Services and Operations, April 2002).
- Access to hydrologic information will be provided through national and local Web pages. Information will be accessed through user-friendly menus and scalable maps which zoom in or out of the area of interest. A national Web page will provide one-stop shopping access to the core suite of AHPS products. WFO and RFC web pages may include hydrologic products outside the national core suite which are designed to fulfill the NWS mission and meet the needs of local customers and partners (AHPS Concept of Services and Operations, April 2002).
- RFCs will conduct hydrologic modeling operations for streams, reservoirs, and lakes within large river basins and provide forecast information which serves as the basis for NWS hydrologic products. ...Their primary focus will be on river forecasts for the short-term period – i.e., from 0 out to 7 days – since these will continue to serve as the key input to WFO flood products and the decision-making process of customers and partners. ...When high water or flooding is imminent, RFC forecasters will prepare unscheduled or "event- based" river forecasts. These forecasts will be similar in content and form to daily forecasts (AHPS Concept of Services and Operations, April 2002).
- As NWS offices with the most localized areas of responsibility, WFOs will provide products for individual hydrologic events ranging from short-fused flash floods to slow rising floods on large rivers. Products include warnings, watches, and statements covering areas and streams of all sizes (AHPS Concept of Services and Operations, April 2002).

- Outreach, training, and service evaluation activities will be expanded on a local through national scale. These activities will ensure the NWS clearly understands our partners and customers need and products and services continue to meet their needs (AHPS Concept of Services and Operations, April 2002).
- The NWS will strengthen existing and establish new partnerships with local, state, regional, and Federal agencies, universities, and the private sector to be use resources to improve services (AHPS Concept of Services and Operations, April 2002).

Insight from Corporate Experts

- "RFCs need to make much more of their developed information available to customers, partners, and the public."
- "WFOs require access to hydrologic expertise and hydrologic field support to ensure a successful hydrologic forecast program."
- "RFCs must retain, or in some cases regain, a high level of hydrologic expertise."
- "The gap between academic research and operational implementation needs to be bridged."
- "The NWS should be seen as a player in the hydrologic science arena."
- "We have to make our capabilities KNOWN. WHFS gives the RFCs a way to get all that info out to the folks who need it ..... other agencies....emergency action folks,,,and the general public. I know WHFS raises other issues....but to ignore it would be like trying to hold back the tide."
- "Strengthen ties with the Corps of Engineers, USGS, and all professional hydrology/engineering organizations."

Operational Staff Web Survey

- WFO staff requested more forecast locations and more routine forecasts.
- WFOs requested improved quality in RFC river forecast guidance and increase responsiveness to feedback and requests for updates.
- Less than 40% of the RFC staff have a hydrology, civil engineering, or related background.
- Approximately 35% of the SHs have a hydrology, civil engineering or related, or a hydrology and meteorology background.
- Less than 20% of the HFPs have a hydrology and meteorology background.
- "Increase outreach to customers and partners" was a common response by both WFOs and RFCs in the internal survey of NWS operations.

Future Assumptions and Factors

- NWS customer and partner requirements for high quality hydrologic forecast information will increase in the future.
- Heightened resource management will demand forecast information that supports decision support tools.
- NWS is significantly engaged in the AHPS program. This program involves deployment of probabilistic hydrologic forecasts and visualization products that many user segments are unfamiliar with the concept or how to incorporate this new spectrum of information into there current decision support process. To realize potential of NWS AHPS products it is essential that users are involved in the process of how the NWS will package and disseminate information to realize potential benefits in advanced technology.

- In general users are becoming more sophistication in their needs of NWS products and services.
- Success of current and future product and service delivery depends on providing the customer or user what they need to either mitigate losses from extreme events or optimize decisions on water use and management.
- In the past, the NWS has selectively engaged users through a variety of conferences, workshops, and meetings. This approach is no longer satisfactory. The current pace of NWS hydrologic service development requires a much greater level of interaction and feedback to ensure proper customer focus and relevance.

