Delivery of Warnings of Hydrometeorological Hazards
Southern Africa Region

PROJECT BRIEF

October 2015

Project Overview

The USAID Office of U.S. Foreign Disaster Assistance (OFDA) along with the World Meteorological Organization (WMO), RSMC (Regional Specialized Meteorological Centre) Pretoria , the U.S. National Oceanic and Atmospheric Administration / National Weather Service (NOAA/NWS) and the Hydrologic Research Center (HRC) have agreed to develop a project to link and enhance the Southern Africa – Severe Weather Forecast Demonstration Project (SWFDP) and Southern Africa Region Flash Flood Guidance (SARFFG) systems with an objective to provide improved service delivery of forecasts, warnings and information to the Disaster Risk Reduction (DRR) agencies/organizations at the regional, national and local levels in Southern Africa in order to reduce loss of life and property. See Appendix A for an overview of the SWFDP and SARFFG systems.

This project will: 1) integrate/link hardware, software and data in both the SARFFG and SWFDP systems; 2) improve forecast operations at RSMC Pretoria and the nine Southern African countries that have access to both systems; 3) build capacity of the hydrological and meteorological operations of each national center and RSMC Pretoria; and 4) improve service delivery to the National and Regional Disaster Management agencies and DRR users through improved warnings(e.g., lead time, message content and impact information), dissemination and enhancement of severe weather disaster awareness, preparedness and response. For this project to deliver improved services, it will integrate/link and enhance two fully operational systems, build capacity through training and develop and implement a severe weather/flash flood concept of operations (CONOPS) for each country for warning services to connect to disaster response operations and users so that lives can be saved.

Both the SWFDP and the SARFFG are regional-based systems that have been designed to provide forecasters at the National Meteorological and Hydrological Services (NMHSs) the necessary data and information to provide timely and effective warnings of severe hydrometeorological events, including conditions for rainfall that could lead to flash floods, thus protecting life and property in their countries. Because they are regional-based systems, they provide these data and information efficiently and cost-effectively. Both systems encompass end-to-end early warning system (EWS) concepts by including the elements of 1) observing, detecting and developing hazard forecasts and warnings; 2) assessing the potential risks and integrating risk information in the warning messages; and, 3) distributing, rapidly and reliably, understandable warnings to authorities, risk managers and the population at risk as well as many other users, such as the agricultural sector. Linking the two systems both programmatically and technically enhance their capabilities to address the fourth element of an end-to-end EWS – emergency preparedness and response to warnings at all relevant levels (national to local) to minimize the potential impacts of extreme hydrometeorological events.

Linkages between the systems will lead to improvements in the capabilities of both initiatives and create closer collaborations between NMHSs, leading to improved service delivery. A particular emphasis will be placed on “reaching the last mile”, making sure warnings developed from both systems reach the affected population and users timely and accurately and are in a format that can be easily understood and acted upon to achieve maximum value in resulting disaster response actions. Improved linkage between NMHS warning products and services to national and community disaster response activities is the principal goal for integrating these two successful forecast and warning systems.

Project Definition

The overall goal of the project is to improve accuracy, lead time, communication and dissemination of severe weather and flash flood warnings to communities. To accomplish this goal, the project will consist of the following elements:

- Linking the SARFFG and SWFDP systems that are now operating separately at RSMC Pretoria with products available at nine NMHSs in Southern Africa.
- Improving Forecast Operations – In both systems there are daily operational and maintenance functions conducted that need to be better synthesized. In addition, the dissemination of products from each system needs to be better organized so meteorological forecasters can transmit alerts and warnings faster and directly to user agencies allowing them to take response actions more quickly.
- Capacity Building – There is a significant need to train forecasters at RSMC Pretoria, and the forecasters at the nine NMHSs on operations and applications of the two systems. In addition training is essential for the user community which primarily consists of national, regional and local disaster management agencies as well as active NGOs.
- Awareness, Preparedness and Response —For the Disaster Risk Reduction (DRR) sector in each country, the degree of outreach and readiness needs to be assessed. This includes the available materials and brochures, as well as the legal frameworks in effect to assure effective use of improved warnings and forecasts. An essential aspect of this project is having the DRR community clearly define the information and products they need to maximize response and minimize loss of life and property.

All activities will be undertaken in three phases over a three year period.

