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Multi-Government Management of Floodplains in Small Watersheds

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FEDERAL EMERGENCY MANAGEMENT AGENCY

MULTI-GOVERNMENTAL MANAGEMENT OF FLOODPLAINS: COOPERATION AMONG PUBLIC AUTHORITIES IN SMALL WATERSHEDS

Federal Emergency Management Agency
Office of Training and Education

In 1978, a team of researchers under the direction of Dr. Rutherford Platt of the University of Massachusetts conducted a national study to assess the extent of fragmentation of floodplain management authority along small- to medium-sized streams and to identify means for achieving better intergovernmental coordination. That study was sponsored by the U.S. Army Corps of Engineers' Office of Floodplain Management Services, and it was published in 1980 under the title *Intergovernmental Management of Floodplains* by the Institute of Behavioral Science, University of Colorado at Boulder. The present document is a condensed version of the earlier study and has been prepared under contract with the Federal Emergency Management Agency (Training and Education) for use in short courses and training sessions on natural hazard mitigation. Case studies were originally prepared by Mary Read English, Michael Grahek, George M. McMullen, Richard Paton, and Ann Patton. Ms. English provided re-write and editorial assistance. Graphics were prepared by William Nechamen, Barbara Rosander, and Katherine Price. The manuscript was typed by Judith Stark.

This report is limited to consideration of floods, primarily in the context of small urbanizing watersheds. Large rivers and coastal areas are not considered here, due to their different physical and political circumstances. The various floodplain management arrangements described here, however, may well be generally applicable in other situations involving the need for cooperation and consistency among governmental units which confront a common peril.

Contract Number EMW-0-2909

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PART I: FLOODS AND FLOODPLAIN MANAGEMENT

Introduction

Flood losses in the United States average more than $3.5 billion per year according to the U.S. Water Resources Council. Much of this damage is occurring along small to medium-sized streams, particularly in urbanizing metropolitan areas such as Houston, Tulsa, Chicago, St. Paul/Minneapolis, Washington, D.C., Phoenix, and so on. These smaller streams typically have few or no federal flood control works such as dams, reservoirs, and large-scale channelizing. Instead, their flood management is in the hands of countless decision-makers—private owners, public authorities, and various levels of government—who independently "control" a small segment of the total watershed and floodplain of the stream in question. Each of these decision-makers, acting alone, attempts to maximize benefits to itself from development and use of its floodplains. At the same time, each may try to avoid the penalty of flooding through improvised filling, flood walls, and other means—which, however, often result in increased flood problems for neighboring areas. In summary, small stream management is a crazy quilt of conflicting policies, haphazard attempts to deflect floodwaters, and ultimately an overall increase in flooding and flood losses.

In 1978, a team of researchers under the direction of Dr. Rutherford Platt of the University of Massachusetts conducted a national study to assess the extent of this fragmentation of floodplain management authority and to identify means for achieving better intergovernmental coordination. That study was sponsored by the U.S. Army Corps of Engineers' Office of Floodplain Management Services, and it was published in 1980 under the title *Intergovernmental Management of Floodplains* by the Institute of Behavioral Science, University of Colorado at Boulder. The present document is a condensed version of the earlier study and has been prepared under contract with the Federal Emergency Management Agency (Training and Education) for use in short courses and training sessions on natural hazard mitigation. Case studies were originally prepared by Mary Read English, Michael Grahek, George M. McMullen, Richard Paton, and Ann Patton. Ms. English provided re-write and editorial assistance. Graphics were prepared by William Nechamen, Barbara Rosander, and Katherine Price. The manuscript was typed by Judith Stark.

This report is limited to consideration of floods, primarily in the context of small urbanizing watersheds. Large rivers and coastal areas are not considered here, due to their different physical and political circumstances. The various floodplain management arrangements described here, however, may well be generally applicable in other situations involving the need for cooperation and consistency among governmental units which confront a common peril.