Other

- The USGS and the Corps of Engineers are actively developing and applying hydrologic forecast systems domestically and internationally.

Finding 3: NWS customers and partners would benefit from improved WFO/RFC interaction and teamwork.

Assessment of Customer and Partner Service Requirements.

- Address intra and inter WFO/RFC partnership inconsistencies.
- Increase communication and coordination with counties.
- Hydrologic experts are not always available at the WFO.
- The level of expertise is not consistent between different WFOs.

Internal Assessments, Documents, and Disaster Survey Reports.

- The West Gulf RFC was not staffed the evening of May 1 even though area lakes were full... However, the RFC forecaster.. was in telephone contact with WSFO Fort Worth. (Disastrous Floods on the Trinity, Red and Arkansas Rivers, 1990).
- Many meteorological forecasters did not feel proficient handling prolonged and major hydrologic operations when a SH was not in the office or on staff. (The Great Flood of 1993).
- Both MBRFC and the NCRFC provided extended coverage for most of the protracted flood events on a 7-days-a-week schedule well into the evening (usually until 10 or 11 p.m.). Nevertheless, certain users cited an inability to acquire needed information during hours when the RFCs were not in operation, and many end users require 24-hour RFC support during major flood events. The NCRFC provided around-the-clock coverage for 4 days ...MBRFC provided 24-hour coverage for 2 days. (The Great Flood of 1993).
- Coordination is required between RFC and the WFO for updating river forecasts when needed (Northeast Floods of January 1996).
- NCRFC HIC and FGF MIC spent many hours providing interviews and other media responses, but they did not have a clear agreement on how they would manage media inquires (Red River of the North 1997 Floods).
- Although it is not explicitly stated, WFOs and RFCs will need to cooperate and collaborate at a very high level to achieve the full potential benefits of AHPS (AHPS Concept of Services and Operations, April 2002).

- Opportunities to improve 24-hour service availability have been identified: 1) Investigate off hour RFC contact procedures for WFOs and external partners to see if they can be optimized, 2) Identify specific RFC personnel to monitor hydrologic conditions when the RFC is not staffed, 3) Establish routine WFO coordination procedures for RFC extended staffing decisions, 4) Advise external partners when RFC extends their operational staffing. (Evaluation of Southern Region's River Forecast Center 24x7 Operations Test).

External Assessment (NRC Report).

- "Collocation of RFCs with WFOs to date has demonstrated that direct personal interaction can enhance office operations. However, even at these collocated offices, potential benefits are not being realized because of limited staffing, minimal amounts of cross-training..."
- "The NWS can best exploit the opportunity that the modernization affords not only by emphasizing technology bu also by capitalizing on the overlapping aspects of hydrologic and meteorologic science and technology and by developing new operations to aid interaction and transfer of information between hydrologists and meteorologists."

Insight from Corporate Experts

- "Significant improvements in service can be attained by improving interactions between the meteorologic and hydrologic sides of the agency. Hydrologists and meteorologists need to work side-by-side. The gap between WFOs and RFCs needs to be bridged.
- "RFCs probably cannot integrate both river and flash flood programs. Team work between the RFCs and WFOs has to be effective."
- "RFCs were located and staffed to account for differences in hydrometeorological regime."
- "24 hour per day service can be achieved without routine 24 hour per day staffing through creative use of modern communications and computational technology."

