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PROPOSED FLOOD DETECTION SYSTEMS FOR THE BLACK CREEK DRAINAGE BASIN, NORTHEAST FLORIDA

by

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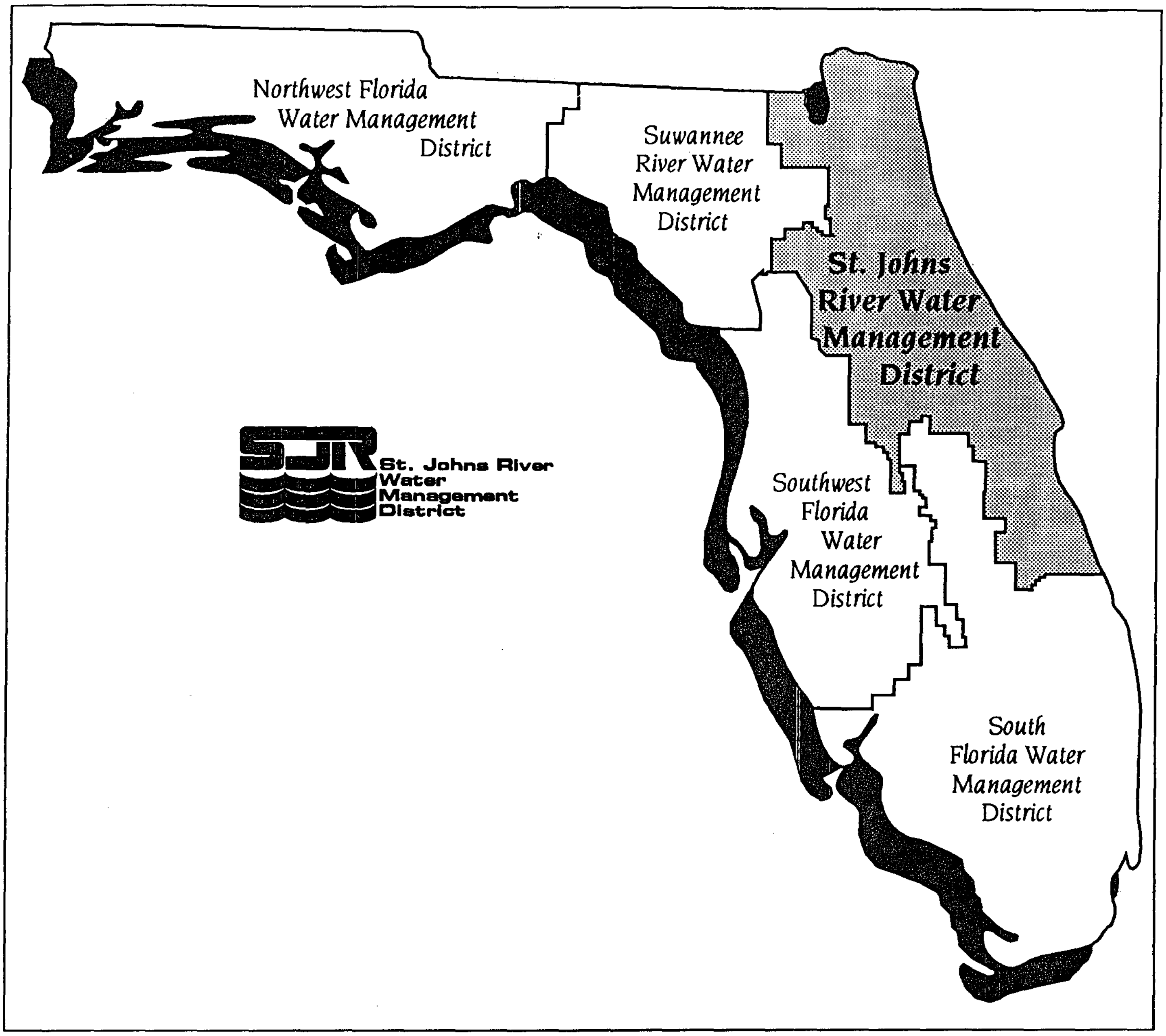
St. Johns River Water Management District
Palatka, Florida
1993



The **St. Johns River Water Management District** (SJRWMD) was created by the Florida Legislature in 1972 to be one of five water management districts in Florida. It includes all or part of 19 counties in northeast Florida. The mission of SJRWMD is to manage water resources to ensure their continued availability while maximizing environmental and economic benefits. It accomplishes its mission through regulation; applied research; assistance to federal, state, and local governments; operation and maintenance of water control works; and land acquisition and management.

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EXECUTIVE SUMMARY

This technical report describes flood detection system options for the Black Creek drainage basin. The options were developed by the St. Johns River Water Management District at the request of the Clay County Department of Public Safety (DPS).

A well-planned flood warning system contains three general components: the scientific, emergency management, and public response. This report focuses on the data collection network of the scientific component. In order for any flood warning system to be successful, all components must be implemented. DPS and the National Weather Service (NWS) need to work closely and cooperatively to further ensure a successful flood warning network for the Black Creek drainage basin.

The existing flood warning network for the drainage basin includes two rain gauges and four stream gauges. This network is not extensive enough to provide adequate data to represent conditions in the basin. Only two of the existing stream gauges are telemetered. Data at the remaining sites are collected manually.

This report outlines six options. Implementation of Option 1, 2, 3, 4, or 5 will allow flood forecasting. Implementation of Option 6 will result only in a determination of when flood waters have reached any preset float switch at the flood alarm station.

Option 1 This option is a 15-gauge network using RTU-0850™ data logging equipment. It will take 2 years to implement and will cost an estimated $302,650.

Option 2 This option is a 15-gauge network using RTU-5096™ data logging equipment capable of interfacing with the SJRWMD system. It will take 2 years to implement and will cost an estimated $281,650.

Option 3 This option is configured like Option 2, but Clay County utilizes less expensive and less versatile equipment; this system is incapable of interfacing with the SJRWMD system. It will take about 3 years to implement and will cost an estimated $305,450.

Option 4 This option is an 8-gauge network using RTU-0850™ data logging equipment and U.S. Geological Survey (USGS) stream gauges. It will take 1 year to implement and will cost an estimated $95,589.

Option 5 This option uses the USGS GOES satellite system to send data to NWS through the NWS AFOS system. It requires that USGS install six telemetered rain gauges and continuey to maintain the two existing telemetered stream gauges. It will take 1 year to implement; the cost of the system is approximately $36,000.

Option 6 This option uses telephone lines and is a flood alarm system. It will take about 1 year to implement and will cost at least $18,410.

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INTRODUCTION

This technical report describes flood detection system options for the Black Creek drainage basin. The options were developed by the St. Johns River Water Management District (SJRWMD) at the request of the Clay County Department of Public Safety (DPS). Any of these options can be incorporated into a flood warning system for the basin. Robison (1993) described the flooding characteristics of the Black Creek drainage basin and recommended an initial size for an automated network of rain and stream gauges. Some of the flood detection system options presented in this report are based on the basic size and general configuration of the network recommended by Robison (1993).

The Black Creek drainage basin is located within the lower St. Johns River surface water basin (Figure 1). Black Creek is the primary tributary of the Black Creek drainage basin (Figure 2). The North Fork and South Fork join east of Middleburg to form Black Creek. Black Creek flows into the St. Johns River, which flows north to the Atlantic Ocean.

As demonstrated in September 1988, the potential for damaging floods exists along Black Creek in and around Middleburg. The potential for property damage and loss of life caused by flooding will increase as the population increases and the area is further developed. Installation and management of a flood warning system will provide early warning of impending floods to area residents.

According to Adams (1991), the goal of any weather warning system, which can include a flood warning system, is "to maximize the number of people who take appropriate and timely action to minimize death, injury, and property damage during severe weather and flooding." A well-planned warning system contains three general components: the scientific, emergency management, and public response (Figure 3). Tasks performed as

