101287 *EXTREME* DATA COLLECTION - THE ARIZONA EXPERIENCE

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1. ABSTRACT

While the Mississippi River received continual headlines during the spring of 1993, Arizona experienced a more significant flood event that went unnoticed outside the state. The aftermath of that Arizona flood brought a mandate from the Governor to improve communications among state and federal agencies during extreme flood events. The result of the mandate was the evolution of the Arizona Flood Warning System (AFWS).

While for much of the last decade, Arizona and much of the West has been gripped by serious drought conditions that resulted in little acclaim for the AFWS. The heart of the development of the AFWS was the partnering among 23 federal, state, and local agencies to develop a communications network designed to share critical hydrometeorological data *in real time* among those agencies, and to provide key decision makers with sufficient information to make the best hydrometeorological decisions possible. The designers of the AFWS recognized that the same hydrometeorological data monitored for flood episodes would be equally critical for monitoring drought conditions. With this in mind, the AFWS interagency committee has set its sights on restructuring the emphasis of the AFWS to become a decision management and information system that focuses on the monitoring and display of hydrometeorological data for *extreme weather* events, like floods *and* droughts. The committee believes such an effort would not only build on its existing partnerships, but also support collaborative research to ensure further development and implementation of a comprehensive framework for the delivery of water resources information to the residents of Arizona.

This paper will describe the evolution of AFWS and illustrate some of its more significant data collection and graphical display features. It will also demonstrate how the AFWS and much of its infrastructure could serve as a prototypical foundation for the National Integrated Data Information System (NIDIS).

2. INTRODUCTION

To many people, Arizona is envisioned as vast and flat desert area, void of vegetation and mountains. While Arizona is indeed arid, it is certainly not flat. In a typical year, the precipitation over Arizona comes in two distinct periods.

Winter rains on the desert, and snow in the mountains; and statewide convective storms during the summer. Generally, precipitation in both wet seasons only produces minor floods. By contrast, the wet winter of 1992-93 produced record flood levels throughout the state. The return period of the Arizona flood rivaled the Mississippi Flood, and on a few rivers, exceeded it. Much like the situation in the Mississippi Basin, all of Arizona's dams and reservoirs produced very challenging decisions for local water managers.

In the aftermath of the 1993 Flood, Arizona Governor Fife Symington directed the Arizona Department of Water Resources (ADWR) to conduct a flood symposium to obtain ideas to improve communications during extreme flood events. At the conclusion of the symposium a small interagency committee was formed to review the material presented, and to make recommendations to the Governor to improve communications during a flood crisis.

The essence of the recommendations focused on two areas: 1. filling in hydrometeorological data gaps in the state; and, 2. the creation of a statewide *real time* data network. The purpose of the network would be to provide a suite of products and data to all agencies involved in making water management decisions during Arizona's flood episodes.

3. THE STRATEGY

Prior to the 1993 Flood, considerable effort had been undertaken in the state's most populated counties to collect rainfall and stream flow data in real time to support county-level flood fight activities during the convective season when flash floods prevail. As one might expect, these activities had a local focus and made it difficult for water managers of Arizona's larger river basins to readily obtain these data for use in their basin-wide decisions. Conversely, county-level flood fight activities were impacted by these decisions as they affected the larger rivers that run through their counties. What was needed was a means to integrate hydrometeorological data in *real time* from the various networks throughout Arizona.

The interagency committee formed as a result of the flood symposium was initially chaired by the Arizona Department of Water Resources. Using funds appropriated by the State Legislature, the ADWR-lead committee decided to enlist the services of a private contractor to assess the state of, and functionalities of, several flood warning systems in place across the U.S. In addition, the contractor was to provide the results of its assessments to the interagency committee and, in conjunction with the committee, develop a design for a

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flood warning system. In parallel with these design efforts, the contractor was to work with various local, state, and federal level agencies to identify hydrometeorological data gaps in the state.