Phase 1 Activities

Since Phase 1 activities are more clearly defined than those for Phases 2 and 3 at this time, the focus on this project brief will be on Phase 1. Activities for Phase 1 include those noted in Table 1.

TABLE 1. PHASE 1 ACTIVITIES AND CURRENT STATUS

ACTIVITY	STATUS (As of October 2015)
2015 regional cross-training workshop on SARFFG and SWFDP systems operations – THIS IS PROVIDED FOR INFORMATION ONLY, THIS IS NOT A PROJECT PHASE I ACTIVITY AS IT HAS A SEPARATE FUNDING SOURCE	Planned for November 2015 in Pretoria (RSMC Pretoria)
Regional technical meeting on SARFFG-SWFDP integration/system linkages Develop Roadmap for regional and country end-to-end warning development applying linked SARFFG and SWFDP systems Regional user workshop to define warning requirements Regional and country linked SARFFG-SWFDP system application	All activities planned for a workshop 26-30 October 2015 in Pretoria (WMO, USAID/OFDA, HRC, RSMC Pretoria)

TABLE 1. PHASE 1 ACTIVITIES AND CURRENT STATUS

ACTIVITY	STATUS (As of October 2015)
CONOPS workshop (in conjunction with user workshop) Develop Draft CONOPS for nine SARFFG/SWFDP countries	
SARFFG operations training at HRC for nine SARFFG countries	Scheduled for 8 September – 2 October 2015 (WMO and HRC)
SARFFG system interface upgrade	Preliminary design started (HRC and RSMC Pretoria)
Begin other SARFFG and SWFDP systems development	Preliminary designs started (HRC and RSMC Pretoria)
Begin satellite rainfall QPE validation	Started (HRC and RSMC Pretoria)
Develop and disseminate project information through various media	Started (WMO)

There are two principle goals for Phase 1. These are to: 1) determine the requirements of regional and country forecasters to produce products and data needed by users as well as requirements needed by the national-to-local DRR community for improving severe weather and flash flood warnings; and 2) begin SARFFG and SWFDP systems linkage development work.

To accomplish these Phase 1 goals, the following will be determined: a) data and information needed by both forecasters and users; b) definition of new and improved user products and services that will assist disaster managers in establishing appropriate response actions to the forecasted hazard; c) dissemination and communication links needed to reach users; d) the required NMHS forecaster resources and skills; and e) the outreach processes and practices of the Disaster Management community and stakeholders. Essentially, the end-to-end forecast-warning-response system needs to be evaluated regionally and individually for each of the nine SARFFG/SWFDP countries. Gaps need to be identified and overcome to ensure effective and maximum response to severe weather and flash flood threats to communities. In other words, each of the components of the end-to-end system needs to be fully functional. This process will be accomplished through country NMHS and stakeholder discussions and products defined at the technical and user workshops to be held in October 2015 (as noted in Table 1).

Important activities in Phase 1 include the development of the Roadmap (or framework) and Concept of Operations (CONOPS) documents during the October 2015 workshop. Development of these documents will be a joint effort among WMO-OFDA-HRC-country participants.

In addition to developing a Regional Roadmap, each NMHS will construct a Roadmap specific to their country. These Roadmaps are a detailed plan to provide guidance towards meeting the overall project goal as defined earlier and applying the linked SWFDP and SARFFG systems. The Roadmap will outline project objectives, deliverables, work plans, timelines and organizational makeup. A Roadmap template will be provided and discussed during the October 2015 workshop. An example output from a Roadmap work plan for the South Asia Flash Flood Guidance (SAsia-FFG) system is as shown in Figures 1 and 2. In the example, the roadmap steps and subsequent activities and the partner responsibilities required to meet the goal are noted.