I. THE FLOOD PROBLEM IN THE UNITED STATES

Public knowledge of floods—their causes and effects—is minimal. Some people believe that the problem was solved long ago by the Army Corps of Engineers or other federal agencies. Others believe that a "100-year flood" can only happen once every hundred years. Residents of coastal barrier islands sometimes view tropical hurricanes as occasions for parties. Few people realize urbanization in the upstream portions of a small watershed can increase the depth, extent, and rapidity of flooding of downstream areas—that property never before known to flood may be inundated due to changes in upstream land use patterns.

This short document cannot supply detailed treatment of all these topics. However, as an introduction for readers with no prior knowledge of floods, the report's first section will briefly review a flood's *geographical* aspects. We will then consider in more detail its *governmental* aspects: how floodplain management by multiple governments can work in theory and in practice.

A. Floods as a Natural Process

It is often observed that floods are natural but flood losses are man-made. This perhaps oversimplifies the situation, since human actions may greatly influence natural flooding, and natural flood "losses" may occur in the form of erosion and other physical damage. But the distinction does indicate the importance of understanding the natural process of flooding before considering how to deal with its consequences.

Flooding may be defined as the occasional overflow of surface water onto adjoining land. It is estimated that about seven percent of the continental land area of the United States is subject to occasional flooding. Floods arise from a variety of causes.

- *Coastal flooding:* In coastal areas, flooding is caused by tropical storms and hurricanes along the Atlantic and Gulf coasts and by earthquakes and tsunamis on the Pacific coast. Coastal flooding usually takes the form of an abnormally high tide known as a "storm surge," accompanied by heavy wave action in areas exposed to the open sea.

- *Flooding of rivers and streams:* Inland flooding chiefly occurs along rivers and streams ("riverine flooding"), due to rapid snowmelt, severe thunderstorms, or prolonged rainfall.

- *Lake flooding:* Flooding along lakes can arise from sudden changes in atmospheric pressure ("seiches"), although along the Great Lakes floods are of less concern than shore erosion. But seiches can be a problem: for example, Lake Okeechobee in Florida in 1928 experienced a serious flood induced by seiche.

This report will be largely concerned with riverine floods.

1. The Hydrologic Cycle

Flooding is one aspect of the "hydrologic cycle." A brief review of this cycle is therefore a good starting point (Fig. 1). Precipitation falling as rain or snow on land surfaces must go somewhere. Much of it is returned to the atmosphere through evaporation from exposed surfaces and as transpiration from trees and other plants. Some of the precipitation is absorbed by the land itself by percolation through the soil. Such groundwater may be stored for considerable lengths of time in geologic formations called "aquifers." Groundwater gradually moves through its aquifer until it eventually reaches the surface through a spring or other outlet. Still other precipitation may be stored on the surface for varying lengths of time in the form of ice and snow; much of the world's fresh water supply is frozen in the polar ice caps.

All other precipitation—which is not evaporated, absorbed into the ground, or frozen—begins its descent from wherever it fell towards sea level in the form of surface runoff. At first, this runoff moves in minute quantities by overland "sheet flow." As gathering quantities of runoff accumulate, more defined pathways are created in the form of rills, gullies, and rivulets. These in turn combine to form brooks, streams, and finally rivers whose destination is the ocean. The hydrologic cycle is completed as moisture returns to the atmosphere from the oceans of the world.

2. What Is a Watershed?

For floods to be understood, watersheds (also known as drainage basins) must be understood also (Fig. 2). It was stated above that water flowing across land becomes concentrated in defined channels. This is the result of the influence of gravity: water always flows downhill. Thus, the route of surface runoff from rain to ocean follows a generally predictable watercourse, and all land areas contributing their runoff constitute the watershed of that watercourse. The amount of water in the watercourse in turn is directly dependent upon the amount of runoff contributed by its watershed (including groundwater which reaches the surface).