4. DESIGN PHILOSOPHY

Armed with the above recommendations, the interagency committee set out to refine the network design. The Arizona flood warning system had to provide real time data to local entities so they could conduct flood fight activities in their flash flood prone areas. It had to provide appropriate data from water managers on the larger rivers to local responders to assist them in their flood fight efforts along the larger rivers. The system also had to integrate the county-level data with data from larger networks operated by state and federal agencies. In addition, the various hydrometeorological forecasts, warnings, and other products issued by these, and other agencies, had to be resident in the system. And last, but not least, all of this information had to be available to the public.

The second area the committee addressed was improving data availability and filling in the proverbial data gaps in the state. The committee evaluated and prioritized the installation of the numerous data sites identified by the contractor. With few exceptions, these were virtually all precipitation or stream flow sites.

Throughout the design process and thereafter, the size of the interagency committee increased. In conjunction with this increase, a decision was made that the committee would be lead by co-chairs, one from ADWR, and a second from the National Weather Service. This decision was made to broaden the scope of committee activities, and to provide increased emphasis on the early warning aspects of the system.

A requirement that evolved because of the increasingly diverse nature of the committee, was additional interest in sharing preliminary water and weather data and information. Hence, it became a requirement that the flood warning system also have two-way communications capabilities. This would facilitate the ability of water management agencies, and those agencies that either provide input to water managers, or are impacted by their decisions, to be able to communicate among themselves and share insights of actions under consideration. Hence, a secure, internal interagency mechanism within the system evolved, one on which questions and answers could be shared, and preliminary plans or decisions discussed.

5. IMPLEMENTATION

The details of the design of the Arizona flood warning system were eventually agreed upon by the interagency committee members. The next step was to obtain funding. After months of negotiations, the U.S. Army Corps of Engineers entered in a cost sharing agreement with the State of Arizona setting the stage for the birth of the Arizona Flood Warning System (AFWS). In addition to this funding, all member agencies of the AFWS interagency committee committed additional funds or services in kind to make the AFWS a reality.

Over the course of several years, the collective efforts of the member agencies resulted in a real time data network that has “hard wired” connections to the data bases of all agencies involved in support of, or response to, water management decisions made in Arizona. In addition to these connections, the AFWS incorporated a communications backbone that not only facilitated the exchange of the data, but also provided a means to exchange preliminary plans and decisions internally among the agencies. Built into the system were three nodes that function as redundant data servers in the event the backbone of the network became interrupted (Figure 1).

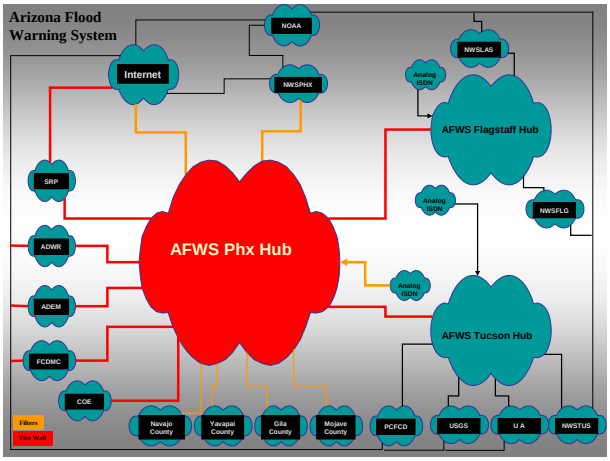

Figure 1 - Network Topology

6. DATA AND INFORMATION

The primary purpose of the AFWS is to provide decision makers throughout Arizona with critical information to aid in their decision-making process. The data and information available on the system ranges in scope from individual precipitation reports, to snow course data, to river stages, to radar and satellite imagery, to weather forecasts and warnings, to reservoir levels, to releases from the dams, and finally to river forecasts and warnings. While much of the information is in a text format, there has been an increase in the amount of information provided in graphical format as the AFWS evolves.

