CHAPTER 5

TYPES OF LOCAL FLOOD WARNING SYSTEMS

5.0 Introduction

Determining the most effective type of LFWS for a community is a complicated problem. The type of system used will depend on the familiarity and comfort of community officials with the technological options. Perhaps their confidence in vendors' presentations or recommendations by surrounding communities that have a successful LFWS will be enough information to choose a system. Quite often, though, communities do not know they have options. There are two basic types of LFWSs: manual systems and automated systems.

5.1 Manual LFWS

Many of the LFWSs in operation today are manual self-help systems that are inexpensive and simple to operate. The manual self-help system is comprised of a local data collection system, a community flood coordinator, a simple-to-use flood forecast procedure, a communication network to distribute warnings, and a response plan.

The simplest and least expensive approach to data collection is to recruit volunteer observers to collect rainfall and stream/river stage data. Inexpensive, plastic rain gages may be supplied by the NWS to volunteer observers who report rainfall amounts to a community flood coordinator. The flood coordinator maintains the volunteer networks. More sophisticated automated rain gages may be necessary in remote areas or in situations where observers are not available. Stream gages also vary in sophistication from staff gages to Limited Automatic Remote Collection systems, radios, etc.

An RFC, at the request of and through the Meteorologist in Charge at the appropriate WFO, can provide the cooperator's representative (flood coordinator) with a simple, easy-to-use forecast procedure. This procedure normally consists of tables, graphs, or charts that use observed and/or forecast rainfall and an index for flood potential to estimate a flood forecast. These indices for flood potential (known as Headwater Advisory Guidance) are determined by the RFC and are provided to the appropriate WFO; the WFO in turn provides them to the cooperator(s). Flood forecasts vary from a categorical forecast of flooding to a numerical crest value. Forecasts may also include the time remaining before flood stage will be reached or the time when the crest will occur.

5.2 Automated LFWS

An automated LFWS is composed of sensors that report environmental conditions to a computer using an observation platform communication protocol and a second communication protocol by which information is sent between the base station and other computer system(s). An automated LFWS has either a stand-alone configuration or a network configuration and can consist of the following equipment: automatic reporting river and rainfall gages, a communications system, automated data collection and processing equipment, a microprocessor, and analysis and forecasting software.

Some automatic rainfall gages report rainfall data every time a tipping bucket tips. This is known as event-type rainfall sampling. For river stage, every time a change in stage of a preselected increment is measured, a new river stage value is transmitted from the sensor to a base station.

Automated LFWSs have been designed, developed, and implemented by the NWS, other Federal agencies, state and local governments, and private vendors; and they vary in design, capability, and operation. A community must assess its needs to determine the level of sophistication (and associated costs) required. Automated system operation may vary from a simple flash flood alarm gage that audibly announces imminent flooding to a continuous computerized analysis of precipitation and streamflow and a hydrologic model to forecast flood levels.

In the past decade, a substantial growth in technology and a decrease in the cost of microcomputer systems have resulted in the development of automated flood warning systems. Three of the more prominent automated LFWSs described below include flash flood alarm systems, ALERT, and IFLOWS.

5.2.1 Flash Flood Alarm System

A flash flood alarm system consists of a water-level sensor(s) connected to an audible and/or visible alarm device located at a community agency with 24-hour operation. Water levels exceeding one or more preset levels trigger the alarm. If the system is configured to detect two preset levels, the rate of rise can be determined. The water level sensor(s) is set at a predetermined critical water level and is located a sufficient distance upstream of a community to provide adequate lead-time to issue a warning. Rain gages can also be located upstream of a community; each gage is preset with alarms that sound when a predetermined flood-causing rainfall amount is exceeded. Communication between the sensor(s) and a base station can be via radio or telephone.

5.2.2 Automated Local Evaluation in Real Time

The ALERT system was developed by the California-Nevada RFC in Sacramento, California, and consists of automated event-reporting meteorological and hydrologic sensors, communications equipment, and computer software and hardware. In its simplest form, ALERT sensors transmit coded signals, usually via very high frequency (VHF) and ultra high frequency (UHF) radio, to a base station, often through one or more relay or radio repeater sites (refer to Figure 5-1). The base station, which consists of radio receiving equipment and a microprocessor running ALERT software, collects these coded signals and processes them into meaningful hydrometeorological information. Processed information can be displayed on a computer screen according to various preset criteria, with both visual and audible alarms activated when these criteria are reached. Some systems have the capability of dialing up preselected lists of individuals or initiating other programmed actions when preset criteria are exceeded.