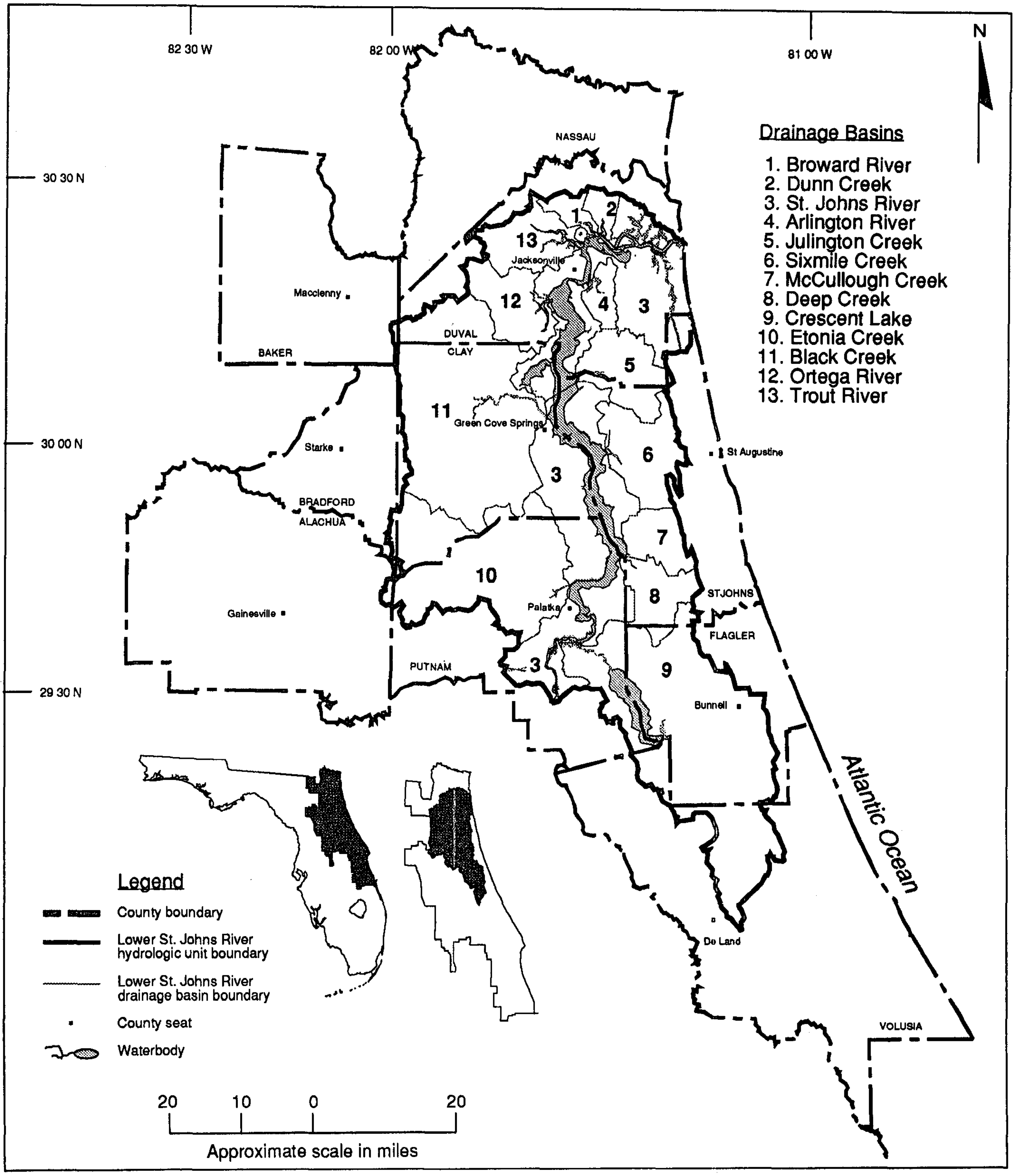

Figure 1. Lower St. Johns River surface water basin

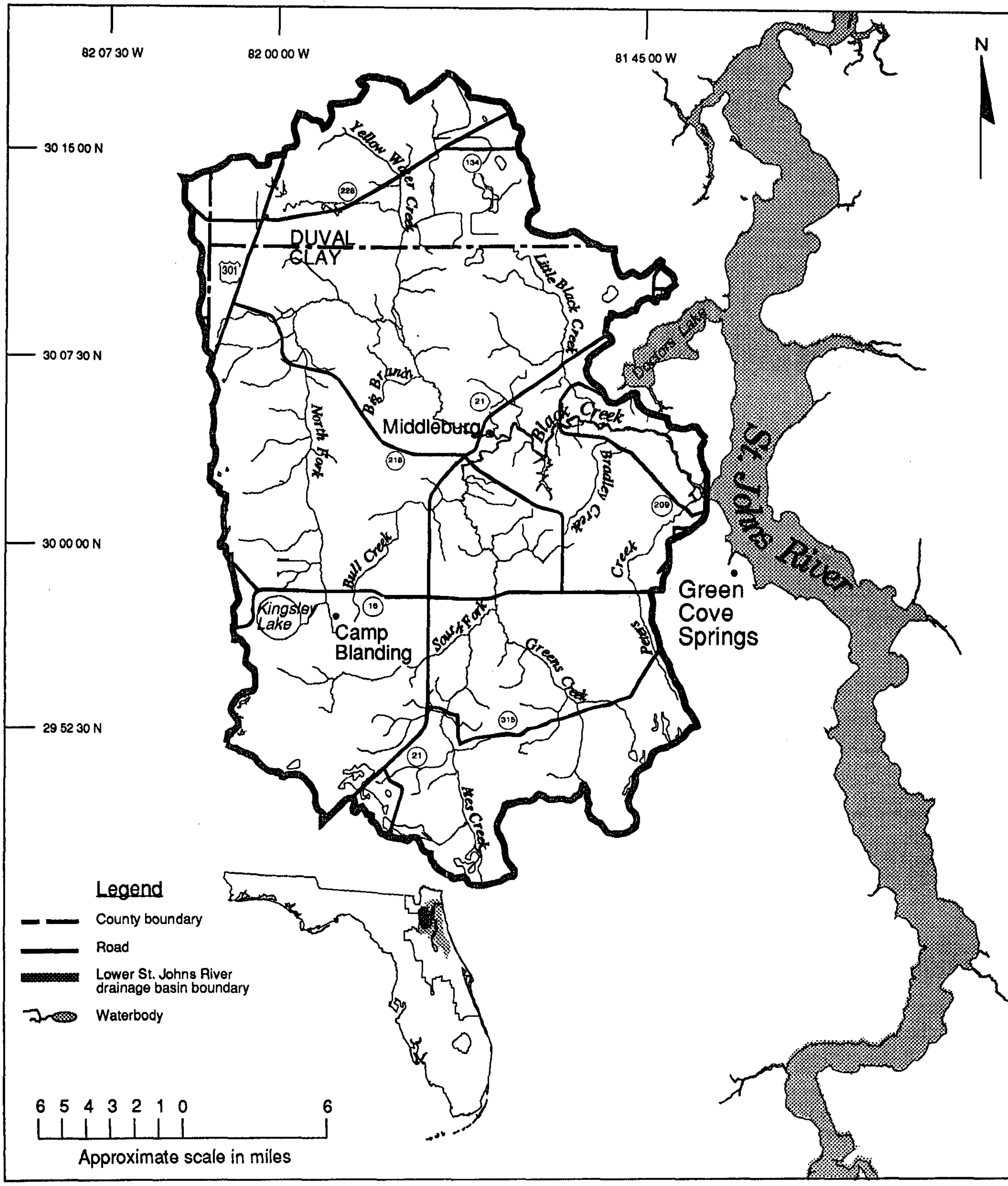

Figure 2. The Black Creek drainage basin

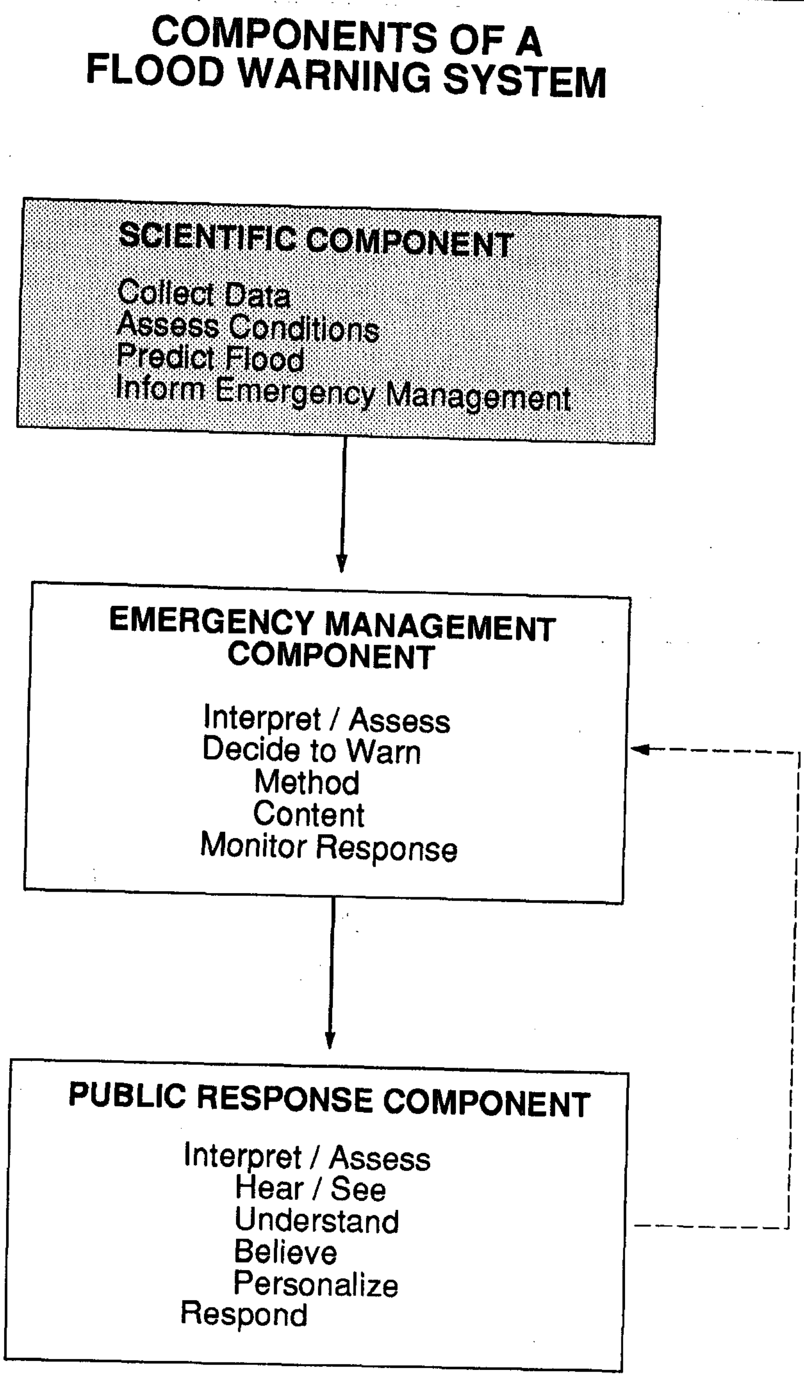

Figure 3. **Components of a flood warning system (adapted from Adams 1991).** *This report primarily deals with the scientific component.*

part of the scientific component include collecting rainfall and stream gauge data, assessing the data, predicting the potential for flooding, and informing authorities of an impending flood. Tasks performed as part of the emergency management component include interpreting flood prediction data, deciding whether or not to warn the residents, deciding how to warn them and the content of the warning, and monitoring their response. Emergency management also includes increasing public awareness by planning pre- and postflooding activities and rehearsals, training flood warning system personnel, and reviewing or monitoring all portions of the system. The public response component involves how the residents interpret the warning and how they respond to the flood warning message (i.e., hear, understand, believe, personalize, and act). All three general components must be in place in order for a flood warning system to be successful. In addition, successful systems in the United States have been identified as being tied closely to the National Weather Service (NWS).

This report on a proposed flood detection system describes only part of a flood warning system. It focuses on the detection and data assessment subcomponents of the scientific component as they relate to a complete flood warning system for the Black Creek drainage basin in Clay County. This report does not include the emergency management and the public response components of a flood warning system. DPS must incorporate all three components to have a successful flood warning system—the placement of equipment alone will not result in a successful flood warning system.

The detection subcomponent consists of collecting data from the field and getting it to the organization(s) responsible for assessing the flooding threat. Data can be collected manually, or data can be collected through automated data collection platforms (ADCP). Rainfall and stream gauge data are not collected when a flood alarm is triggered by rising water.

The data assessment subcomponent involves quantifying the flooding threat. Emergency managers want the largest lead time possible when the potential for flooding exists. For every 4-hour increase in lead time, damages can be reduced from 2 to 25 percent, and the possible numbers of injuries and deaths can be reduced (USACE 1990a).

To collect data manually, an agency could use volunteer observers to read rain and staff gauges. This is an inexpensive and quick way to implement a flood detection network. Such networks quickly break down, however, because a volunteer observer might be on vacation or asleep or cannot read the gauge if it is raining too hard or it is too dark. Consequently, data might not always be available for emergency managers to rely on when forecasting a flood. NWS used a volunteer network in the Black Creek drainage basin. The network proved to be unreliable—only one in ten observers contacted the NWS office to report data (Jack Schnable, NWS, pers. com.). No further detail is given about manually collecting data, because this is not a reliable source of data during times of impending floods.

ADCPs come in a variety of configurations. The equipment can be programmed to report by events (e.g., tips of a rain gauge) or by preset changes in a stream stage (e.g., 0.01 foot [ft]). Data can be collected hourly, daily, or weekly. An ADCP can transmit and/or receive data via telephone, radio, or satellite. ADCPs can either receive instructions from and transmit data to a base station (two-way communication) or only transmit data to a base station (one-way communication). Through a computer at a base station (for two-way communication), an individual can reprogram the ADCP to record different kinds of data.

The data collected from an ADCP can be transmitted directly as input to the computer models that forecast the flooding potential of streams and rivers. These models would run on the base station computer receiving the collected data. More details about ADCPs are presented in a later chapter (p. 12).

In a flood alarm system, water level sensors are connected to an alarm in an area that is flood prone (USACE 1990b). When the rising waters reach a preset level, an alarm goes off. The alarm could be audible in order to be heard locally, or it could trigger a telephone program that would automatically dial predetermined telephone numbers. This type of alarm would signal rising water levels in the Black Creek drainage basin when there is no lead time for residents to take precautionary action. Because rainfall and stream stage data are not collected by a flood alarm system, the use of flood alarms precludes any flood forecasting. More details on flood alarm stations are presented in a later chapter (p. 36).

EXISTING FLOOD WARNING SYSTEM

The flood warning system operated by NWS in Clay County for the Black Creek drainage basin contains two components of a flood warning system: the scientific component and the emergency management component.

SCIENTIFIC COMPONENT

The flooding potential of the Black Creek drainage basin is determined by evaluating radar-estimated rainfall and stream gauge data. Currently, rainfall and stream gauge data in the Black Creek drainage basin are collected using a gauging network. Also, NWS uses WSR-57 radar units to estimate rainfall. The actual method of transmitting the data can vary from one site to the next.

Gauging Network

The gauging network in the Black Creek drainage basin is composed of six gauges (Figure 4). The rain gauge at the Cecil Field Weather Station (north of the Duval-Clay county line) has the longest period of record (since at least 1947). A rain gauge that is operated by SJRWMD and located at the Penney Farms fire tower (on State Road [S.R.] 16) has been recording since April 1989. The U.S. Geological Survey (USGS) operates four recording stream gauges in the drainage basin.

According to Robison (1993), rainfall data collected as part of the fire tower network operated by the Florida Division of Forestry is not in a useable data base and is incomplete (i.e., missing data). Four of the five stations in the network (Louis Hill, Sun Garden, Black Creek, and Keystone Heights; see Robison 1993, p. 5) are outside the Black Creek drainage basin. The fire tower near Penney Farms is the only station in the basin. The fire tower network, per se, is not considered part of the existing flood warning system network.