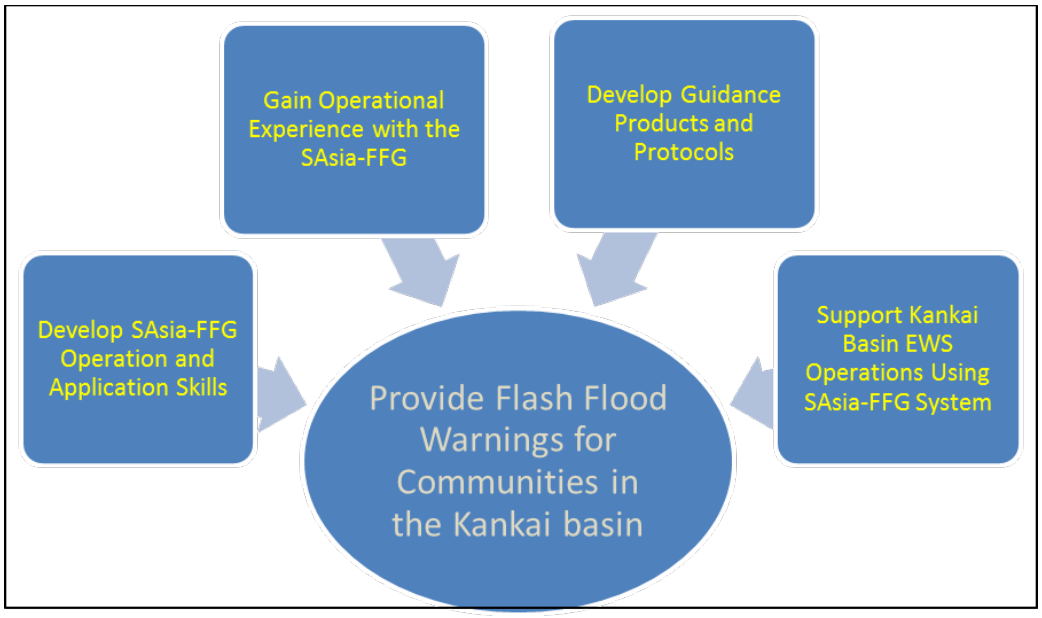

Figure 1. Example Roadmap Steps from SAsia-FFG for Meeting the Goal of Providing Flash Flood Warnings for Communities