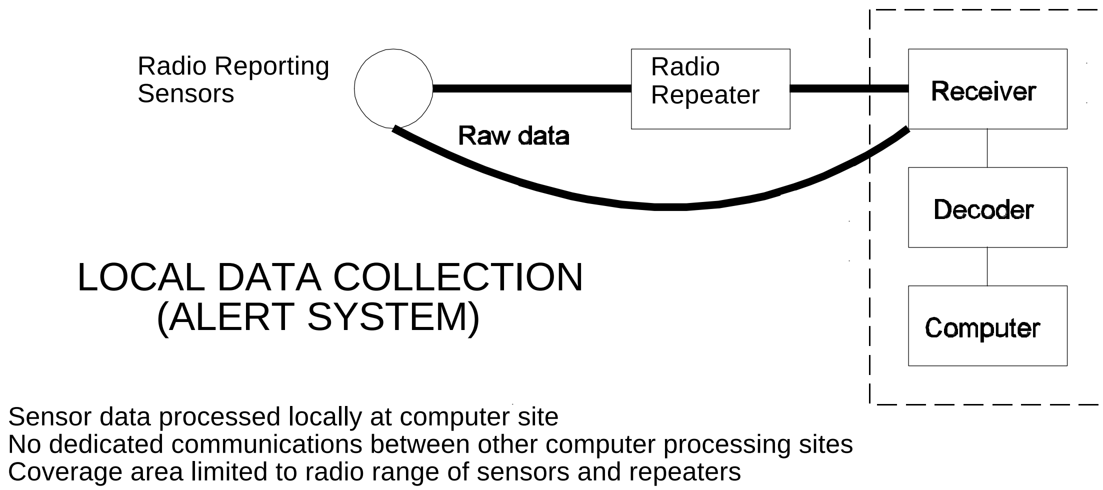

Figure 5-1. *Schematic of an ALERT system.*

ALERT systems in use today are quite sophisticated. Some have the capability to graphically display information, singly or in combination (such as the areal extent of flooding, inundation of roads, evacuation routes, supply depots, hospitals, population centers) on wall-size projection screens. A system can consist of more than one base station connected through repeater networks to pass along raw, unprocessed information from one user group to another. ALERT systems are basically one-way data collection systems developed to deal with specific local problems and normally have little or no computer networking capability.

ALERT systems are locally funded and supported. There are several very active and growing regional user groups. Many systems are owned or maintained by more than one participating organization with each ALERT participant owning or maintaining a small portion of the entire system. In many cases, the NWS does not own any of the equipment in a particular system. In some cases, local system sponsors have provided equipment to the NWS for use in its field offices because they recognize the benefits of NWS forecasts and warnings. NWS Western Region supports the NWS version of ALERT software and sets standards for support of this package. Private vendor versions of this software are also available and in use. ALERT systems are found throughout the United States and in some foreign countries.

5.2.3 Integrated Flood Observing and Warning System

IFLOWS is a wide-area network of ALERT-type systems with enhanced, full, two-way communications capability (voice, data, and text). If desired, IFLOWS can be configured as a stand-alone system for a local community. On the other hand, the ALERT system is normally configured as a stand-alone system for a local government entity. The potential user of the LFWS, in the design phase, should consider the network configuration with its associated area-wide capabilities and costs as well as the stand-alone configuration with its local capabilities. Chapter 7, Standards for Automated Local Flood Warning Systems, establishes baseline capabilities for both network and stand-alone configurations of automated LFWSs.

These systems serve as regional data collection and information dissemination networks (refer to Figure 5-2). In addition to performing real-time data acquisition and processing functions, IFLOWS software handles intercomputer networking and information transfer. IFLOWS computers collect and process remote sensor information; act as data concentrators, allowing more information to pass over a given communications channel in a fixed period of time; and serve as ports into regional communications networks. Not all ports into an IFLOWS network perform all of these functions continuously. They all, however, remain continuously on-line. In case of network failure, an IFLOWS computer can function as a stand-alone, ALERT-type base station.