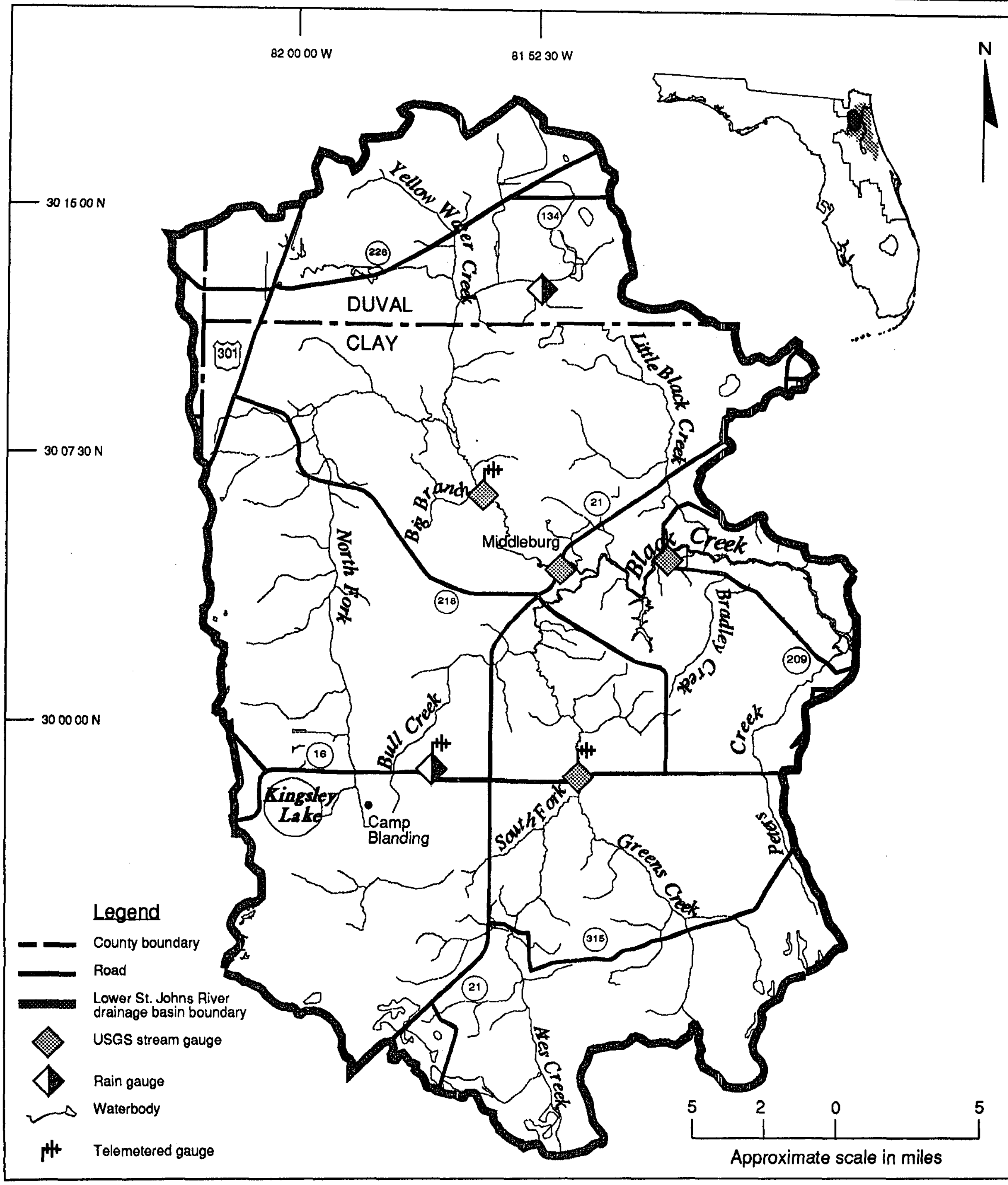

Figure 4. Hydrologic data collection stations in the Black Creek drainage basin. *These stations are part of the existing flood warning system in Clay County.*

NWS uses the data collected from the existing rainfall and stage gauges in the basin along with data from WSR-57 radar units to predict the flooding potential on Black Creek. NWS uses the radar from Daytona Beach, Florida, and Waycross, Georgia, to estimate the rainfall in areas where there are no rainfall or stage gauges. The WSR-57 units are not very accurate.

NWS has plans to replace all WSR-57 radar units in Florida with WSR-88D units by 1998. These more sophisticated units are capable of more accurately estimating rainfall. The WSR-88D unit closest to the Black Creek drainage basin is located in Melbourne, Florida. It is too far from the Black Creek area to effectively estimate rainfall there. The next closest WSR-88D unit to be installed will be at the Weather Service Office in Jacksonville. This equipment should be installed in 1995.

Transmission of Data

Data gathered in the Black Creek drainage basin is either transmitted electronically (i.e., by satellite or radio telemetry) or delivered manually.

USGS uses the GOES satellite system to transmit data collected at the stream gauge (USGS 02246000) on the North Fork of Black Creek, near Middleburg, and at the stream gauge (USGS 02245500) on the South Fork of Black Creek. The nearest earth-based satellite receiving station is located in South Carolina at the USGS Water Resources Division (WRD). A USGS computer in Tallahassee, Florida, telephones the South Carolina site every 4 hours and downloads station data, at which time station data become available in the USGS-WRD Tallahassee computer. The USGS-WRD Orlando computer telephones the Tallahassee computer, further downloading the data. The data then become available to SJRWMD through a telephone modem. In addition, the same data are downloaded at Suitland, Maryland, into the NWS Automation of Field Operations and Services (AFOS) data distribution network, which distributes data to all NWS offices.

The other three stream gauging stations operated by USGS on Black Creek are included in a cooperative data-gathering program between SJRWMD and USGS. Data are collected by USGS personnel during bimonthly site visits and are delivered manually to the USGS-WRD Orlando computer.

SJRWMD uses a VHF radio telemetry network to transmit rainfall data and ground water levels to computer base stations. Within SJRWMD, there are three base stations, one of which is in Palatka. Each base station is the center of a local data network. Rainfall and ground water level data recorded at SJRWMD's Penney Farms fire tower station are transmitted via VHF radio to the SJRWMD Palatka base station.

EMERGENCY MANAGEMENT COMPONENT

Organizations participating in the existing flood warning system for Clay County, particularly for the Black Creek drainage basin, are DPS (the lead agency), the Clay County Sheriff's Office, and NWS. To date, DPS and the Clay County Sheriff's Office have not been involved formally with NWS (NWS, pers. com.).

NWS is required by federal law to warn the public concerning adverse weather and stream conditions. NWS has located 13 regional river forecast centers throughout the United States. Within each region, NWS maintains local forecast offices staffed by hydrologists. River forecast centers provide direct flood forecasts on the larger streams and rivers and generalized flood watches and warnings for smaller streams. Staff at the Atlanta River Forecast Center and the Melbourne Forecast Office perform hydrologic services for Clay County by issuing flood warnings and watches for the Black Creek drainage basin. The Jacksonville Weather Service Office, a part of NWS, provides service to Clay County with other weather-related data.

Flood Forecasting System

In order for an agency (e.g., NWS) to forecast the threat of flooding, the agency must arrange to have rainfall and stream stage data collected and transmitted to an organization responsible for assessing the flooding threat. ADCPs are one way of collecting and transmitting data and are the preferred mechanism for collecting and transmitting data as part of a gauging network. Data detection is part of the scientific component of a flood warning system. A flood warning system for the Black Creek Basin will have the most flexibility and flood forecasting ability possible using ADCPs.

Automated Data Collection Platforms

The optimal configuration of an ADCP includes the following.

- Automated rain gauges (Figure 5) and/or stream gauges (Figure 6) that collect data without the necessity of individuals being sent to the site to collect the data manually

- Solar rechargeable batteries that power the ADCP

- A radio system that transmits data to a computer at the base station

ADCPs operate based on either one-way or two-way communication. When an ADCP operates on two-way communication, it can receive instructions from the base station, such as reprogramming, or transmit data to the base station. Data or instructions are forwarded usually via VHF radio, although telephone or satellites can be used. Some systems based on one-way communication can only transmit the data to the base station. Other systems based on one-way communication receive data, record the data on data loggers, and transmit the data to the

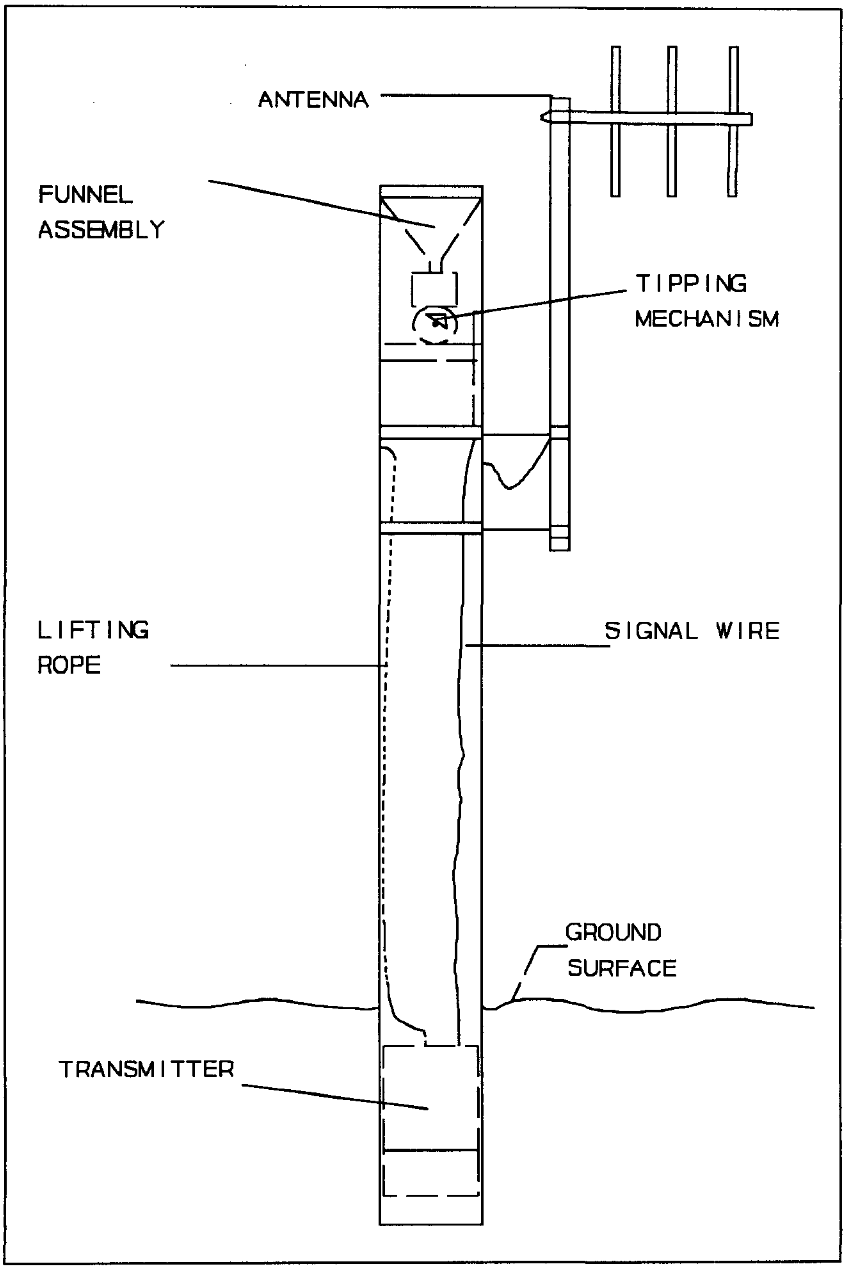

Figure 5. Schematic of an automated rain gauge

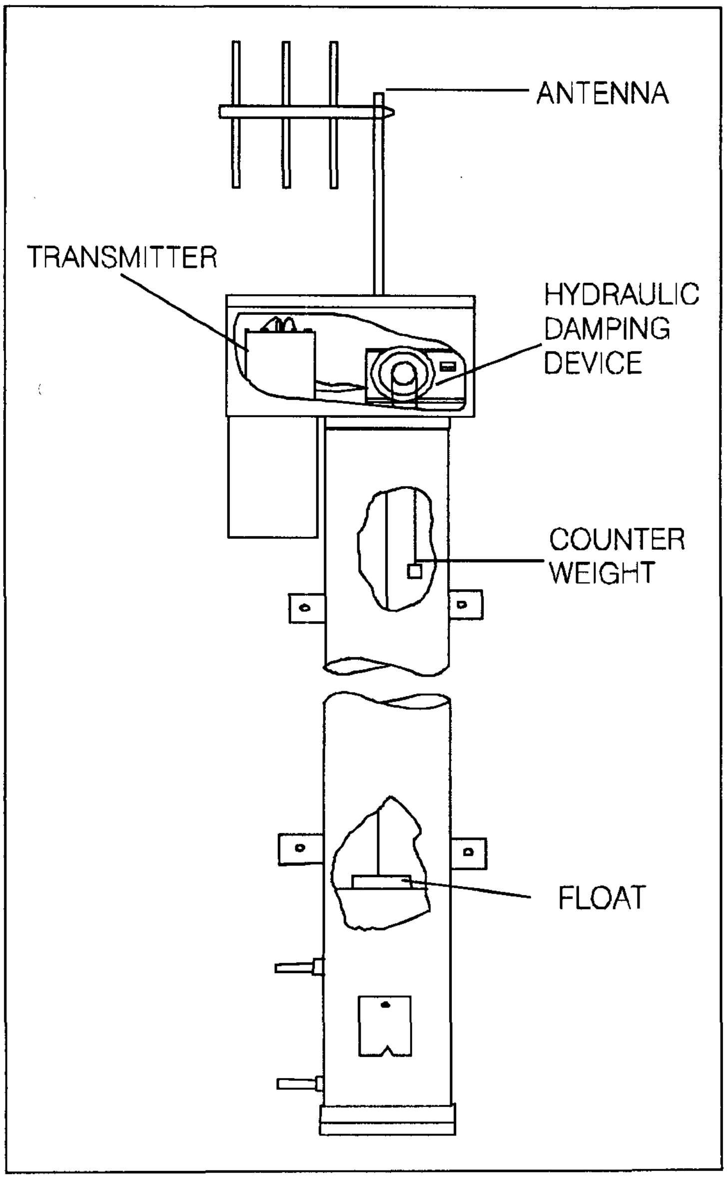

Figure 6. **Schematic of an automated stream gauge**

base station. To get the data from the data loggers when they are not transmitting, an individual must visit the site to collect the data. To reprogram an ADCP, an individual must visit the site and manually make the necessary changes.