All land thus falls within some watershed (although surface runoff may occur only occasionally during dry times). Watersheds adjoin each other along hydrologic "divides"—namely, the contours

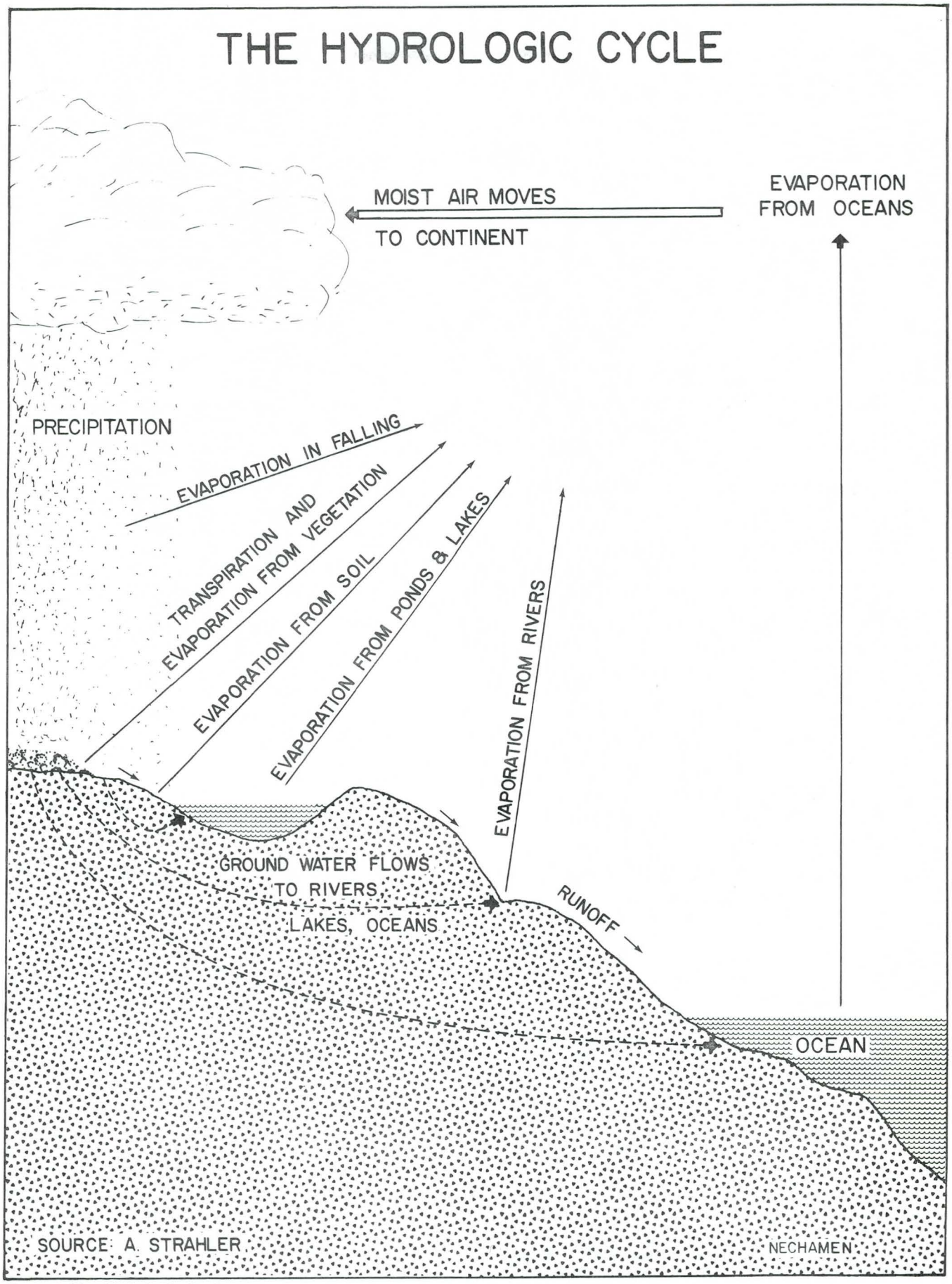


Figure 1. The Hydrologic Cycle