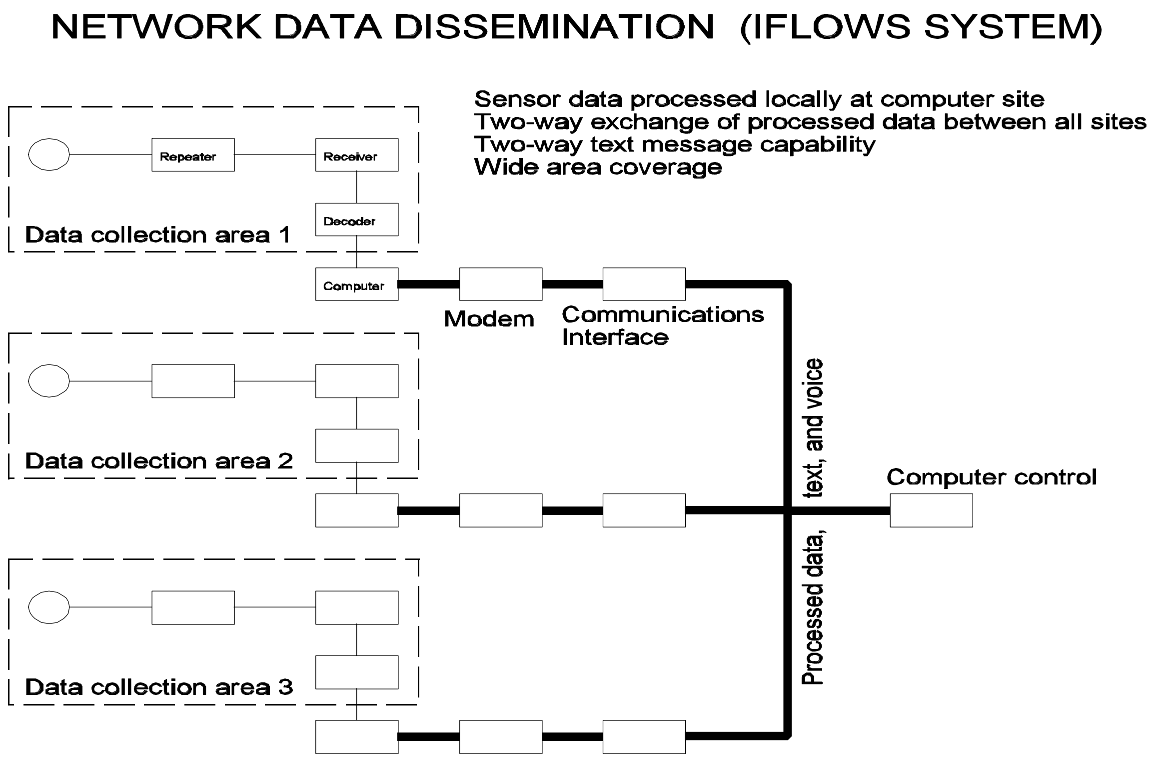

Figure 5-2. *Schematic of a regional IFLOWS.*

Sensor technology for both IFLOWS and ALERT networks is basically the same. IFLOWS software is presently limited to precipitation and river-stage gage applications, while ALERT can handle several other parameters. Section 10.2 provides additional details on IFLOWS software. IFLOWS networks have a backbone communications infrastructure. While the original IFLOWS concept envisioned an all-radio/microwave network, present systems employ leased telephone lines, satellites, VHF/UHF radios, and microwave communications links. IFLOWS networks presently extend into about 200 counties throughout 13 eastern states.

IFLOWS networks (software, hardware, and communications) are supported by the NWS IFLOWS Program. The Program has a defined, centralized management structure primarily located in the Office of Hydrology. NWS Eastern Region Headquarters manages the NWS portion of network operations. IFLOWS, by its very nature, integrates system administration and operation. Multiple levels of government and various agencies at each level of government are involved in operating the systems. Individual systems are usually networked at the state level. Connections between state systems are established at gateways, which are usually at WFOs.

5.3 Additional Considerations

The proliferation of automated system sensors, different hardware and software configurations, multiple hardware and software vendors, and multiple users of automated system data has presented some complex issues that should be addressed by Federal, state, and local agencies contemplating implementation of the LFWS. These issues can be system categorized into the broad elements of data, hydrologic models, and operations.

5.3.1 Data

The rapid increase in number and types of sensors and number of vendors associated with automated LFWS could become a concern if multiple gage formats are developed that restrict access to a very valuable database. LFWS sensor data format issues include the need for standard mark and space frequencies (see Section 7.2).

Another data issue is the need for data exchange between automated LFWSs or between community systems and external users. For instance, a community's automated LFWS may be collecting data needed by an adjacent community.

The NWS has a vested interest in working with communities on quality control of LFWS data, particularly for precipitation data that will be used in NWS forecast models and radar-based precipitation processing operations. Staff at the appropriate WFO and RFC can assist communities in site selection of gages including proper gage exposure (see Section 6.1.1) and in the proper ongoing maintenance of gages (see Section 6.6.2).