The agency operating a flood detection network based on ADCPs, using any radio frequency (e.g., UHF, VHF), must apply to the Federal Communications Commission (FCC) for a license and an assigned radio frequency on which to transmit. FCC has reserved the range from 169.020 to 172.000 megahertz for federal agencies dealing with flood detection systems. Use of this frequency range by non-federal agencies, such as county governments or water management districts, requires a federal government sponsor. Either the federal sponsor or the non-federal user may hold the license. The federal government sponsor for SJRWMD is NWS; SJRWMD holds the license. If a local agency elects to hold the license, the time involved to get the license could be four to six times longer than if the agency had a federal sponsor hold the license.

In addition to monitoring for possible flood threats, ADCPs can be used for other tasks. An ADCP can be wired for almost any type of sensor that emits an electrical signal or has a switch closure. Such sensors might monitor equipment, such as motors at a sewage lift station, or monitor water or air quality. As an example, DPS might use an ADCP to record changes in water quality in Black Creek, for detecting possible acid or other chemical spills. A change in the specific conductivity of the water could reflect a change in the water quality.

PROPOSED GAUGING NETWORK

Robison (1993) and others concluded that streams in the Black Creek drainage basin reflect basin rainfall events approximately 20 to 26 hours after the event (lag time). This lag time is a relatively long lead time for many flood warning systems. In basins with a long lead time, such as the Black Creek drainage basin, a flood detection system based on rainfall and stream gauges can be effective in identifying potential flooding threats.

The placement of rain gauges is essential to maximize the lead time, develop a stream forecast, and provide early warning to residents.

Two different gauging networks are presented in this report. One uses 15 gauges based on a nonradar system; this network does not use USGS gauges. The other network uses eight gauges and the NWS WSR-88D radar system. Two of the eight gauges are USGS stream gauges. The 8-gauge network could be entirely operated by USGS if the six rain gauges were to be installed by USGS.

Fifteen-Gauge Network and No Radar

Robison (1993) recommended a flood warning network composed of 14 gauges: 11 rain and 3 stream. The 11 rain gauges will collect data associated with the North Fork (five gauges), the South Fork (five gauges), and Black Creek, just downstream of the confluence of the North and South forks (one gauge). Two of the North Fork rain gauges should be located along Yellow Water Creek in Duval County (Figure 7). The three stream gauges (one gauge at each location) will record stream levels on the North Fork, the South Fork, and Black Creek just downstream of the confluence of the North and South forks.

The gauging network as proposed by Robison (1993) may not be practical for Clay County, because DPS would have to install, operate, and maintain the rain gauges in Duval County. These two gauges, however, could be located as far north in Clay County as possible (Figure 8) and still provide adequate data to forecast the flooding potential of Yellow Water Creek. An additional stream gauge should be added on Yellow Water Creek at the county boundary to measure runoff from the Duval County portion of the basin. These modifications to the Robison recommendation yield a gauging network of 15 gauges: 11 rain and 4 stream.

The modified or proposed gauging network can be installed in phases. Because the majority of historical flooding events have

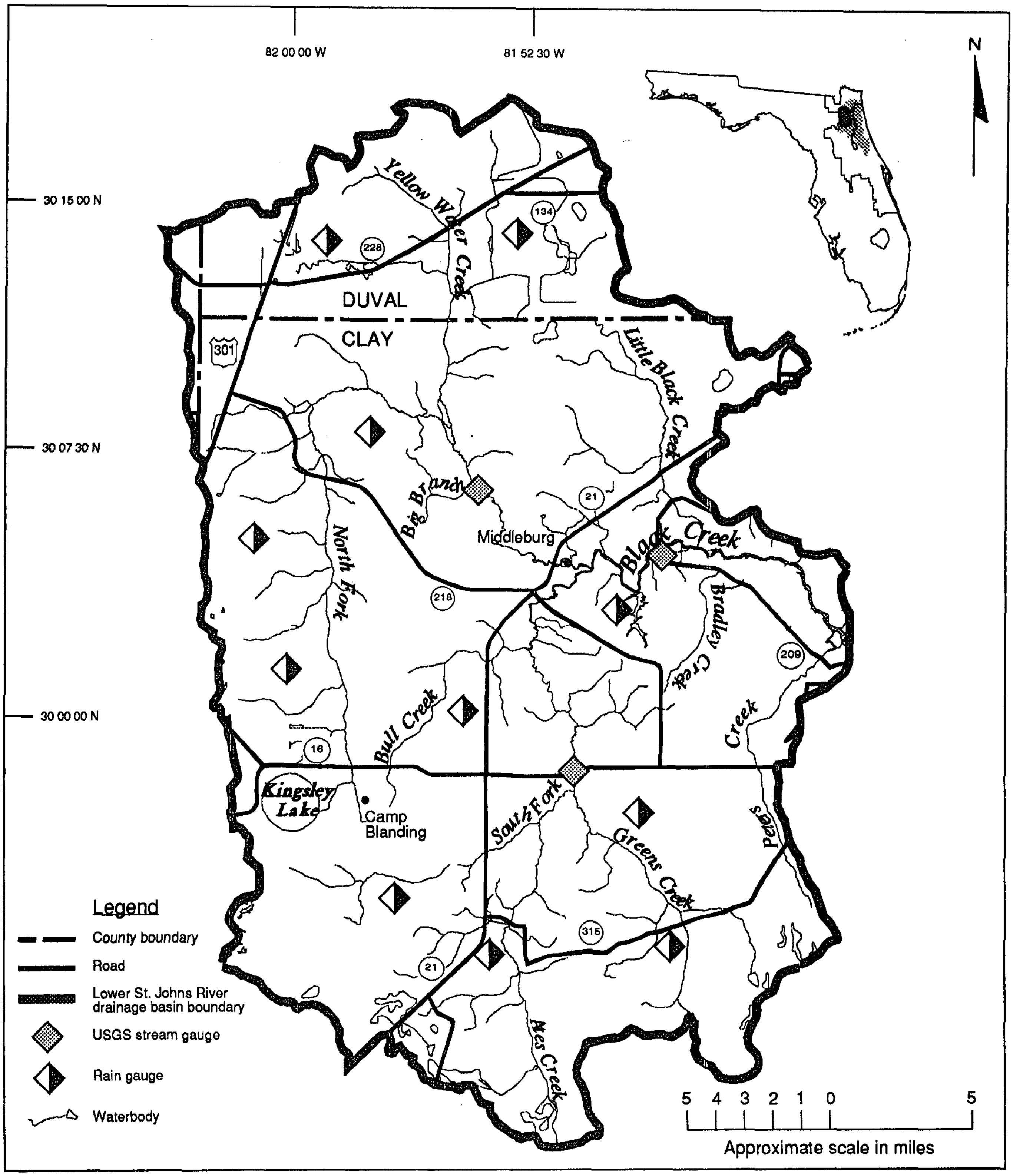

Figure 7. **Ideal location of rain and stream gauges in the Black Creek drainage basin**

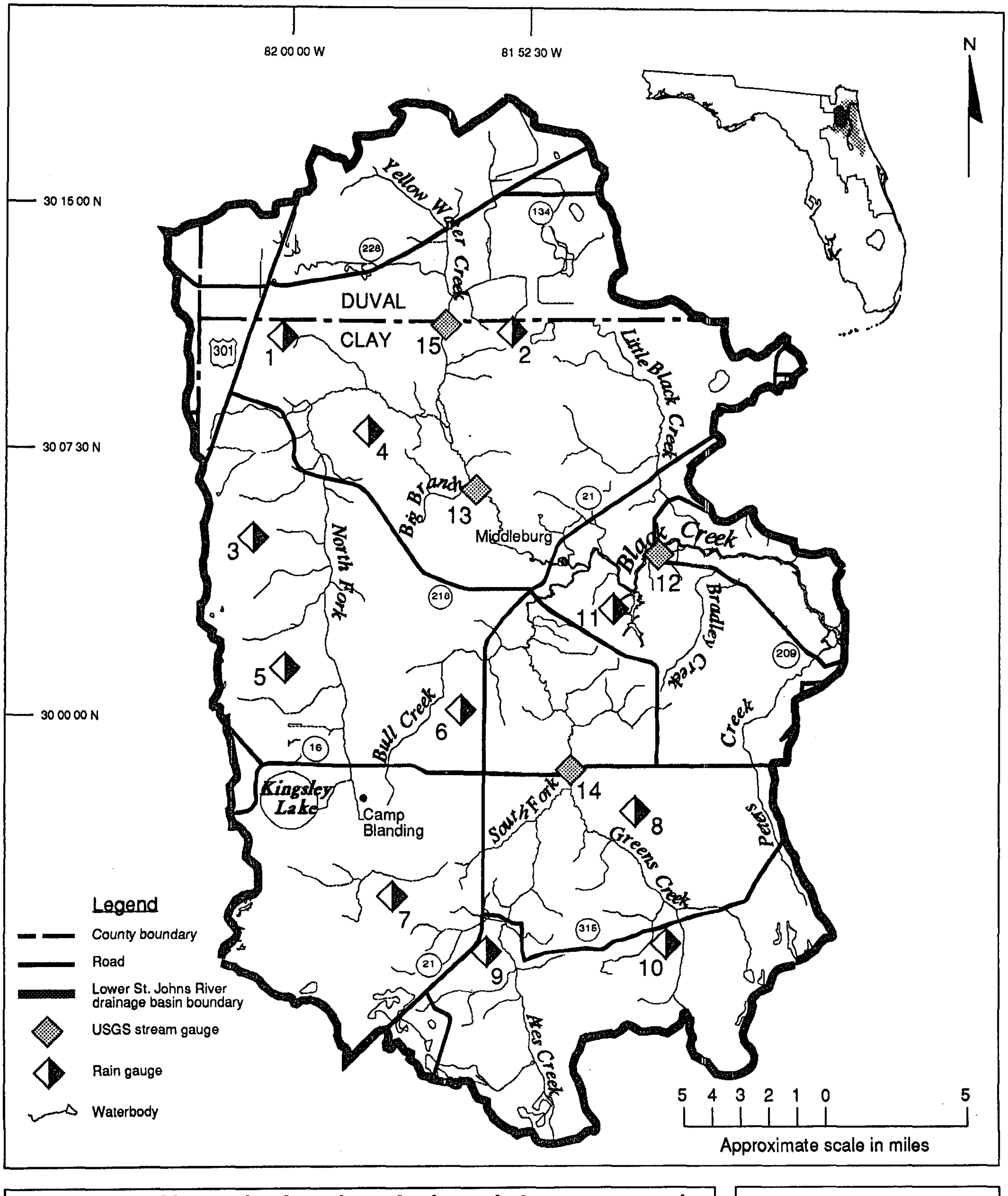

Figure 8. **Alternative location of rain and stream gauges in the Black Creek drainage basin.** *This proposed network of 15 gauges does not use radar.*

occurred on the North Fork (James Corbin, DPS, pers. com.), the initial phase of the network should be concentrated in this area. Phase one of the network includes priorities 1 to 6—rain and stream gauges, repeaters, and base stations (Table 1). Installation of other phases will depend on the budget, local site conditions, and availability of land on which to place the gauges. Local site conditions affect the transmission of VHF radio signals. VHF radios transmit in a line-of-sight and at low power levels (generally 5 watts or less). This means that ADCPs should be above the horizon; otherwise, additional repeater stations may be needed to forward the signals on to the base station. In addition, interference from man-made structures or radio signal reflections off of other buildings not in the line-of-sight affect the transmission of VHF radio signals. Because of the topographic relief in the Black Creek drainage basin, the specifics of the radio transmission paths for each ADCP cannot be determined until the final locations of the proposed sites are determined. The final analysis will be to test the radio path by transmitting data to determine if the base station can receive the data accurately.

Tentative radio path analyses have been done for all proposed sites. The results indicate that at least one radio repeater will be needed within the Black Creek drainage basin, near Middleburg (site 20 on Table 1). From the Clay County radio tower on U.S. Highway 17 in Green Cove Springs, which has an effective height of 200 ft (James Corbin, DPS, pers. com.), another repeater will be needed to retransmit the data to the PC-base station located in the Clay County Emergency Center in Green Cove Springs, a mile west of U.S. Highway 17. A repeater could be placed on the NWS antenna, which is on the Barnett Bank Building in downtown Jacksonville, to forward the radio signals to the NWS office in Jacksonville. This repeater could be eliminated if a tower that was about 300-350 ft above sea level could be located in the Green Cove Springs area. The repeater in Green Cove Springs then could do double duty, that is, forward the signals to both DPS and NWS.