Operational Staff Web Survey

- In "additional comments" from WFO staff, there was a lot of emphasis on communication and coordination. Customers are served best when a strong working relationship exists between the WFO and RFC.
- There is disagreement as to whether RFCs understand the hydrologic needs of WFO customers (RFC 60% yes vs. WFO 32% yes).
- RFC and WFO staff assessed the quality of RFC support for the river flood program differently.
- RFC and WFO staff assessed the quality of RFC support for the flash flood program differently.
- RFC and WFO staff assessed the RFC responsiveness to WFO requests for new or expanded services differently. (RFC 88% excellent to good vs. WFO 45% excellent to good. 25% of WFO respondents did not know).
- On the question of what field office should be accountable for the river flood program 47% of RFC respondents indicted the RFC and 49% indicated a joint RFC/WFO accountability while 24% of WFO respondents indicated the RFC and 60% indicated joint RFC/WFO accountability.
- Expectations for RFC operational support are not consistent between WFOs and RFCs. (RFCs judge their operationally availability much higher than the WFOs.)

- WFO responses to "the impact of AHPS" reveal a great deal of misconception which reflects a lack of teamwork and coordination.
- The web survey response rate of 35% for WFOs (versus 80% for RFCs) suggests a lack of hydrologic interest and involvement on the part of many operational WFO staff.
- A majority (55%) of WFO respondents were not directly involved in hydrologic outreach in the past 12 months.

Future Assumptions and Factors
- Successful implementation of AHPS will, among other things, require improved WFO/RFC collaboration.

Finding 4: Flash Flood Guidance is currently a weak link in the flash flood program.

Assessment of Customer and Partner Service Requirements.
- A variety of users from Federal, State, and Local government, as well as the media and the public require accurate high resolution information on the potential for flash flooding.
- External users identified high quality, consistent Flash Flood Guidance as a current unmet need.
- Customers and users noted that there are only limited forecast services provided for smaller streams. They have a greater need for information on small stream flooding that the NWS currently provides.

Internal Assessments, Documents, and Disaster Survey Reports.
- WFOs need Flash Flood Guidance that is consistent across RFC boundaries (Hurricane Floyd Floods of September 1999).
- The probability of detection (i.e., accuracy) and warning lead time for flash floods will be increased. The false alarm rate will be reduced. These service enhancements will be realized through the use of a monitoring and prediction system which incorporates high-resolution quantitative precipitation estimates (QPE) from radar, ground-based gages, and satellites as well as short-term quantitative precipitation forecasts (QPF) (AHPS Concept of Services and Operations, April 2002).

Insight from Corporate Experts
- "RFCs need to provide more technical support for the flash flood program."
- "Need to improve Flash Flood Guidance. It is useful to both WFOs and NWS customers."

Operational Staff Web Survey
- Staff from both the WFO and RFC generally acknowledge that there is a joint responsibility for supporting the flash flood program, but that public products such as watches and warnings should originate from the WFO.
- Approximately two-thirds of WFO staff rated current RFC support for the flash flood program as adequate or poor.
- The most common response to the question "How can the RFC improve support of the Flash Flood Program" was to improve Flash Flood Guidance. Other responses included a

recognition for additional training on the use of FFG, a consistent definition of a flash flood, and how to verify flash flood warnings.

- Significant portions of Western Region and Alaska do not currently receive flash flood guidance due to inherent problems with the FFG program for their areas. In particular, problems with terrain, scales, and data issues were noted. In many areas in the West, flash flooding is strictly a function of rainfall intensity. In other areas of the county, soil moisture is a significant variable that must be taken into account.
- Implementation of the national gridded threshold runoff program, which was largely developed to assist in reducing inconsistencies introduced new inconsistencies due to variations in state/regional USGS regression equations and implementation choices.

Finding 5: **Hydrologic and hydrology program training for NWS personnel as well as NWS customers and partners is essential to the success of the NWS mission.**

Assessment of Customer and Partner Service Requirements.

- Improve community education on river and flood safety.
- Develop more local programs (training, demonstrations, etc.).
- Improve public awareness and customer education.

Internal Assessments, Documents, and Disaster Survey Reports.