In most instances, hydrometeorological data collected by automated systems, such as precipitation data and river stage data, are archived only at the collecting site. These data are only archived to meet a short-term local need and are usually not available for use by other communities, Federal or state agencies, or universities. Data will be lost unless arrangements are made to centrally archive the rapidly expanding database. Long-term archival of hydrometeorological data is important to the NWS and other cooperators for calibrating hydrologic models.

5.3.2 Hydrologic Models

The adequacy of hydrologic model operation has always been an issue in establishing automated LFWSs. Which hydrologic model to use can be a difficult choice. There is a balance between using simplified versus more sophisticated and complicated models. Simplified models are easy to use but require more user input. Sophisticated hydrologic models require a fairly high level of hydrologic knowledge, both in the calibration of the models and in the tuning or adjustment of the soil moisture state variables. Both the initial calibration and the ongoing maintenance of parameters and state variables are extremely important to the accuracy and reliability of an automated LFWS that has hydrologic models as integral parts of the system. Currently the Sacramento rainfall/runoff model is available in the hydrometeorological program that is the NWS version of ALERT.

The NWS assists communities in selecting the proper flood forecast procedures for their needs, considering local as well as NWS support. The MOU (see examples in Appendix A), an agreement between NWS and the community, identifies the LFWS responsibilities of each party.

5.3.3 Operations

An automated LFWS is only one of many nonstructural methods of flood mitigation. There are many structural and nonstructural methods which, when coordinated in an overall comprehensive effort, can produce synergistic results and outperform each method executed separately. For example, the operation of floodgates can be optimized if the LFWS is established and the two are operated in a coordinated manner.

NWS hydrologists analyze a community's flash flood potential with respect to topography and watershed characteristics and also with regard to the location of commercial, residential, and camping areas. Then, the gaging network can be planned and installed. The NWS is a consultant to the community and can provide forecast tools and guidance to implement the LFWS. However, communities may be interested in additional support that NWS cannot provide. In some areas, the flash flooding problem is so significant that local FWUs have subscribed to commercial services that deliver automated radar, satellite, and other guidance material. Even in these cases, real-time coordination is necessary between the local NWS office and the community LFWS. The level of coordination is determined on a case-by-case basis.

Reports of precipitation and stream levels are relayed automatically by radio (or manually by observers) to the FWU. It is essential that this information is relayed in as near real time as possible to the appropriate WFO so NWS can issue timely flood forecasts and/or flash flood warnings. The FWU uses NWS guidance, forecast tools, and field reports to determine stream response. If at all possible, the Flood Warning Coordinator is instructed to coordinate the evaluation with the NWS before a local flood advisory is issued. The process continues until the rain ends and/or the stream crests. The issuance of local flood advisories and warnings by the FWU generally will depend on the capabilities of the FWU staff, regional NWS policy, and the normal response time of streams.

Once local requirements have been met, it is of utmost importance that the NWS have access to the local data in case watches or warnings need to be issued for other communities in the path of the storm. Thus, the community with the LFWS has a large responsibility to ensure that continuous data flows to the appropriate NWS office(s) and to continually coordinate activities, during and after the flash flood event, with the NWS and other "need-to-know" Federal and state agencies.

5.4 Interagency Cooperation

In November 1982, an Interagency Work Group on LFWSs was established by the Hydrology Subcommittee of the Federal Interagency Advisory Committee on Water Data (IACWD). Subsequently, the name of the Working Group was revised to Local Flood Warning and Response Systems to provide a focus for information exchange on the LFWS. In late 1992, the Hydrology Subcommittee dissolved the Working Group and reassigned the function and responsibilities to the Hydrometeorology Working Group of the Office of the Federal Coordinator for Meteorological Services and Supporting Research. The agencies represented on this Working Group are the Federal Emergency Management Agency, National Aeronautics and Space Administration, National Weather Service, Natural Resources Conservation Service (formerly Soil Conservation Service), Nuclear Regulatory Commission, Tennessee Valley Authority, U.S. Army Corps of Engineers, U.S. Bureau of Reclamation, and U.S. Geological Survey.

The telephone numbers for contacts at these agencies are as follows:

AGENCY	**PHONE**
Federal Emergency Management Agency	202/646-2753
National Aeronautics and Space Administration	202/358-0771
National Weather Service	301/713-0006
Natural Resources Conservation Service	202/720-4909
Nuclear Regulatory Commission	301/415-6502
Office of the Federal Coordinator for Meteorology	301/427-2002
Tennessee Valley Authority	423/632-4203
U.S. Army Corps of Engineers	202/761-0169
U.S. Bureau of Reclamation	303/236-0123x235
U.S. Geological Survey	703/648-5019