A base station for the Jacksonville office of NWS may not be needed if data can be forwarded to the NWS Melbourne Forecast

Table 1. Proposed 15-gauge network for the Black Creek drainage basin

Priority	Site	Site Number	Purpose	Comments
1	Clay County Department of Public Safety, Emergency Center	18	Base station	Required
1	Green Cove Springs	16	Repeater	Required
1	National Weather Service, Jacksonville	17	Base station	
1	Southwest of Middleburg	20	Repeater	Required
1	Barnett Bank Building, Jacksonville	19	Repeater	On the Barnett Bank Building
1	Long Branch	1	Rain gauge	North Fork
2	Big Branch	2	Rain gauge	North Fork
3	Mill Branch	3	Rain gauge	North Fork
4	Clay Hill	4	Rain gauge	North Fork
5	Mine Dump	5	Rain gauge	North Fork
6	North Fork - Big Branch	13	Stream gauge	
7	Yellow Water Creek	15	Stream gauge	North Fork to measure Duval County runoff
8	South Fork	14	Stream gauge	
9	Bull Creek	6	Rain gauge	South Fork
10	Camp Blanding	7	Rain gauge	South Fork
11	Greens Creek	8	Rain gauge	South Fork
12	Upper Greens Creek	10	Rain gauge	South Fork
13	Upper Devils Den	9	Rain gauge	South Fork
14	Black Creek	12	Stream gauge	Black Creek, downstream of flooding
15	Lake Asbury	11	Rain gauge	Black Creek, downstream of flooding

Office. To do this, the existing telemetry network operated by SJRWMD could be utilized to send the data to SJRWMD, which in turn would transmit the data to NWS in Melbourne. This option, however, would require that the same kind of base station equipment used by SJRWMD be purchased. There might be other costs associated with a partnership with SJRWMD—costs for additional equipment or additional staff at Palatka.

Eight-Gauge Network and Radar

As stated earlier (p. 10), NWS plans to upgrade its radar units covering the Black Creek drainage basin. Because these units can better estimate rainfall, an alternative network is proposed. The network incorporates radar with six rain gauges and two existing USGS stream gauges (Table 2 and Figure 9). Three rain gauges would be installed on the North Fork and three on the South Fork. Data collected from the stream gauges would be telemetered via the GOES satellite to the NWS AFOS data

Table 2. Proposed 8-gauge network for the Black Creek drainage basin

Site	Site Number	Purpose	Comments
Southwest of Middleburg	20	Repeater	
Big Branch	2	Rain gauge	Required; North Fork
Clay Hill	4	Rain gauge	Required; North Fork
Mine Dump	5	Rain gauge	Required; North Fork
Upper Greens Creek	10	Rain gauge	Required; South Fork
Upper Devils Den	9	Rain gauge	Required; South Fork
Greens Creek	8	Rain gauge	Required; South Fork
North Fork	13	Stream gauge	Operated by USGS
South Fork	14	Stream gauge	Operated by USGS

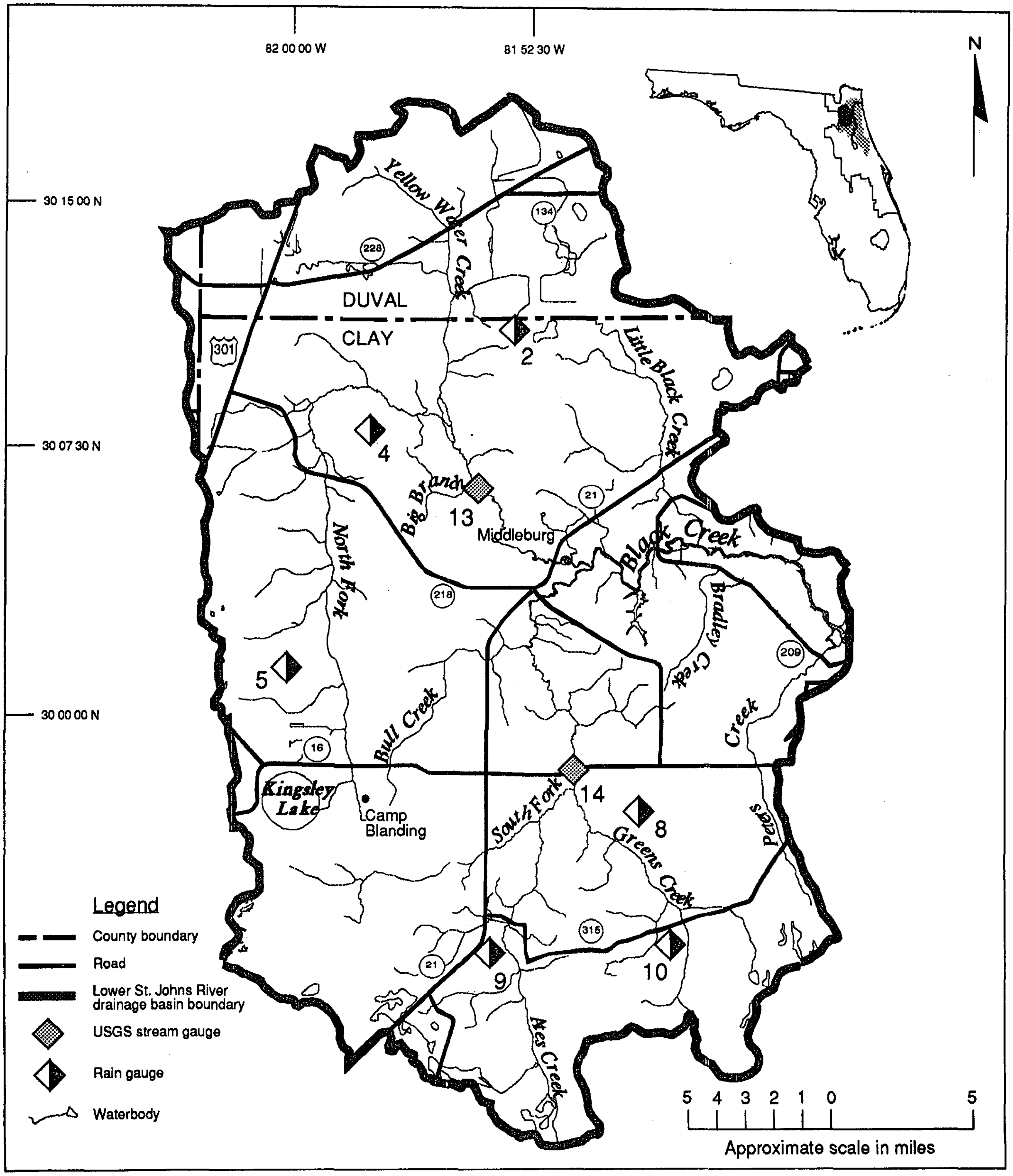

Figure 9. **Location of rain and stream gauges in the Black Creek drainage basin that could be used in conjunction with radar**

distribution network. With the data collected by the rain and stream gauges and WSR-88D radar units, NWS can use its flood forecasting models to predict the potential for flooding in the Black Creek drainage basin.

Using this type of network, only six rain gauges and a repeater would have to be purchased and installed, and the SJRWMD telemetry system would be utilized to forward the rainfall data to NWS. The existing USGS stream gauges would also be utilized. The proposed network would result in a functioning flood detection system.

If DPS wanted to receive data at its office in Green Cove Springs, however, Clay County would have two choices: (1) Clay County could purchase a base station as well as a repeater or (2) DPS could use an existing personal computer and modem to access the base station at SJRWMD. The second option requires the purchase of REMDOS™ software.

Local site conditions affect the transmission of VHF radio signals. VHF radios transmit in a line of sight and at low power levels (generally 5 watts or less). This means that ADCPs should be above the horizon; otherwise, additional repeater stations may be needed to forward the signals to the base station. In addition, interference from man-made structures or radio signal reflections off of other buildings not in the line of sight affect the transmission of VHF radio signals. Because of the topographic relief in the Black Creek drainage basin, the specifics of the radio transmission paths for each ADCP cannot be determined until the final locations of the proposed sites are determined. The final analysis will be to test the radio path by transmitting data to determine if the base station can receive the data accurately.

An alternative 8-gauge network might be installed and operated by utilizing USGS to install and maintain the six rain gauges in addition to the two existing USGS stream gauges. Under this scenerio, all data would be transmitted via the GOES satellite system into the NWS AFOS system. To access the data, DPS would need to be able to tap into the USGS computer system in Orlando.

FLOOD FORECASTING

Flood forecasting is accomplished through computer modeling. Several modeling options are available.

- DOS-based models
- QNX-based models
- NWS models

If DPS plans to forecast flooding events using in-house models (DOS- or QNX-based), it should enter into an agreement with NWS to avoid sending out conflicting warnings to the public during a possible flood event (see appendix for a sample memorandum of understanding).

DOS-based Models

Robison (1993) simulated the flooding potential in the Black Creek drainage basin using two hydrologic models: Streamflow Synthesis and Reservoir Regulation (SSARR) and Dynamic Wave Operational (DWOPER). These models run on a DOS-based computer. The computers SJRWMD and NWS use for the telemetry system are not DOS-based; the SJRWMD telemetry system is QNX-based. The data, therefore, must be transferred from one computer system to the other. This can be done manually by re-entering the data or possibly via some automated system that would have to be developed.

QNX-based Models

Other forecasting models are available that automatically use the real-time data used by SJRWMD on the QNX operating system. These models operate on the same system that receives the data. The Sacramento River Model, the Antecedent Precipitation Index Model, and the U.S. Army Corps of Engineers HEC1F use real-time data directly from the gauging networks. In addition, the

River Forecast Model, which NWS uses, may be available in the future for use on microcomputers operating on a QNX system that collects real-time data.

NWS Models

Instead of using in-house models to predict flood events, DPS could take advantage of the services provided by NWS. The Atlanta River Forecast Center of NWS already has the responsibility to issue flood warnings and advisories for the Black Creek drainage basin. NWS receives real-time satellite, radar, and other weather data from the surrounding region, which allows NWS to determine if and when storms will be moving into the Black Creek drainage basin. NWS uses its own models, such as the River Forecast Model. Currently, the data available to NWS are limited to those data that are recorded at the stream gauge on the North Fork (USGS 02246000) and at the rain gauge at Penney Farms (SJRWMD station). These data are transmitted as either real-time or near real-time.

SYSTEM COSTS—FIFTEEN-GAUGE NETWORK

Anticipated costs for the modified or proposed gauging network of 11 rain gauges, 4 stream gauges, 2 base stations, and 3 repeaters are categorized into basic costs, additional costs, and maintenance costs.

Basic Costs

The estimated basic cost of the proposed Black Creek drainage basin flood detection gauging network is $188,550 (Table 3). The cost could be spread over 2 years, which is the frequency period of flood events. The estimate is based on the type of equipment used by SJRWMD, Sierra-Misco DataCommand™ software, and Sierra-Misco RTU-0850™ data loggers. This data logger uses two-way radio transmission.

The expenses could be reduced by using alternative equipment and installing some of the equipment. Approximately $1,000 per

Table 3. Estimated basic costs for the 15-gauge network that could be used as part of the flood detection system in the Black Creek drainage basin

Site	Type	Priority	Cost*
Phase 1			
County station	Base station	1	$ 21,000
Green Cove Springs	Repeater	1	9,000
National Weather Service, Jacksonville Airport	Base station	1	21,000
Southwest of Middleburg	Repeater	1	9,000
Barnett Bank Building, Jacksonville	Repeater	1	6,950
Long Branch	Rain gauge**	1	7,920
Big Branch	Rain gauge**	2	7,920
Mill Branch	Rain gauge**	3	7,920
Clay Hill	Rain gauge**	4	7,920
Mine Dump	Rain gauge**	5	7,920
North Fork	Stream gauge**	6	8,620
Subtotal			$115,170
Phase 2			
Yellow Water Creek	Stream gauge**	7	8,620
South Fork	Stream gauge**	8	8,620
Bull Creek	Rain gauge**	9	7,920
Camp Blanding	Rain gauge**	10	7,920
Greens Creek	Rain gauge**	11	7,920
Upper Devils Den	Rain gauge**	12	7,920
Upper Greens Creek	Rain gauge**	13	7,920
Lake Asbury	Rain gauge**	14	7,920
Black Creek	Stream gauge**	15	8,620
Subtotal			$ 73,380
Grand Total			$188,550

* Includes cost of computer software and installation

** Prices based on RTU-0850™ data logger. Use of 5096™ data logger would cost approximately $1,000 less per site.

site could be saved by using a one-way radio transmission network and Sierra-Misco 5096™ data loggers. If DPS intends to use ADCPs for purposes other than just collecting and transmitting rainfall and stream gauge data (p. 15), the use of one-way radio may make it more difficult to collect these additional data. Direct installation costs could be reduced if Clay County employees who will be maintaining the system assist in the installation. This will enable the employees to gain valuable on-the-job training.

The basic cost might be increased by 20 percent to cover any unanticipated additional expenses. This would amount to approximately an additional $23,034 for year 1 and $14,676 for year 2.

Additional Costs

Additional costs associated with the proposed gauging network include spare parts inventory, extra equipment, and training. Normally, costs to fence each site would be included in the additional-costs category, but since the exact location of each site has not been determined, costs for fencing are not included.

The cost of spare parts is at least $2,290 (Table 4). SJRWMD maintains an inventory that is based on 20 percent of the equipment in the field. An adequate inventory of spare parts is essential to keep the network as fully operational as possible.