- The MIC and SH must ensure that the staff at WSFOs and WSOs are trained in and carry out hydrologic data collection tasks. This becomes critical during extended floods when the SH becomes overloaded (Disastrous Floods on the Trinity, Red, and Arkansas Rivers, May 1990).
- If WSO and WSFO staff are to continue answering public questions on flood events, more training or guidance should be considered to help them give the best possible answers to the public's questions (Disastrous Floods on the Trinity, Red, and Arkansas Rivers, May 1990).
- The public may not have understood the role of the NWS in the issuance of warnings and river forecasts (Disastrous Floods on the Trinity, Brazos, Colorado, and Guadalupe Rivers in Texas, December 1991 - January 1992).
- Many meteorological forecasters did not feel proficient handling prolonged and major hydrologic operations when an SH was not in the office or on staff (The Great Flood of 1993).
- The SHs should ensure that all office staffs are trained on the appropriate use of product types (The Great Flood of 1993).
- The media and the public do not fully understand hydrologic terminology, procedures, and forecast products (The Great Flood of 1993).
- Additional training should be provided to RFCs on the physics of snow ablation (Northeast Floods of January 1996).
- Many media do not understand hydrologic forecast techniques and the role of the RFC in the NWS infrastructure (Northeast Floods of 1996).
- The NWSFO Boise WCM has hosted several media workshops. The unanimous opinion of the local media and the Boise office is the these workshops are very valuable for improving government-private meteorological partnership (Disastrous Floods from the Severe Winter

Storms in California, Nevada, Washington, Oregon, and Idaho December 1996 - January 1997).

- ...the Payette County EM was unaware of the services provided the NWS (Disastrous Floods from the Severe Winter Storms in California, Nevada, Washington, Oregon, and Idaho December 1996 - January 1997).
- At times, NWSO Eureka and NWSO Sacramento staff were confused on which product header to use in a given situation (Disastrous Floods from the Severe Winter Storms in California, Nevada, Washington, Oregon, and Idaho December 1996 - January 1997).
- One of the media interviewed revealed that if SH or assistant was not the person he was coordinating with, then the services were much slower. The staff appears to have received hydrologic training, but their proficiency was not as sharp as the SH or focal point (Disastrous Floods from the Severe Winter Storms in California, Nevada, Washington, Oregon, and Idaho December 1996 - January 1997).
- NWS products and discussions by NWS staff generally included qualifications intended to convey the uncertainty inherent in NWS outlooks and forecasts. Nevertheless, many users developed a false sense of precision in NWS products (Red River of the North 1997 Floods).
- The local NWS should be more active working with the state and county EMA officials in Kentucky and help plan and conduct periodic training workshops (Ohio River Valley Flood of March 1997).
- Training information will be available to partners and customers on how to access and use the new AHPS products and information. Training will also be conducted for NWS personnel on the new science and modeling approaches used in AHPS and the operational use of the AHPS technology (AHPS Concept of Services and Operations, April 2002).

External Assessment (NRC Report).

- To take optimal advantage of the NWSRFS potential, perhaps the most important need is for advanced training for forecasters in the use of both the calibration features and the interactive capabilities of the system.
- ...One essential key to proper use of WHFS is adequate training for service hydrologists...
- Nevertheless, training and staffing are fundamental issues that are implicit in the modernized operations of a WFO and RFC.
- After reviewing the training plan and course content in light of operational duties and responsibilities ... the committee concludes that new, specialized hydrology training modules are necessary to prepare forecasters for their new and complex duties and to fulfill the potential of modernization.
- Although the new WFO Operational Hydrometeorology Forecasting course may be adequate for WFO meteorological forecasters, it does not adequately meet the needs of service hydrologists, who also serve as the scientific liaisons for WFO hydrology.

Insight from Corporate Experts

- "Training needs to be improved at WFOs. Most service hydrologists are really data hydrologists without adequate background on hydrologic processes."
- "We need real hydrology training such as the USGS gives all new employees. All new hydrologists with the USGS first attend a several month training program in Denver where they learn about hydrology the USGS way."