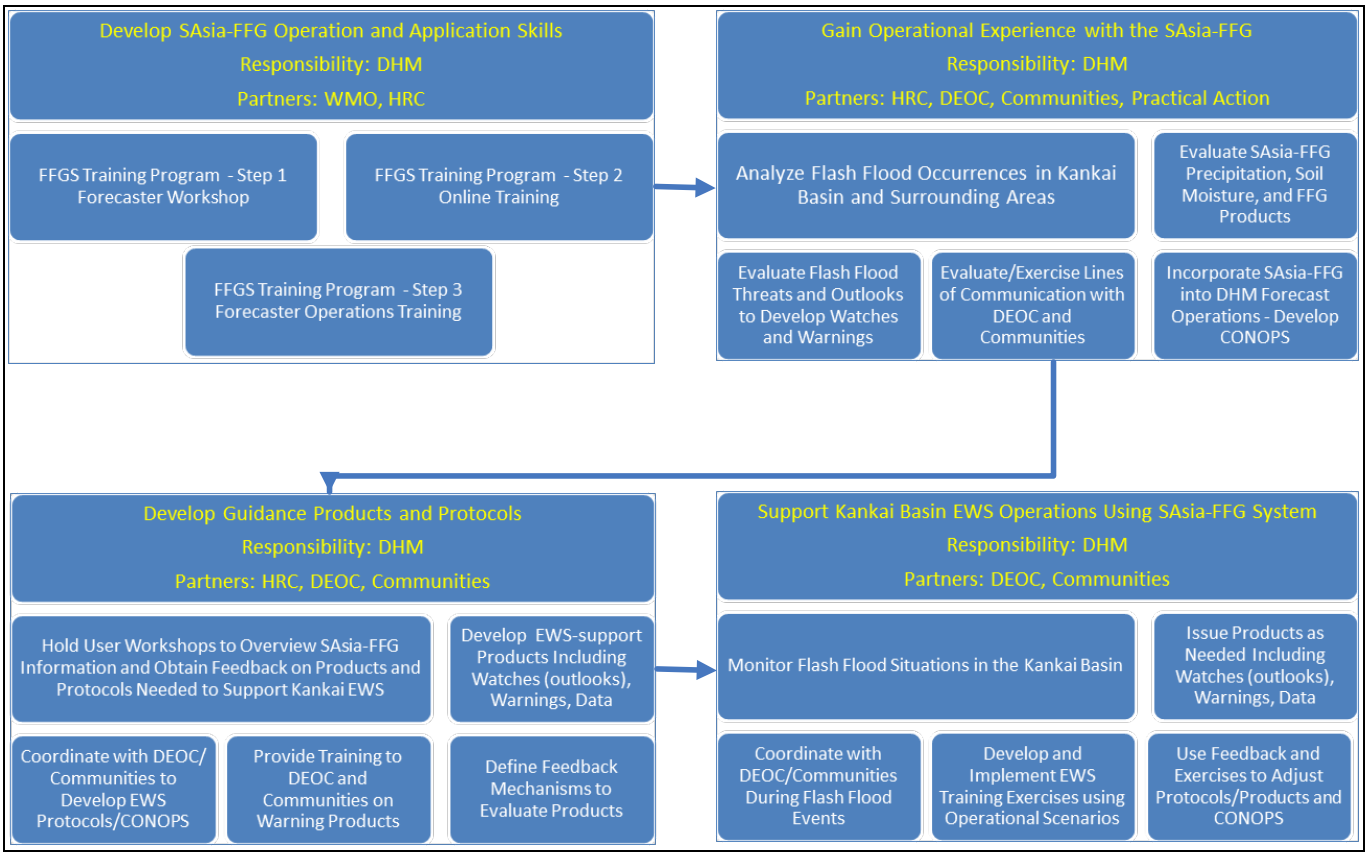

Figure 1. Example Simple Roadmap for SAsia-FFG Showing Activities

A CONOPS document for the integrated and linked systems in each country and for the region will also be prepared during the October 2015 workshop. A CONOPS document is critical and provides a clear outline of the flow of activities necessary to produce routine and non-routine operations, data/information flow, responsibilities, and ongoing training for the linked systems. Included are linkages to all aspects of the end-to-end processes that comprise an EWS and ensure integration into current or future NMHS forecast operations. It provides the top-level technical specifications and functionality of the EWS, as well as its look and feel. A CONOPS template for the integrated systems will be provided and discussed at the workshop. Typical topics in a CONOPS document include:

- Systems descriptions
- Identification and responsibilities of all stakeholders, including NMHSs
- Purpose of the systems, what gaps do they fill, priorities to be addressed, goals and objectives
- Capacity of the systems to fill the gaps
- Time sequence of operational activities – routine operations, non-routine operations
- Physical location of the systems and access requirements
- Resources needed for system operations; identification of and responsibilities of system support structures (e.g., IT)
- Data and information flow, communications
- Training needs and requirements
- Outreach requirements

In preparation for the development of the CONOPS document for an EWS through the SWFDP-SARFFG integrated systems, it is necessary to first document current NMHS forecast operations. The type of information needed for the current operations is provided in Appendix B**. It is requested that the participants determine the information as outlined in Appendix B prior to the workshop.** Appendix C provides a preliminary structure for the SWFDP-SARFFG CONOPS document that will be developed during the workshop.

The development work integrating the systems will also begin during Phase 1. During this phase, an upgrade to the SARFFG forecaster user interface will be developed and implemented. This upgrade will allow viewing of SARFFG system products over a variety of user-defined layers (e.g., terrain, political boundaries, roads, etc.) as well as provide an interactive capability to allow scrolling, zooming and data interrogation (e.g., time series displays). Other system development work will begin during this phase, including:

- Capability for the SARFFG to ingest forecaster prepared products such as adjusted model-derived Quantitative Precipitation Forecasts (QPFs)
- A single forecaster user interface or dashboard that allows the regional or country forecaster to access a *Quick Map Hazard* product suite to visualize current hazards noted from SWFDP forecaster-developed products (e.g., high wind warnings) or from SARFFG output products (e.g.,

flash flood threats). Each NMHS office will have access to the same dashboard to compose forecast and warning products.

- An automated process that will provide location-specific guidance maps for ongoing or forecasted hazards. These maps show hazards over user-defined areas (such as districts, communities) with such forecasts possibly being disseminated to the many local users and disaster management agencies and stakeholders.
- Development of a flash flood risk capability for the SARFFG based on ensemble precipitation forecasts from SWFDP.

A schematic of potential new products and their organization are shown in Figure 3.

These and other potential new products will be discussed during the October 2015 workshop.

Other critical activities under Phase 1 include:

- Validation of the satellite rainfall estimates as provided by the SARFFG (NOAA Global Hydroestimator-based QPE). Once validated and corrected for bias as needed, these high resolution estimates can be used for model-based QPF verification efforts.
- SARFFG operational training of forecasters from the nine countries that are part of the SARFFG initiative. The training will provide background on the technical system components and operations to develop flash flood alerts and warnings.