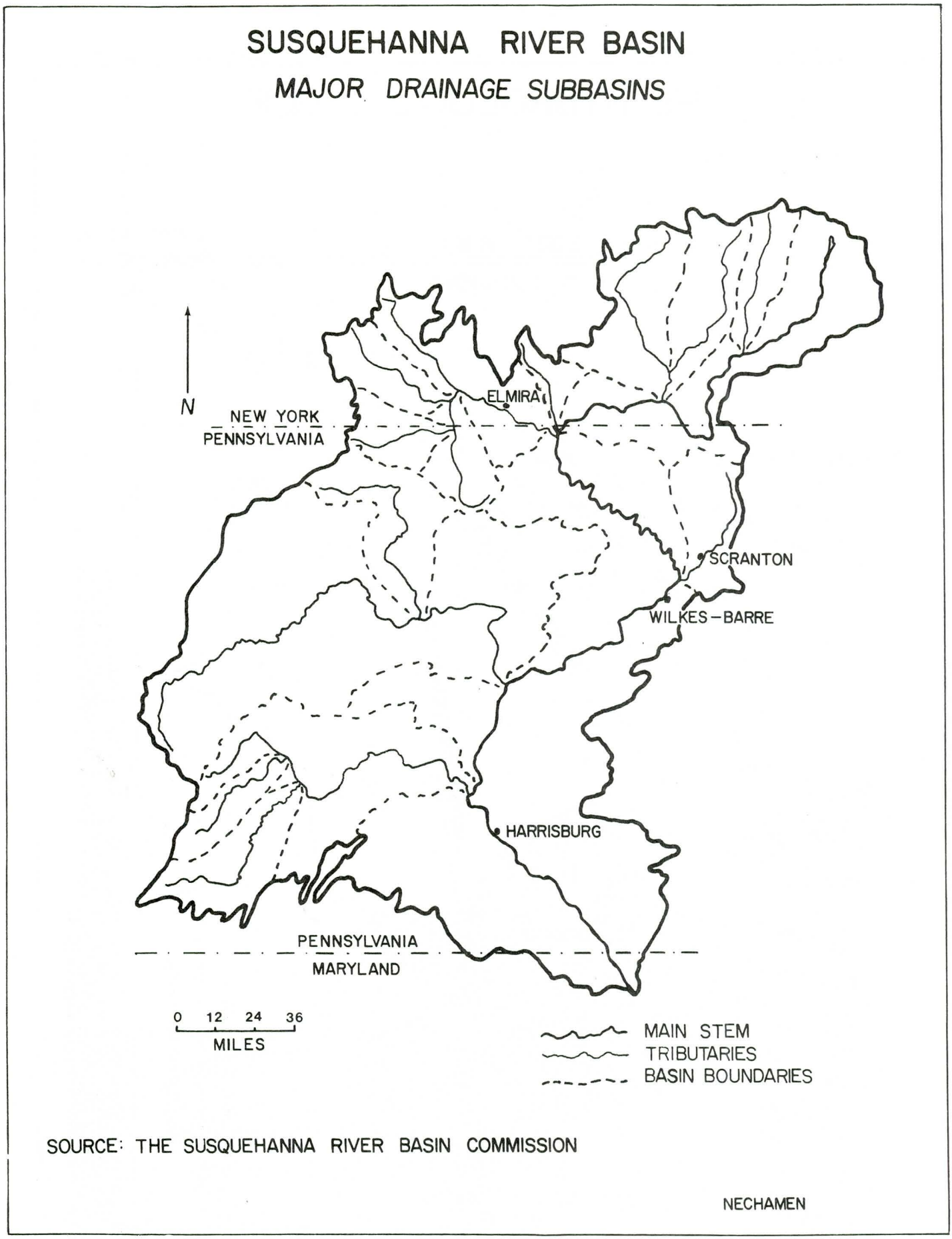


Figure 2. Watersheds and Divides in the Susquehanna River Basin

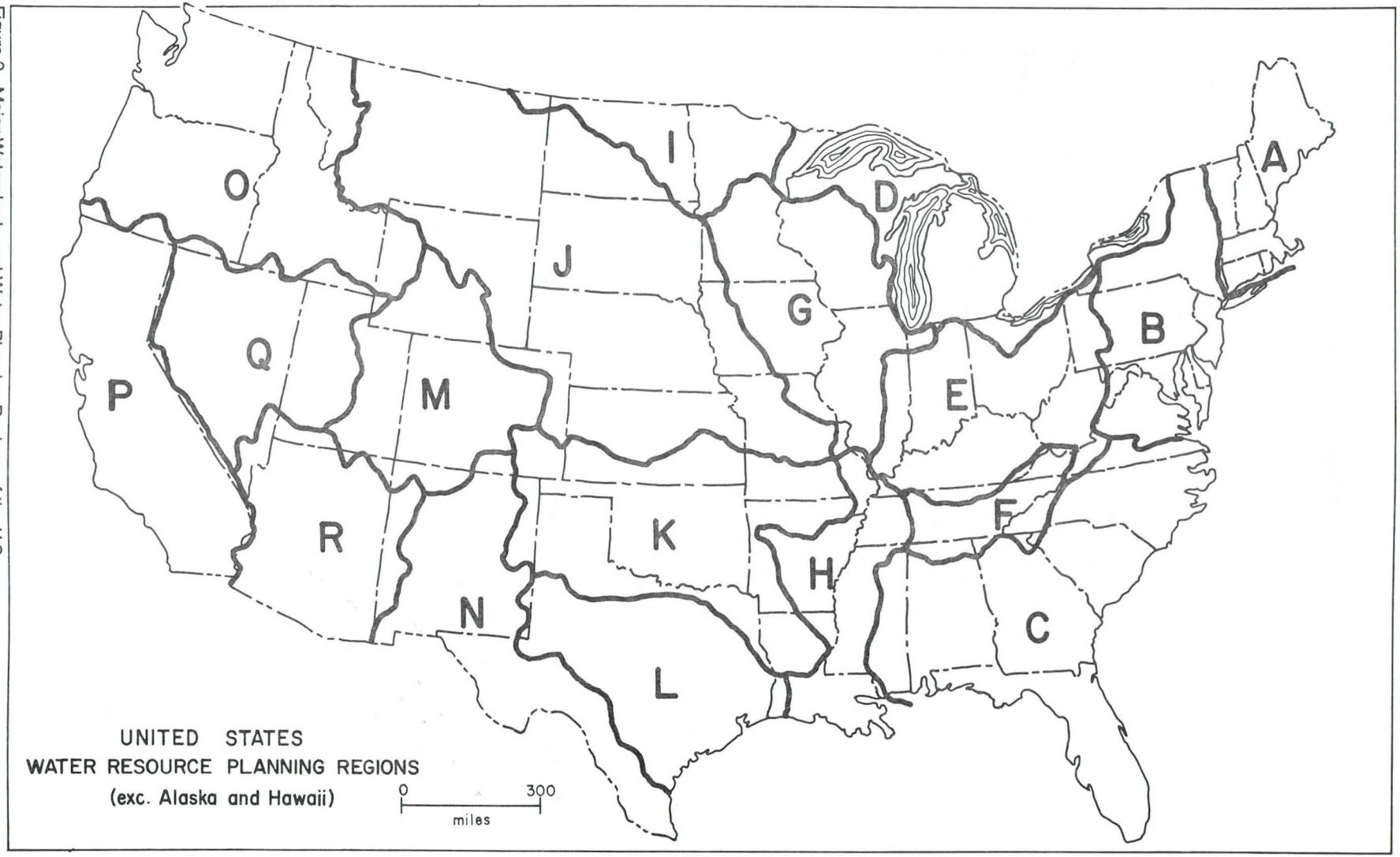


Figure 3. Major Watersheds and Water Planning Regions of the U.S.

A-New England; B-Mid-Atlantic; C-Southeast Basins; D-Great Lakes; E-Ohio; F-Tennessee Valley; G-Upper Mississippi; H-Lower Mississippi; I-Souris-Red-Rainy; J-Missouri; K-Arkansas-White-Red; L-Texas-Gulf; M-Upper Colorado; N-Rio Grande; O-Pacific Northwest; P-California; Q-Great Basin (Title II River Basin Commissions emphasized.)