Operational Staff Web Survey

- 75% of HICs and 83% of hydrologic forecasters feel adequately trained to perform the hydrologic function.
- 15% of RFC staff who routinely work the HAS function indicated they were only "somewhat" trained to perform that function.
- 50% of RFC staff who occasionally work the HAS function indicated they were only "somewhat" trained to perform that function.
- More than 20% of WFO operational staff do not feel adequately trained to perform the hydrologic function.
- HMT staff are routinely involved in performing the hydrologic function but more than 20% indicate that they are not adequately trained.
- When asked how your office can improve its support for the river flood program the most common WFO response was "Improve training for forecasters and HMTs."
- When asked how your office can improve its support for the flash flood program, the majority of responses related to training issues.

Finding 6: Performance measures and standards establish appropriate customer expectations, provide direction, and document progress.

Assessment of Customer and Partner Service Requirements.

- Customers and partners have expressed a need for improved forecast accuracy and dependability as well as expanded service. Without measuring and tracking performance, the NWS and its customers cannot reasonably determine if (1) requests are realistic and (2) if attempts to improve performance are successful.

Internal Assessments, Documents, and Disaster Survey Reports.

- Routine procedures must be implemented at the NMC and the RFCs, as a part of modernized system capabilities, to archive all data and products in digital format that are pertinent to ongoing developmental, operational, and verification programs (The Great Flood of 1993).
- Enhanced hydrologic services provided through AHPS will be verified to document improvements in forecast and warning accuracy (AHPS Concept of Services and Operations, April 2002).

Insight from Corporate Experts

- The WFO interface with customers is very important. Need to develop trust with NWS customers.

Operational Staff Web Survey

- Many WFO staff requested better quality controlled products and fewer errors in river forecast guidance issued by RFCs.

Future Assumptions and Factor

- Resource and emergency management in the future will make increasing use of decision making based on risk. Risk management requires an accurate assessment of service (forecast) reliability.

Other

- The National Weather Service Strategic Plan for Weather, Water, and Climate Services 2000-2005, establishes performance measures of hydrologic services and stresses the value of measuring and improving service.

Appendix I

Assessment of
Service Improvement Opportunities from the
Evaluation of Southern Region's River Forecast Center 24x7 Operations Test

RFC Operations

Investigate off hour RFC contact procedures for WFOs and external partners to see if they can be optimized.

Identify specific RFC personnel to monitor hydrologic conditions when the RFC is not staffed.

Establish routine WFO coordination procedures for RFC extended staffing decisions.

Advise external partners when RFCs extend their operational staffing.

The provision of 24 hour RFC service availability will necessarily require that each of these recommendations be fully implemented. RFCs must provide a consistent and reliable contact protocol that achieves agency goals and is fair to employees. Most events can be anticipated, but some (i.e. dam breaks) cannot. The use of technology such as pagers and cell phones should be embraced and integrated. Off-site monitoring to ensure that RFC forecasts remain viable is important. Remote access to AWIPS computational and communications resources would facilitate this needed function. RFC staff should be fairly compensated for their off-site work. Since this will likely involve a change in work, the NWSEO must be a partner in developing the procedures. Implementation of these four service improvement opportunities is recommended.

Service Issues

Establish consistent products and product formats.

Customers and partners consistently indicate that they are confused by all the different NWS products and formats. At the same time, local and regional customers benefit from products specifically designed to meet their needs. Therefore, the Team recommends that this service improvement opportunity be implemented, but not to the detriment of local and regional customers and partners.

Provide graphical Internet products.

The ability of the agency to convey information is dramatically enhanced through graphics and imagery. It is also important to note that the Internet has really become the primary product delivery system for all non-warning products as evidenced by the customer survey information provided in Appendix B. The Team recommends that this service improvement opportunity be implemented as feasible and appropriate as indicated by customer requirements.

Provide one-stop-shopping for hydrologic products on the Internet.