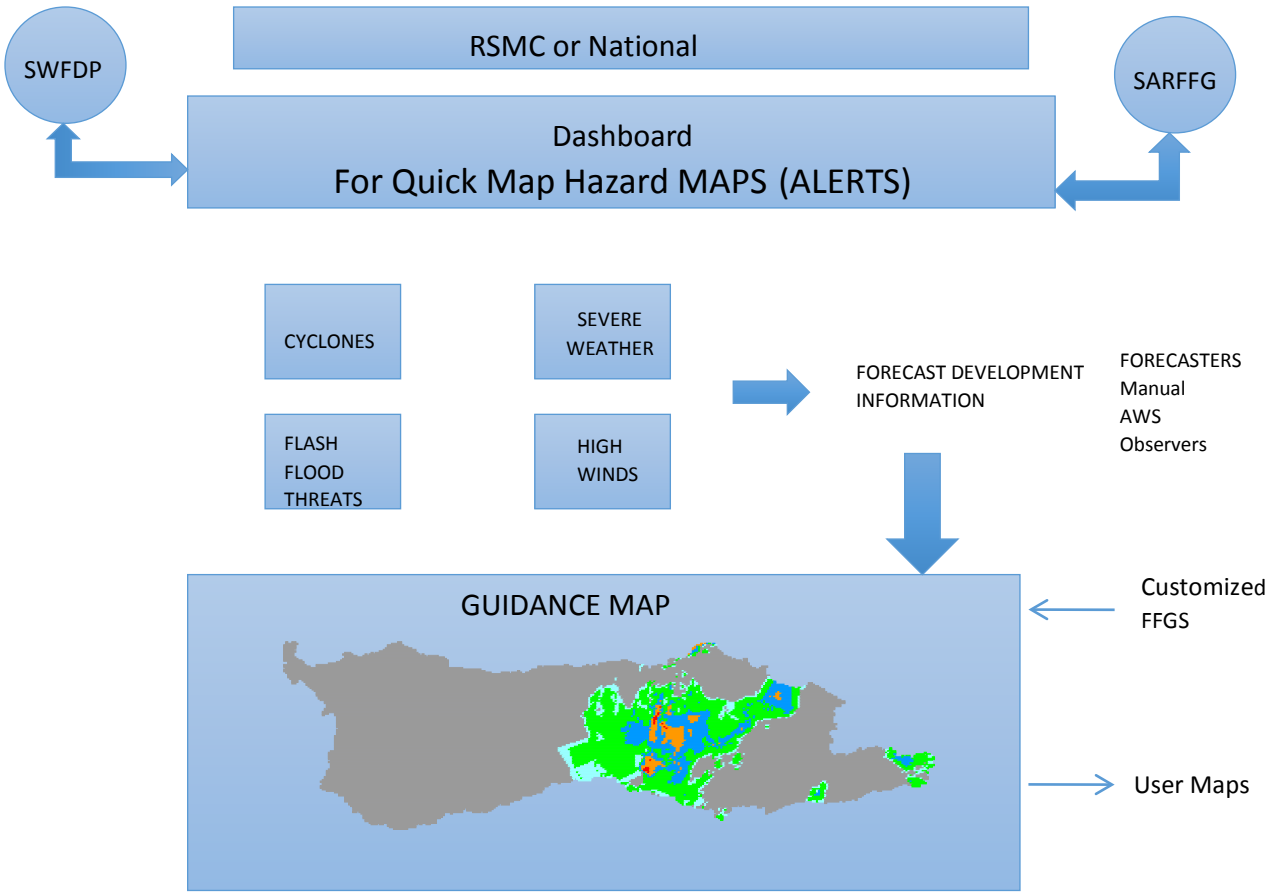

Figure 3. Potential New Products Schematic

Appendix A

Overview of the SWFDP and SARFFG Systems

Severe Weather Forecasting Demonstration Project (SWFDP)

The SWFDP has improved the lead-time and reliability for alerts about high-impact events such as heavy precipitation, strong winds, and damaging waves. It has strengthened NMHS interaction with disaster management and civil protection agencies, local communities and media. The SWFDP is making a major contribution to disaster risk reduction and is contributing to the Millennium Development Goals, in sustainable development, as well as climate change adaptation. More broadly, the project is benefitting society and its key socio-economic sectors both in safety of population and operations, including disaster risk reduction, and in economic performance, including agriculture, fisheries, aviation, water resource management and marine transportation, where meteorological prediction is crucial.