The cost of extra equipment is about $18,500 (Table 4). This equipment is particularly important to have in stock during severe storm months, when lightning strikes can be frequent.

The cost of training is estimated to be $8,000 (Table 4). This is based on one to ten employees receiving 10 days of training during the first 6 months that the network is in operation. Additional training will depend on employee turnover rate.

Table 4. Additional costs associated with the 15-gauge network that could be used in the flood detection system for the Black Creek drainage basin

Additional Items	Equipment	Quantity	Total Cost
Extra equipment	Data loggers	3*	$ 7,350
	Radio transceivers	3	2,700
	Lightning protection for RTU-0850™	6	660
	Rain gauge	2	1,100
	Stream gauge	1	950
	Antenna with cable	1	350
	Solar panel	2	540
	Modem (MNP5)	1	450
	Fiber optic modem	2	450
	Wattmeter	1	450
	Station tester with software	1	3,500
Spare parts	Miscellaneous lightning protection	4	240
	Batteries	6	450
	Rain gauge standpipe	1	800
	Stream gauge standpipe	1	800
Training	10 days over 6-month period		8,000
	Total		$28,790

* Costs could be reduced by $1,000 each if less expensive equipment were used (see Table 3).

Maintenance Costs

The estimated maintenance costs for a fully implemented gauging network in the Black Creek drainage basin are approximately $23,800 a year (Table 5). Operation and maintenance of the flood detection system will be required for the lifetime of the system. For a flood warning system to work properly, the flood detection system must be maintained. All too often, agencies do not regularly maintain flood detection systems, and, just before a storm event, crews try frantically to get inoperable gauges working.

Table 5. Estimated annual maintenance costs of a fully implemented 15-gauge network in the Black Creek drainage basin

Item	Cost
Hardware	
11 Rain gauges	
Inspection	$ 9,900
Repair	5,500
4 Stream gauges	
Inspection	1,800
Repair	2,500
3 Repeaters	
Inspection	600
Repair of 1 repeater	1,500
1 Base station	1,000
Software maintenance for base station	1,000
Total	$23,800

In the Black Creek drainage basin, storms that result in flooding occur about every 2 years. It is very important for the system operator to invest about $23,800 each year to keep the gauging network operational.

Gauges should be checked on a regular basis. Rain gauges should be checked every other month for correct operation and calibrated twice a year. Stream gauges should be calibrated monthly at first (until confidence is established in the gauges), then calibrated every other month. SJRWMD presently checks stream gauges every other month to make sure they are still calibrated and checks rain gauges every other month. Gauges should be checked periodically to make sure they have not been vandalized or struck by lightning. SJRWMD experiences vandalism, especially in urban areas. RTU-0850™ data loggers can be used to detect a removed rain gauge, an opened fence gate or door, or a tampered-with gauge. However, this information may not indicate the extent of the damage. During lightning season, extra site inspections should be conducted.

SYSTEM COSTS—EIGHT-GAUGE NETWORK

Anticipated costs for the proposed gauging network of six rain gauges, two USGS stream gauges, and one repeater and for the use of NWS WSR-88D radar units are categorized into basic costs, additional costs, and maintenance costs.

Basic Costs

The estimated basic cost of the proposed Black Creek drainage basin flood detection gauging network is $56,520 (Table 6). Direct installation costs could be reduced if Clay County employees who will be maintaining the system assist in the installation. This will enable the employees to gain valuable on-the-job training.

The basic costs might be increased by 20 percent to cover any unanticipated additional expenses. This would amount to approximately $11,304.

Table 6. Estimated basic costs for the 8-gauge network that could be used as part of the flood detection system in the Black Creek drainage basin

Site	Type	Cost
Southwest of Middleburg	Repeater	$ 9,000
Big Branch	Rain gauge	7,920
Clay Hill	Rain gauge	7,920
Mine Dump	Rain gauge	7,920
Upper Greens Creek	Rain gauge	7,920
Upper Devils Den	Rain gauge	7,920
Greens Creek	Rain gauge	7,920
North Fork	Stream gauge*	0
South Fork	Stream gauge*	0
Total		$56,520

* Operated by USGS under SJRWMD–USGS cooperative program

The cost of USGS installing and operating the six rain gauges for the first year is estimated to be $36,000 ($6,000 per site). If federal matching funds from USGS are not available, then the total installation cost of the rain gauges ($36,000) would have to be paid to USGS.

Additional Costs

Additional costs associated with the proposed gauging network include spare parts inventory, extra equipment, and training. Normally, costs to fence each site would be included in the additional-costs category, but since the exact location of each site has not been determined, costs for fencing are not included.

The cost of spare parts is at least $1,085 (Table 7). SJRWMD maintains an inventory that is based on 20 percent of the equipment in the field. An adequate inventory of spare parts is essential in keeping the network as fully operational as possible.

The cost of extra equipment is about $8,580 (Table 7). This equipment is particularly important to have in stock during severe storm months, when lightning strikes can be frequent.

Table 7. Additional costs associated with the 8-gauge network that could be used in the flood detection system for the Black Creek drainage basin

Additional Items	Equipment	Quantity	Total Cost
Extra equipment	Data loggers	1	$ 2,450
	Radio transceivers	1	900
	Lightning protection for RTU-0850™	1	110
	Rain gauge	1	550
	Antenna with cable	1	350
	Solar panel	1	270
	Wattmeter	1	450
	Station tester with software	1	3,500
Spare parts	Batteries	3	225
	Miscellaneous lightning protection	1	60
	Rain gauge standpipe	1	800
Training	10 days over 6-month period		8,000
Total			$17,665

The cost of training is estimated to be $8,000 (Table 7). This is based on one to ten employees receiving 10 days of training during the first 6 months that the network is in operation. Additional training will depend on employee turnover rate.

Other costs might include a base station and repeater or the purchase of REMDOS™ software for about $450 (see discussion on p. 23). These costs are not included in any of the options presented in this report.

There are no additional costs if USGS is to install and maintain the rain gauges. However, the county cannot gain access to the rainfall or stream stage data unless it is able to access either the USGS computer or the SJRWMD telemetry base station. USGS rainfall data may not be available in the SJRWMD base station computer due to a format incompatability between USGS and SJRWMD.

Maintenance Costs

The estimated maintenance costs for a fully implemented gauging network in the Black Creek drainage basin are approximately $10,100 a year (Table 8). Operation and maintenance of the flood detection system will be required for the lifetime of the system. For a flood warning system to work properly, DPS must maintain the flood detection system. All too often, agencies do not regularly maintain flood detection systems, and, just before a storm event, crews try frantically to get inoperable gauges working. In the Black Creek drainage basin, major storms occur about every 2 years. It is very important for DPS to invest about $10,100 each year to keep the gauging network operational.

Gauges should be checked on a regular basis. Rain gauges should be checked every other month for correct operation and calibrated twice a year. Gauges should be checked periodically to make sure they have not been vandalized or struck by lightning. SJRWMD experiences vandalism, especially in urban areas. RTU-0850™ data loggers can be used to detect a removed rain gauge, an opened fence gate or door, or a tampered-with gauge.

However, this information may not indicate the extent of damage. During lightning season, extra site inspections should be conducted.

Table 8. Estimated annual maintenance costs of a fully implemented 8-gauge network in the Black Creek drainage basin

Item	Cost
Hardware	
6 Rain gauges	
Inspection	$5,400
Repair	3,000
1 Repeater	
Inspection	200
Repair	1,500
Total	$10,100

The yearly maintenance costs for the USGS-installed rain gauges will be $36,000. If federal matching funds from USGS are not available, then the total yearly maintenance costs of the rain gauges ($36,000) would have to be paid to USGS.

CONFIGURATION OPTIONS

One of the following options should be selected to implement a flood detection system, which provides the ability to forecast floods.

Option 1 This option uses the radio telemetry system operated by SJRWMD. It is a 15-gauge network. DPS would increase the number of ADCPs and install additional repeaters and base stations. This option will take 2 years to implement. The estimated Phase I cost for this option is $167,760.

Option 2 This option uses a radio telemetry system other than that operated by SJRWMD. This 15-gauge network would transmit on a radio frequency that is totally independent from SJRWMD. It would be capable of interfacing with SJRWMD via PC-base stations. DPS installs ADCPs, using less expensive and less versatile equipment (e.g., RTU-5096™ data logger). This option will take 2 years to implement. The estimated Phase I cost for this option is $158,760.

Option 3 This option uses a radio telemetry system. This 15-gauge network would transmit on a radio frequency that is totally independent from SJRWMD. It would not be capable of interfacing with SJRWMD. Less expensive and less versatile ADCPs would be installed (e.g., the RTU-5096™ data logger). This option will take 3 years to implement. The estimated Phase I cost for this option is $158,760.

Option 4 This option uses the radio telemetry system operated by SJRWMD. It is an 8-gauge network. Six rain gauges and one repeater would be installed and two USGS stream gauges would be utilized. Data would be collected by the SJRWMD radio telemetry network and forwarded to NWS for determining the potential for flooding. This option will take 1 year to implement. The estimated cost for this option is $84,285.

Option 5 This option uses the USGS GOES satellite system to send data to NWS through the NWS AFOS system. It requires that USGS install six telemetered rain gauges and continue to maintain the two existing telemetered stream gauges. It will take 1 year to implement; the cost of the system is approximately $36,000.

FLOOD ALARM SYSTEM

A flood alarm system is designed to detect only rising or falling stream stages—not to forecast flooding events. This kind of system usually has fewer gauge sites than flood detection systems; therefore, it is less expensive to install and easier to maintain and operate (USACE 1990b). The equipment used in a flood alarm system precludes the ability to collect various types of data beyond the preset elevation of the water in a stream.

A flood alarm system detects when rising water levels reach a preset point, or points, at a station. Alarms do not have to be installed at existing stream gauging stations. Each flood alarm station typically is located upstream of where flooding is expected. Flood alarm stations provide early warning to residents, depending on the rise time of the stream. If a stream typically rises quite rapidly, a flood alarm system should not be used. In the Black Creek drainage basin, where lag time is about 20 to 26 hours, a flood alarm system is practical and may be of interest to DPS.

The time between any two alarms from a flood alarm station gives a rough indication of the rate of rise of the stream at the station. When the flood alarm system is activated, the site should be visited immediately to continue to evaluate the flooding threat.

EQUIPMENT

The equipment used in most flood alarm systems is very simple. A series of two, three, or more float switches is connected to a telephone alarm dialer (Figure 10). Float switches and the telephone alarm dialer are enclosed in a stilling well, which is made of 18-inch corrugated metal pipe (CMP). The stilling well is installed at the level at which the alarm should be activated.

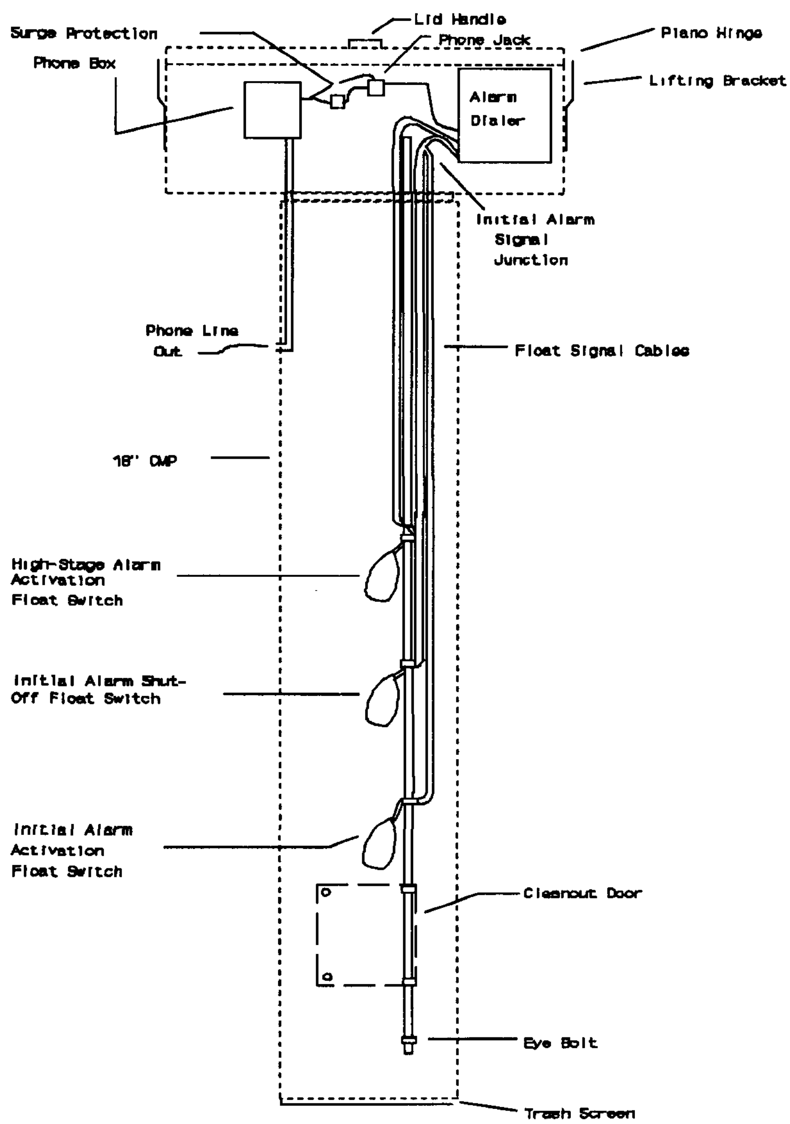

Figure 10. **Schematic of a flood alarm**

When the lowest float switch is activated, the telephone alarm dialer triggers a telephone program, which automatically dials predetermined telephone numbers and plays a prerecorded message. As long as the water continues to rise, different prerecorded messages are sent, depending on the float triggered. The audible signal goes off each time a float is triggered by the rising water. The audible signal is preset to one level; it does not change when a different alarm is triggered.