The notion of putting everything in one place is obsolete. The NWS needs to effectively link product and service availability to create the illusion of one-stop-shopping. Information access should be consistent. The implementation of the NWS corporate web image facilitates this goal. Implementation of one-stop-shopping for core hydrologic products and services is recommended.

Provide more timely updates during severe floods.

NWS customers and partners require up-to-date information and forecasts upon which sound decisions can be based. It must be recognized, however, that during extreme large-scale events the resources of the RFC may be taxed to the point where updates are not available as often as desired for all locations. This goal is, however, consistent with the Team's vision for improved technical capability. As our capabilities improve, our ability to provide more timely forecasts should increase. Implementation of this service improvement opportunity is therefore recommended as a natural consequence of improved science and technology.

Include more flood potential information in hazardous weather outlooks.

WFOs should be cognizant of flood hazards that may accompany or follow severe weather. Implementation of this service improvement opportunity is recommended.

Reduce the number of hydrologic product types.

The Team found that NWS customers and partners are not well served by the vast number of hydrologic product types. Implementation of this service improvement opportunity is recommended through the NextE22 Team.

Clarify flood product terminology.

This should take place in concert with the NextE22 efforts. WFO web sites and outreach should provide clear definitions of flood product terminology.

Provide shorter time steps for fast responding streams.

The need for improved forecasts and information associated with fast responding watersheds was clear in our assessment. Gains can only be made through enhanced science and technology. The Team recommendations are fully consistent with this specific recommendation. Implementation of this service improvement opportunity is recommended as technology, science, data, and resources permit.

Improve low flow forecast information for navigable rivers.

The Team envisions that demands for hydrologic forecast service in all flow regimes will increase. The ability of RFCs to meet this demand depends upon the degree to which our science and technology objectives are achieved. This service improvement opportunity is consistent with the Team's vision and the AHPS Concept of Services and Operations and should be implemented when and where feasible.

Include uncertainty in river forecasts.

Some NWS customers and partners are capable of using forecast uncertainty today and others will demand it in the future. The development of forecasts that accurately portray the uncertainty and the education of our customers and partners are key. This should be achieved through AHPS efforts. Implementation of this service improvement opportunity is recommended as technology, science, and resources permit.

Provide more timely access to all archived flood event data after an event. (Involves several agencies, not an RFC function).

The NWS is not staffed and does not have the resources to support a public archive function for all flood related information. If additional resources were identified, then it would be appropriate and desirable. Implementation of this service improvement opportunity, given current resources, is therefore, not recommended. It is possible, however, to envision that resources may be available through the development of multi-agency forecast operations and partnerships. Additionally, WFOs and RFCs should consider providing access and awareness of existing information that may meet some customers requirements.

Issue routine morning hydrologic forecasts earlier.

To the extent possible, RFCs should ensure that its customers and partners receive forecast information that meets their requirements for timeliness. This must be worked out locally through interaction with local customers. Agency-wide implementation of this service improvement opportunity is not necessarily feasible or required.

Establish consistent update frequencies for flash flood guidance.

The Team agreed that flash flood guidance should be updated at least once per day. Where and as data resources and other required information are available, the frequency of updates should be increased. Implementation of this service improvement opportunity is recommended.

Partner Relations

Clarify the roles of WFOs and RFCs regarding interaction with the media and emergency management.

The Team acknowledged the media role of the RFC in wide-spread flood events but identified the WFO as the primary contact for local media within the CWA. Local emergency management should be working with the WFO. During significant widespread flood events, regional and national emergency services agencies may be better served through direct interaction with the RFC. This process should escalate explicitly through WFO referral of customers to the RFC. Implementation of this service improvement opportunity is recommended.

Conduct more frequent meetings with partners to assess their needs.

Remaining in touch with current and envisioned customer and partners needs is essential. The Team echos this recommendation through Recommendation 2C and associated suggested action 2C1. Implementation of this service improvement opportunity is recommended.

Educate our partners on how to be use our services.