In essence the SWFDP is a process whereby scientists from global and regional centres work with severe weather forecasters at the national level to identify services that would assist the national disaster response and risk reduction efforts, and that can be implemented almost immediately by tailoring numerical weather prediction model outputs and other forecasting tools that exist in the most advanced centres, and making them routinely available at the national level. The majority of NMHSs are not able to develop or run the weather forecast models due to lack of capacity and resources. The SWFDP employs a 'Cascading Forecasting Process' whereby outputs from forecast systems that are available and free in advanced global centres are cascaded to NMHSs through a designated regional centre which provides interpretation and guidance on severe weather from the next few hours (nowcasting) to the next 5 days (short- to medium-range forecasting). This allows forecasters at the NMHSs to focus limited resources on considering the impact of this weather in their country and on service delivery and communicating the message to users in their countries to ensure timely and effective early warnings and protective responses. A SWFDP project includes building capacity of national meteorologists in the application of the cascaded information and in the development of services to meet the disaster management communities' needs. Opportunities are taken to involve disaster managers, and the news media in preparation of the user requirements.

Southern African Region Flash Flood Guidance (SARFFG) System

The SARFFG system was designed and developed for use by meteorological and hydrological forecasters in the Southern African region (specifically the countries of Botswana, Malawi, Mozambique, Namibia, South Africa, Zambia and Zimbabwe; also included in the SARFFG domain are Lesotho and Swaziland). The primary purpose of the SARFFG is to provide operational forecasters and disaster management agencies with real-time informational guidance products pertaining to the threat of small-scale flash flooding throughout the region. The SARFFG provides the necessary products to support the development of warnings for flash floods from rainfall events through the use of satellite-based rainfall estimates and hydrological models.

The SARFFG outputs are made available to users to support their analysis of weather-related events that can initiate flash floods (e.g., heavy rainfall, rainfall on saturated soils) and then to make a rapid evaluation of the potential for a flash flood at a location. To assess the threat of a local flash flood, the SARFFG is designed to allow product adjustments based on the forecaster's experience with local conditions, incorporation of other information (e.g., Numerical Weather Prediction output) and any last minute local observations (e.g., non-traditional rain gauge data) or local observer reports. The system can be used in its real-time mode or in a forecast mode when outputs are used along with nowcasting and NWP precipitation forecasts. The system supports evaluations of the threat of flash flooding over hourly to six-hourly time scales.

Important technical elements of the SARFFG system are the development and use of a bias-corrected satellite precipitation estimated field and the use of land-surface hydrological modelling. The system then provides information on rainfall and hydrological response, the two important factors in determining the potential for a flash flood. The system is based on the concept of **Flash Flood Guidance** and **Flash Flood Threat.** Both indices provide the user with the information needed to evaluate the potential for a flash flood, including assessing the uncertainty associated with the data.

In February 2009, a Memorandum of Understanding (MOU) was signed among the World Meteorological Organization, the U.S. Agency for International Development/Office of U.S. Foreign Disaster Assistance, the U.S. National Oceanic and Atmospheric Administration/National Weather Service, and the Hydrologic Research Center to work together under a cooperative initiative to implement systems such as the SARFFG system worldwide.

Linkage of the SWFDP and the SARFFG Systems

In essence, these two activities have been implemented in the region of southern Africa in parallel and have similar concepts of operation and basic approaches. At the same time, they have distinct differences in relation to both the temporal and spatial nature of each extreme hydrometeorological event and on the emphasis of the hazards they address, SWFDP being meteorological and SARFFG being hydrological hazards, which requires different approaches, yet each separate system could benefit from technical linkages.

Appendix B

NMHS Forecast Operations Documentation

Administrative Structure

- Describe your NMHS administrative structure, staff size
    - Your NMHS Headquarters
        - Location
        - Number of staff
        - Number of Meteorologists/Hydrologists/IT personnel?
    - Field Offices (if appropriate)
        - Location(s)
        - Number of staff
        - Number of Meteorologist/Hydrologists/IT personnel?
        - Does this office have operational responsibility, administrative responsibility, or both?