Telephone lines are important to the success of a flood alarm system. In Florida, telephone lines are affected greatly by weather conditions—especially lightning. Lightning can destroy the telephone line, telephone switching station, or a flood alarm station just prior to flooding. The result is that the flood alarm system may become inoperable prior to or during flooding events. As a result of lightning, SJRWMD has experienced numerous problems with most of its electronic data loggers attached to telephone lines. This problem has made many of the SJRWMD sites impossible to operate during the lightning season. A possible alternative to telephone lines might be the use of cellular phones.

SYSTEM CONFIGURATION

Two floodprone areas on Black Creek are of interest to Clay County. On the North Fork, the floodprone area of interest extends upstream from the confluence of the North and South forks to approximately 1.75 miles (mi) above the S.R. 21 bridge—a total distance of approximately 3.25 mi (Figure 2). On the South Fork, the floodprone area of interest extends upstream from the confluence of the North and South forks to approximately 2.75 mi above the S.R. 218 bridge—a total distance of approximately 5.25 mi. In the immediate vicinity of Middleburg, only the S.R. 21 and S.R. 218 bridges cross tributaries to Black Creek; these bridges are ideal flood monitoring points.

Four flood alarm stations should be installed. Three sites are part of Robison's (1993) recommendation regarding the location of stream gauges (flood forecasting system). Instead of installing three stream gauges where USGS currently has recorders on the North and South forks, DPS could install the flood alarm equipment (Figure 11). Telephone lines would need to be available at these sites. If telephone lines are not available at these USGS sites, then DPS would have to find other sites in the vicinity or consider using cellular phones. DPS would have to get permission to install a flood alarm station on private property. The final alarm station should be located on the South Fork as close as possible to the area that is inhabited.

SYSTEM COSTS

Anticipated costs for a flood alarm system of four stations are categorized into basic costs, additional costs, and maintenance costs.

Basic Costs

The basic cost of a flood alarm system on Black Creek will cost an estimated $12,400 (Table 9). The actual cost may be much

Table 9. Estimated basic costs for the proposed flood alarm system in the Black Creek drainage basin

Site Label	Location	Tributary	Cost
A	North Fork*	North Fork	$ 3,100
B	S.R. 21	North Fork	3,100
C	Penney Farms	South Fork	3,100
D	S.R. 218	South Fork	3,100
Total			$12,400

* Actual costs may be higher or lower due to site-specific conditions. The exact location of this site has not been determined.

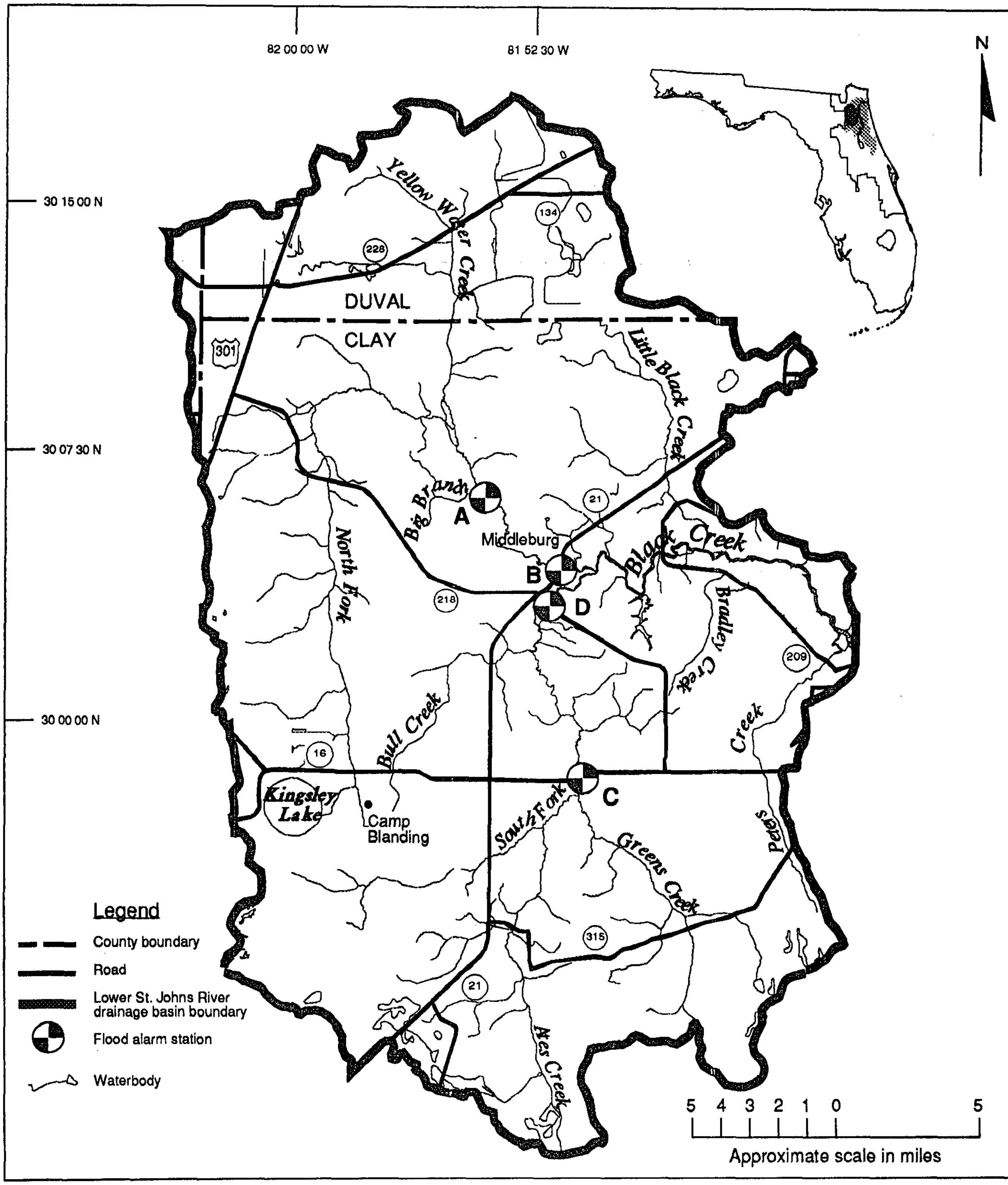

Figure 11. Proposed location of flood alarm stations in the Black Creek drainage basin

higher or lower, depending on site-specific installation costs related to items such as the length of the stilling well to be installed, the number of alarm points, the suitability of the platform, and the availability of telephone lines. A gauge upstream of the S.R. 21 bridge on the North Fork will be more expensive to install than at any of the other three stations because of installation of telephone lines.

Additional Costs

Additional costs associated with the proposed flood alarm system (four stations) include spare parts inventory and extra equipment. The cost of spare parts is at least $500; the cost of extra equipment is about $790 (Table 10).

Table 10. Additional costs associated with the proposed flood alarm system for the Black Creek drainage basin

Additional Items	Equipment	Quantity	Total Cost
Spare parts	Batteries	2	$160
	Battery charger	1	40
	Blank tapes	2	50
	NEMA box	1	150
	Corrugated metal pipe	1	100
Extra equipment	Telephone dialer	1	250
	Float switches	4	200
	Solar panels	2	100
	Staff gauges	6	240
Total			$1,290

Maintenance Costs

The estimated maintenance costs for a fully implemented flood alarm system in the Black Creek drainage basin are approximately $2,240 per year (Table 11). These costs include costs associated with annual replacement of batteries and monthly site visits, interspersed with more rigorous semiannual maintenance checks. Although a flood alarm system is simpler than a flood detection system, operation and maintenance still will be required for the lifetime of the system. For a flood warning system to work properly, DPS must maintain the flood alarm system. All too often, agencies do not regularly maintain flood alarm systems, and, just before a storm event, crews try frantically to get inoperable equipment working. In the Black Creek drainage basin, major storms occur about every 2 years. It is very important for DPS to invest about $2,240 each year to keep the system operational.

Table 11. Estimated annual maintenance costs of a proposed flood alarm system in the Black Creek drainage basin

Item	Quantity	Total Cost
Monthly site visits*	10	$1,600
Semiannual site visits*	2	320
Batteries	4	320
Total		$2,240

* Cost is based on one man-day at $20 per hour. The number of additional visits that may be needed will depend on the number of alarms received during any year.

DPS will have to make additional site visits when the float switches are tripped or after any flooding event. When DPS receives notification that an alarm has been triggered when it has not rained, DPS will need to check the site to make sure that it has not been tampered with or vandalized. The staff gauges always should be checked for blockages or other problems after any rise in water levels. Flood waters may block ports to stilling wells, deposit sediment in wells, or remove stilling wells.

SUMMARY

Equipment that is installed for a flood detection gauging network or a flood alarm system is just a portion of a total flood warning system. The emergency management component of the system should be implemented at the same time a flood detection gauging network or a flood alarm system (Figure 12) is implemented. DPS will need to work closely with NWS to have a successful flood warning system, which will take time to implement.

Choosing the actual locations for either gauges or alarms is very important and affects the estimated costs of upgrading the existing flood warning system. Locations for rain and stream gauges must be chosen so that VHF radio signals emanating from each ADCP reach either a repeater or the Clay County base station, if installed. In addition, rain gauges must be located in relatively open areas to record rainfall accurately. The location of a second flood alarm station on the North Fork upstream of the S.R. 21 bridge can affect greatly the overall costs of a flood alarm system. Specifics about each site will be an integral part of any quotation for installation. SJRWMD staff can assist Clay County in choosing the proper sites.

One of the following options (see Table 12) can be considered to begin implementation of a flood detection gauging network or a flood alarm system, thereby replacing the existing flood warning system for the Black Creek drainage basin. Implementation of Option 1, 2, 3, 4, or 5 will allow flood forecasting. Implementation of Option 6 will result only in a determination of when flood waters have reached any preset float switch at the flood alarm station.

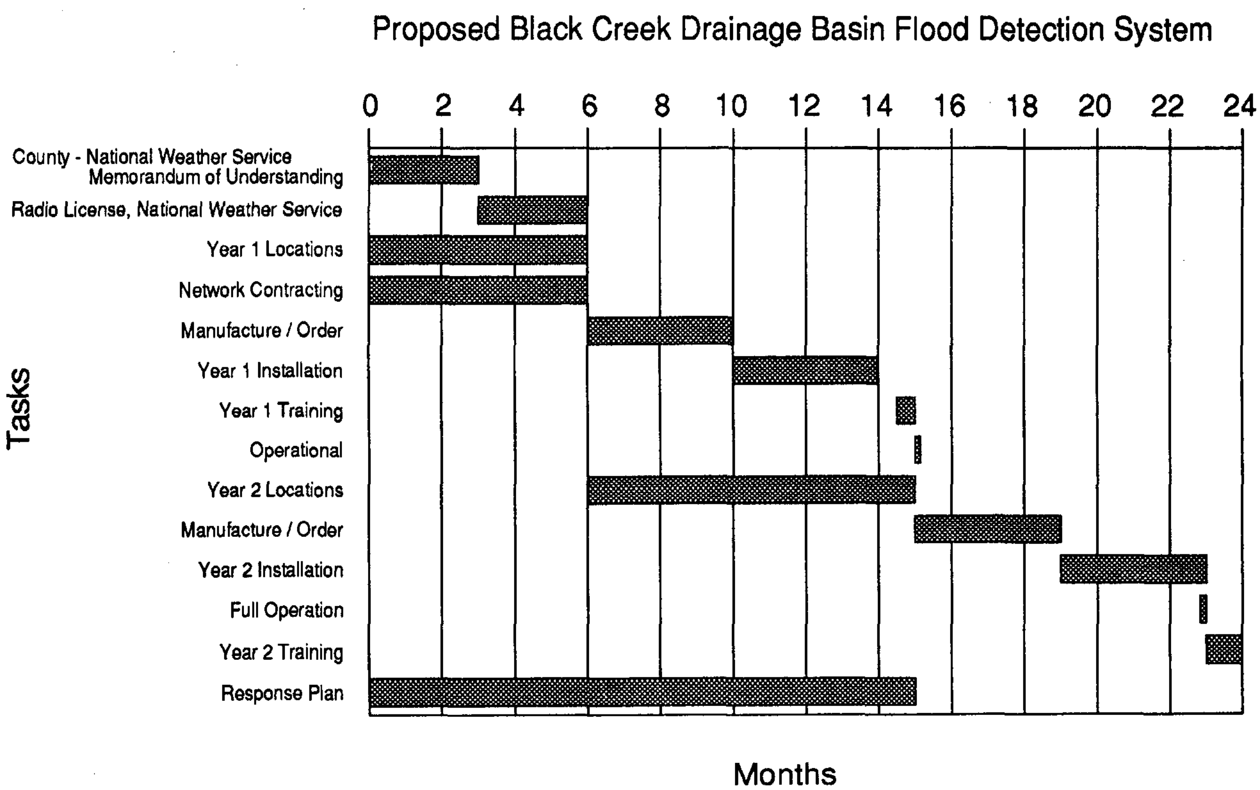

Figure 12. **Implementation schedule for a 15-gauge flood detection and forecasting system for the Black Creek drainage basin**