7. MOTHER NATURE’S ROADBLOCK

Arizona did not become an arid state overnight. On the heels of the record floods of 1993, and just as the AFWS got into full swing in the mid 90s, Mother Nature began a prolonged period of drought throughout the state. As one can imagine, support for a flood warning system during times of drought did NOT rank high on anyone’s priority list. Consequently, the fiscal resources needed to expand and improve the AFWS dwindled dramatically. The fiscal resources available during the drought years were barely enough to fund the system’s communications costs. As a result, limited funds were

left for system enhancements. None the less, some enhancement did occur, most notably was the integration of a GIS-based structure to facilitate the location and display of all the data that flows on the AFWS. Improved software that capitalized on this structure was developed to provide flexibility when viewing the data and various graphical products as well as the imagery products.

8. AFWS DISPLAY "HIGHLIGHTS"

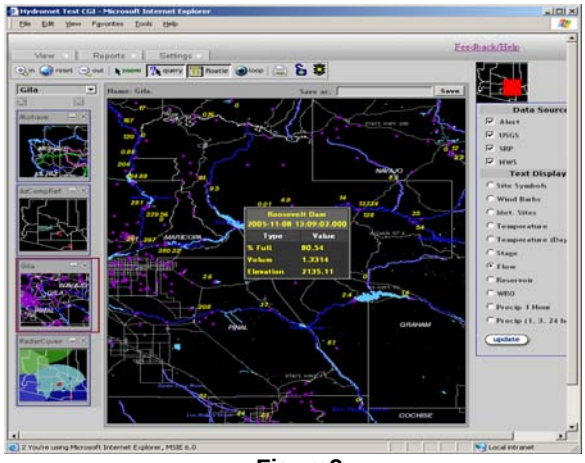

Figure2

While many of the AFWS users focus on the values of various data types displayed in text or tabular format, the GIS–based structure of the system flexibility for the user to customize the views they routinely see by choosing a specific geographical area(s) of interest. Once the area is selected,
by "hovering" over a data site with the cursor, the user can see the most current data reported from the site. (Figure 2)

Time series plots of various data from a given site can be generated to examine data trends. (Figure 3)

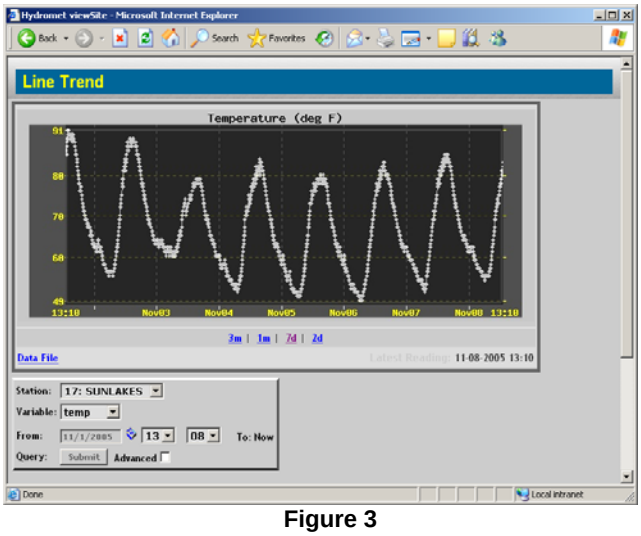

Figure 3

Current satellite and radar imagery are available in static or looped format. (Figure 4)

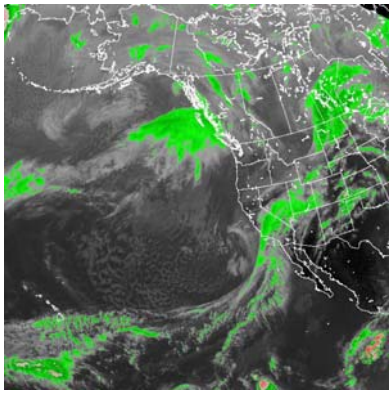

Figure 4

The GIS-based displays allow various data fields to be overlain, e.g. real time precipitation and river reports with radar imagery. (Figure 5)