System Descriptions

- Describe the current capability your hydrometeorological systems have in place. For example
    - Radar
    - Satellite
    - Lightning
    - Surface Observation Networks
        - Real-time
        - Other
    - Rain Gauge
    - Flood Gauges
    - Volunteers/ Weather Spotters (if appropriate)
        - Are your Weather Spotters trained? (briefly describe training and reporting process)
        - Do you receive reports from untrained observers or public reports? (briefly describe how these are received)
        - Do you receive reports through social media, e.g., Facebook, Twitter, etc. ?
    - Do you generate forecast model or other guidance generated in your own country or do you use guidance from an International Centre?
        - If you use your own guidance, please elaborate on what you generate and how you use it.
        - If you use externally generated guidance:
            - What do you use, where do you get it from
            - Does it meet your needs?
            - If not, what improvements could you use in guidance?

- Dissemination systems descriptions
    - Forecast and warning dissemination systems
    - Communication systems between operational offices
    - Describe the communication systems you use to warn Emergency Management Services authorities, media, and the public.
    - Do you have warning system in place using mobile phones?
    - Do you have warning systems in place using social media?
    - To the extent possible, provide a description and diagram of how data flow is managed

Purpose of the Systems Described Above

- For the systems identified above, please answer the following questions:
    - What is the purpose of each system?
    - What area of observation do they cover?
    - What are the priorities of the systems?
        - Rank the system according to how important they are in terms of ongoing and emergency repair/maintenance support.

Gap Filling Capabilities

- Are there gaps in your observational networks?
    - If so please describe
        - Location(s)
        - Type of gap (what information is missing?)
- Are there any efforts underway or planned to fill observational gaps?
    - If so please describe

Operational Activities

- Please describe the routine products issued by your NMHS
    - How frequently are they issued?
    - What are the stakeholders of each product?
- Please describe the non-routine (as needed) products issued by your NHMS
    - What are the stakeholders of each product?

Identification of Stakeholders

- Who are the stakeholders for your products? (We will define a “stakeholder” as a person with an interest or concern in your activities.)
- What are the needs of the various stakeholders for warning services?
    - Number of Meteorologist/Hydrologists/ IT personnel involved in developing/disseminating warnings?

Location of Your Physical Systems (Radar, Computers, Weather Sensors, etc)

- Please provide a map of these systems (if readily available).

Resources needed for system operations

- What resources are needed to continue system operations with your present level of service?
- What resources are needed to support system operations in levels of service with planned improvements/upgrades over the next five years?

Training Needs/Requirements

- What are your anticipated training needs/requirements for the new systems being implemented?

Outreach/Education Requirements

- What types of outreach and education efforts are planned to help support the implementation of this system? Include the following:
    - Internal: NMHS staff
    - External:
        - Media
        - Emergency Services
        - Public

Appendix C

Integrated SWFDP-SARFFG System

Early Warning System Concept of Operations Document Structure (Preliminary)

1. Introduction
    - Purpose of document

2. Background
    - Overview of the SWFDP-SARFFG linked system, its operations, and components

3. Institutional Responsibilities
    - Information Flow

4. Staff Operational Responsibilities and Specialty Areas (Various offices if appropriate)

5. Hours of Operation
    - Routine and extended
    - Contacts (normal and off hours)

6. Continuous Product/data system viability

7. National Forecast Centre
    - Operational roles and responsibilities
    - System management/maintenance roles and responsibilities

8. Regional Forecast Offices (if appropriate)
    - Operational roles and responsibilities
    - System management/maintenance roles and responsibilities

9. Routine Operations
    - FFG product overview
    - Preliminary evaluations
        - Meteorological evaluations
            - Previous, current, forecast
            - Radar operations
        - Hydrological evaluations
            - Stream conditions
            - Reservoir levels
        - Quantitative precipitation forecasts
    - SWFDP and SARFFG product evaluations and applications
    - Information dissemination
        - Routine bulletins
        - Watches/warnings/alerts

- Reporting requirements

10. Staff training

11. Outreach
    - Coordination with users (other agencies, media, public) on existing products and services, providing training on new products

12. System Validation

13. Non-real-time operations
    - System maintenance/review

14. Non-routine operations – Operations during unusual events