Table 12. Summary of options for a Black Creek flood detection gauging network or a flood alarm system

Option	Total Cost	Basic Costs	Contingency Costs (20%)	Additional Costs	Maintenance Costs	Years to Implement	Advantages	Disadvantages
1	$302,650	$188,550	$37,710	$28,790	$23,800 per year	2	Flood detection SJRWMD* as a backup site Alternative uses Able to share data automatically with NWS* and SJRWMD Possible integration with EMS* system	Highest cost Greatest complexity New personnel
2	281,650	173,550	34,710	25,790	23,800 per year	2	Flood detection Alternative uses Possible integration with EMS system Able to share data automatically with NWS and SJRWMD	High cost Complex New personnel
3	305,450	173,550	34,710	25,790	23,800 per year	3	Flood detection Alternative uses Possible integration with EMS system Able to share data easily with NWS and SJRWMD	High cost Complex New personnel

* SJRWMD is St. Johns River Water Management District; NWS is National Weather Service; EMS is Emergency Management System; USGS is U.S. Geological Survey; and AFOS is automation of field operations and services.

** Unable to accurately estimate site installation costs.

Table 12.— *Continued*

Option	Total Cost	Basic Costs	Contingency Costs (20%)	Additional Costs	Maintenance Costs	Years to Implement	Advantages	Disadvantages
4	95,589	56,520	11,304	17,665	10,100 per year	1	Flood detection Alternative uses Possible integration with EMS system Able to share data easily with NWS and SJRWMD Low cost	May need new personnel
5	36,000				36,000 per year	1	Flood detection USGS* maintenance AFOS* compatible No new personnel	High yearly maintenance cost if there are not federal matching funds
6	18,410**	12,400	2,480	1,290	2,240 per year	1	Low cost	Flood alarm only—not a flood detection system
							Simple	No alternative uses
							Possibly no new personnel	No integration with EMS system No data to share
								Cannot be upgraded to an automated data collection platform

* SJRWMD is St. Johns River Water Management District; NWS is National Weather Service; EMS is Emergency Management System; USGS is U.S. Geological Survey; and AFOS is automation of field operations and services.

** Unable to accurately estimate site installation costs.

Option 1 This option uses the radio telemetry system operated by SJRWMD. It is a 15-gauge network. DPS would increase the number of ADCPs and install additional repeaters and base stations. This option will take 2 years to implement. The estimated total cost for this option is $302,650.

Option 2 This option uses a radio telemetry system. This 15-gauge network would transmit on a radio frequency that is totally independent from SJRWMD. It would be capable of interfacing with SJRWMD via PC-base stations. DPS installs ADCPs, using less expensive and less versatile equipment (e.g., RTU-5096™ data logger). This option will take 2 years to implement. The estimated total cost for this option is $281,650.

Option 3 This option uses a radio telemetry system. This 15-gauge network would transmit on a radio frequency that is totally independent from SJRWMD. DPS installs ADCPs, using less expensive and less versatile equipment (e.g., RTU-5096™ data logger). This option will take 3 years to implement. The estimated total cost for this option is $305,450.

Option 4 This option uses the radio telemetry system operated by SJRWMD. It is an 8-gauge network. DPS would install six rain gauges and one repeater and use two USGS stream gauges. Data would be collected by the SJRWMD radio telemetry network and forwarded to NWS for determining the potential for flooding. This option will take 1 year to implement. The estimated total cost for this option is $95,589.

Option 5 This option uses the USGS GOES satellite system to send data to NWS through the NWS AFOS system. It requires that USGS install six telemetered rain gauges and continue to maintain the two existing telemetered stream gauges. It will take 1 year to implement; the cost of the system is approximately $36,000.

Option 6 This option uses telephone lines. It is a flood alarm system that does not provide DPS with the ability to forecast flooding events. This option will take 1 year to implement. The estimated total cost for this option is $18,410.

Choosing Option 1 requires the use of the same hardware and software used by SJRWMD. A network that is compatible between the two agencies provides backup capabilities in case of failure at one of the PC-base stations. Data could be easily shared by Clay County, SJRWMD, and NWS. Implementation could begin as soon as memorandums of understanding have been approved by all parties.

Choosing Option 2 allows for the flexibility to purchase less sophisticated equipment for ADCPs; software for the PC-base station must match that used by SJRWMD. Implementation would take between 3 and 12 months longer than for Option 1, because of the time needed to get a radio license. Data could be shared easily among Clay County, SJRWMD, and NWS.

Choosing Option 3 allows for the flexibility to purchase less sophisticated equipment for ADCPs; software for the PC-base station does not need to match that used by SJRWMD. The cost of this option is about the same as for Option 2; PC-base station software could be slightly less expensive. NWS would get the data it needed to work with Clay County in issuing flood warnings and advisories. SJRWMD could obtain any data from Clay County on floppy disks via ASCII files.

Choosing Option 4 allows for a flood detection system at a low cost. NWS would be able to get the data it needs to work with Clay County in issuing flood warnings and flood advisory statements. The existing telemetry system between SJRWMD and NWS would be utilized to get the data to NWS. In order for DPS to receive data in Green Cove Springs, a base station would need to be installed in Green Cove Springs. Alternatively, DPS could use an existing personal computer and modem to access the Palatka base station at SJRWMD. This option requires the purchase of REMDOS™ software. In order to expand the network, additional stations would have to be created in conjunction with SJRWMD.

Choosing Option 5 allows for a flood detection system at the lowest initial costs. NWS would be able to get the data it needs to work with Clay County in issuing flood warnings and flood advisory statements. In order for Clay County to access any of the data, it would need to have access to the USGS computer in Orlando or the SJRWMD telemetry base station in Palatka. However, the USGS rainfall data may not be available in the SJRWMD base station computer due to a format incompatability between USGS and SJRWMD.

Choosing Option 6 does not provide Clay County with the ability to forecast floods. Clay County will be able to choose the stream stage levels that trigger the flood alarm. Clay County will choose the location of the four alarm stations on the North and South forks of Black Creek. A flood alarm system relies on the telephone system rather than on VHF radios.

A gannt chart indicating an implementation schedule for a proposed Black Creek flood detection system was developed for Option 1 or 2 (Figure 12). The time estimated to install the first phase is 15 months for Option 1 or 2. If the second phase is started upon completion of the first phase, the full network should be finished in another 9 months. Option 3 might take 3 years to complete.

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APPENDIX—SAMPLE NATIONAL WEATHER SERVICE MEMORANDUM OF UNDERSTANDING

Source: Gimmestad and Barrett 1986 (modified)

SAMPLE

MEMORANDUM OF UNDERSTANDING FOR COMMUNITY-SPONSORED AUTOMATED FLOOD WARNING SYSTEM

This Memorandum of Understanding between the National Oceanic and Atmospheric Administration (NOAA), National Weather Service (NWS) and the county of Clay is undertaken for the purpose of defining a mutual assistance program designed to develop an Automated Flood Warning System for the county of Clay.

I. Authority

NWS undertakes this Memorandum of Understanding pursuant to its authority in 15 U.S.C. 313, 15 U.S.C. 1525, and 7 U.S.C. 450b, in order to carry out its functions relating to flood warnings.

II. Nature of Agreement

The Flood Warning System is being implemented in high-risk flash flood areas. The system utilizes state-of-the-art techniques that can be incorporated into an operational flood warning program. The overall concept calls for federal, state, county, and municipal cooperation.

NWS and the county of Clay will cooperate to accomplish the installation and operation of an Automated Flood Warning System to help provide advance flood warning for the county of Clay.

III. Responsibilities of NWS

NWS shall:

1. Assist county of Clay and state of Florida officials to identify the need for specific equipment for the warning system.

2. Provide standards for automated local flood warning systems in cooperation with other agencies, as necessary.

3. Assist community officials in the site selection of hydrologic gauges and consult with federal, state, local, or private vendors on the calibration of hydrological models.

4. Provide training for county flood coordinators and municipal officials. The scope of the training shall cover:

    a. NWS Flood/Flash Flood Watch/Warning Program

b. Municipal Flood Warning Programs

c. Operation and maintenance procedures for communications and hydrologic instrumentation

d. The need for emergency response planning

e. Periodic drills to test the program

5. Issue, according to the severity of the hydrometeorological threat, flash flood watch, flash flood warnings, or Local Statements.

6. In conjunction with the Federal Emergency Management Agency, assure that the activities of the Automated Flood Warning System are coordinated with designated municipal, county, state, and federal disaster officials.

7. Be responsible for obtaining Federal Communications Commission approval of the necessary radio frequencies.

8. Assist in the site location of the field equipment and train the personnel in its operation.

9. Provide forecast advisory service for the selected river basins.

10. Provide system monitoring and consult with the community concerning forecast model recalibration needs, as required.

IV. Responsibilities of the county of Clay

The county shall:

1. Pay for the initial capital cost of flood warning equipment and all installation costs, with the exception of river staff gauges and manual rain gauges, and pay for the capital cost of major equipment replacement or upgrading for the continued operation of the flood warning system.

   The funding by the county of the operational and capital costs is conditional on the availability of appropriated funds within the county budget.

   Flood warning equipment may include any combination or all of the following:

   a. Telemetered receiver, printers, and minicomputer systems

   b. Telemetered rain gauges

   c. Radio repeaters for radio-telemetry

d. Flash flood alarms

e. Telemetered river gauges

f. Software installation and model calibration

2. Operate, maintain, and assume recurring costs for those portions of the program of the flood warning system which include:

   a. County operations center, including utilities and physical space

   b. Equipment used to support the county program, including telemetered river and rain gauges, flash flood alarms, mini-computer systems, radio equipment, data receivers, repeater system, staff gauges, and plastic rain gauges

   c. Communications and utility costs to support the county activities

3. Designate a County Flood Warning Coordinator by title to be trained in and be responsible for the operation of a county preparedness plan.

4. Prepare a county preparedness plan to detail the necessary responsible actions to be taken, including coordination with NWS whenever river and rainfall data indicate a possible need for statements and/or warnings. The plan will recognize that all flood warnings, including flash flood warnings, are to be initiated by NWS except when, in the judgment of the County Flood Warning Coordinator, an emergency situation exists and time does not permit consultation with NWS. At such times, the coordinator may issue a warning to the public and local officials prior to informing NWS.

5. Establish a county communication and action center to operate continually or as required for the purpose of:

   a. Operating the automated data receiver and mini-computer communication center, where applicable

   b. Receiving and recording all reports of rainfall and flood conditions

   c. Promptly relaying or making available all such reports to the designated Municipal Flood Warning Coordinator

   d. Serving as the official distribution point for all warnings and statements issued by or for the designated County Flood Warning Coordinator

   e. Ensuring, in addition to general public distribution, that flood warnings or statements reach warning action points as listed in the county preparedness plan

f. Relaying river and rainfall reports, flood data, and warnings to the NWS office in ______________ as soon as practicable after local requirements have been satisfied

V. Title to Equipment

Title to equipment purchased under this Memorandum of Understanding shall remain vested with the county of Clay.

VI. Amendments or Modifications

This Memorandum of Understanding may be amended or modified by mutual agreement of NWS and the county of Clay.

VII. Termination

This Memorandum of Understanding may be terminated by either party upon sixty (60) days written notice to the other party, notice to begin with date of mailing. Upon termination, all equipment listed by NWS as accountable shall be returned within sixty (60) days to NWS in the condition it was at the time of termination.

VIII. Effective Date

This Memorandum of Understanding is effective as of the last date shown below upon execution by both parties hereto.

Clay County

By: ____________________

Title: ____________________

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Approved by:
National Weather Service Director,

____________________ Region Headquarters

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Signature

United States Department of Commerce
National Oceanic & Atmospheric Administration
National Weather Service

Prepared by:

____
Weather Service Forecast Office
Address: ____________________
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Meteorologist in Charge