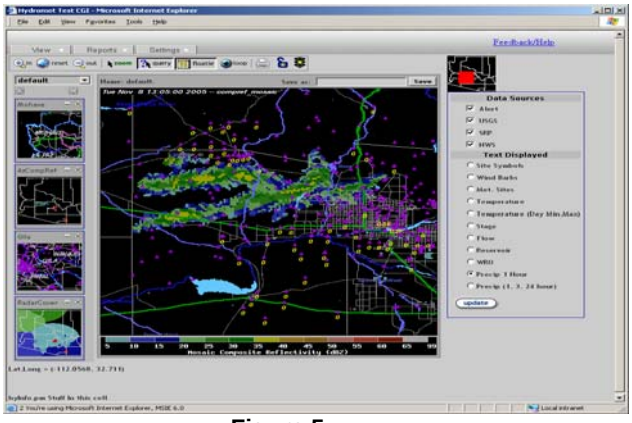

Figure 5

To facilitate verbal communication among the user agencies, discussion groups were created. (Figure 6)

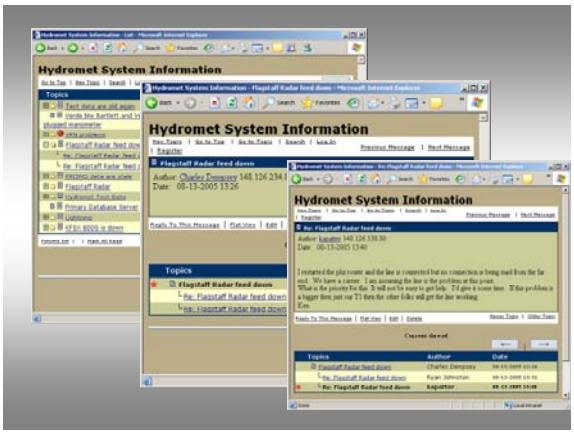

Figure 6

This allows one user to ask questions of other users, and leaves a "thread" of messages for others to view. While virtually all discussion group communication is able to be viewed by the public, one discussion group is reserved for internal communications among the user agencies and emergency managers. This discussion group is password protected. The AFWS is online at www.afws.org .

9. UPON FURTHER REVIEW…

In spite of Mother Nature's roadblock, it is clear that virtually all the hydrometeorological parameters one monitors in a flood are likewise monitored during drought conditions. These two of Mother Nature's *extreme* events pose significant challenges for all levels of government. The AFWS interagency committee (comprised of 23 local, state, and federal agencies[1]), realizes much of the data and products available on the AFWS have some relevance to assessing drought conditions. As a result, collaboration is underway with the Arizona Drought Monitoring Committee, which reports to the Director of ADWR, to explore ways to use the AFWS as a foundation from which an Arizona flood and drought monitoring system can be developed.

10. FUTURE DIRECTIONS

A number of this Nation's key leaders have a vision of developing a National Integrated Drought Information System (NIDIS). Some of the key goals of the NIDIS are cornerstones of the AFWS. Perhaps of greatest significance are the AFWS' key partnerships among the local, state, and federal agencies that have made the AFWS a coordinated reality. Also important is the AFWS concept of "early warning" via improved communication and data monitoring. Such premises would serve well as a foundation upon which the Arizona portion of the NIDIS could begin to be built.

It is hoped that through further collaboration with the Governor's Drought Monitoring Committee, that among other things, incorporation of climate data, as well as links to many drought-related websites, coupled with modified "packaging" of the hydrometeorological data contained within the AFWS database, will set the stage for the development of a prototype, state-level portion of the NIDIS.

[1] Arizona Department of Water Resources
Arizona Division of Emergency Management
Arizona Game and Fish
City of Flagstaff
City of Show Low
Flood Control District of Maricopa County
Gila County Flood Control District
JE Fuller Hydrology & Geomorphology
LTM Engineering
Mohave County Flood Control District
National Resource Conservation Service (USDA)
National Weather Service (NOAA)
Navajo County Flood Control District
Pima County Flood Control District
Pinal County Public Works
Salt River Project
Santa Cruz County
State Climatologist Office
Tohono O'odham Nation
US Army Corp of Engineers
US Bureau of Reclamation
US Geological Survey
Yavapai County Flood Control District