The NWS wants its products and services to be put to productive use. This requires outreach and an effort to educate our partners. This is true today and will become more important in the future as the complexity of our products and services increases. Implementation of this service improvement opportunity is recommended.

Increase site survey travel for model calibrations.

This is a local issue. Hydrologists responsible for watershed calibration should have access to an effective set of information which may include a tour of the watershed. No specific action on this service improvement opportunity is recommended.

Model Issues

Calibrate models using observed instantaneous discharge rather than mean daily flows.

To the extent that instantaneous discharge data are available, this can be done today. The desirability of doing this depends on the intended use of the model and

is up to the discretion of the RFC. No specific action on this service improvement opportunity is recommended.

Modernize the hydrologic models through distributed modeling techniques.

Although NWS customers and partners are calling for products and services most easily derived from a distributed process, they are not calling for distributed modeling specifically. The Team's recommendation for improved technical capability is consistent with the goal of this recommendation, although not with its degree of specificity.

Enhance flash flood program through improved science.

Poor flash flood guidance is the weakest link in the flash flood program. The NWS needs to direct resources towards the development of scientifically sound and nationally consistent flash flood guidance. Near realtime multi-sensor precipitation estimation also needs improvement. In many areas the radar-centric approach available today does not provide adequate information. Implementation of this service improvement opportunity is recommended.

Put more hydrologic expertise into the Flash Flood Monitoring and Prediction System

Same comments as above.

Data Issues

Increase availability of timely stream gage data.

The NWS can and should encourage and facilitate the efforts of other agencies to collect timely stream gage data. Effective implementation of this service improvement opportunity is not feasible.

Review, update, and enhance river stage history data.

WFOs should have a regular schedule for reviewing, updating, and enhancing the information contained in E-19s. Implementation of this service improvement opportunity is recommended.

Modernize the Cooperative Observer Program and provide customers and partners with improved access to near real-time and historical records.

NWS customers and partners noted dissatisfaction with the timeliness of data provided through the Cooperative Observer Program. This is particularly true in the West where water supply forecasts often rely on monthly precipitation reports. Pressures on water management require forecasts be issued sooner and requests for mid-month forecasts are becoming more frequent. Some offices (both NWS and

others) have eliminated the use of these data because they no longer meet their requirements. The modernization of the Cooperative Observer Program is recommended.

Although NWS customers and partners are seeking access to a seamless data resource of near-realtime and historical data, the WFOs and RFCs cannot afford to become a public source for all hydrometeorological data. The time and effort required to do this properly is well beyond our ability to deliver and would compete with more important resource requirements more directly associated with the agency mission. Implementation of improved access to near-time and historical records is not recommended given current resources and priorities.

Appendix J

Acronyms

AHPS	Advanced Hydrologic Prediction Services
CWA	County Warning Area
DOH	Development and Operations Hydrologist
EOC	Emergency Operations Center
FTE	Full Time Equivalent
HAS	Hydrometeorological Analysis and Support
HIC	Hydrologist in Charge
HMT	Hydrometeorological Technician
HSA	Hydrologic Service Area
HSD	Hydrologic Services Division
NRC	National Research Council
NSETP	National Strategic Education and Training Program
NWSEO	National Weather Service Employees Organization
NWSRFS	National Weather Service River Forecast System
NWSTC	National Weather Service Training Center
MIC	Meteorologist in Charge
OCWWS	Office of Climate, Water, and Weather Services, NWS Headquarters
OHD	Office of Hydrologic Development, NWS Headquarters.
OHD/HL	Office of Hydrologic Development, Hydrologic Laboratory, NWS Headquarters.
QPE	Quantitative Precipitation Estimate

QPF	Quantitative Precipitation Forecast
RFC	River Forecast Center
RVD	Daily River Statement
RVS	River Statement
SH	Service Hydrologist
SSH	Senior Service Hydrologist
WFO	Weather Forecast Office
WSFO	Weather Service Forecast Office