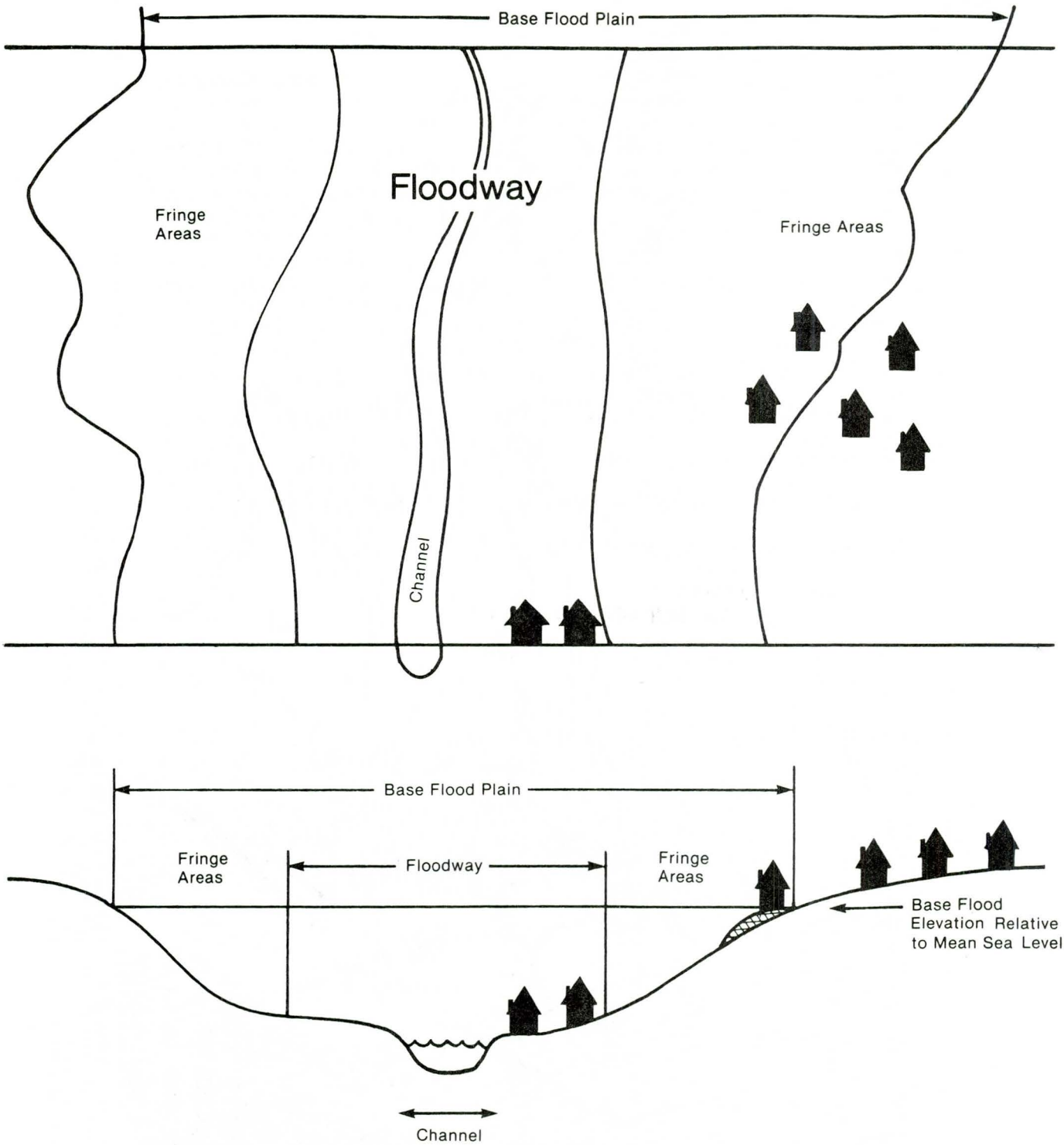


Figure 4. Overview and Cross-Section of Typical Floodway and Floodway Fringe.

of highest elevation which enclose the area drained by each watercourse. Watersheds of major rivers like the Connecticut or the Ohio are the sum of the subwatersheds of tributary streams such as the Deerfield or the Allegheny. These in turn encompass still smaller watersheds of *their* tributaries. The entire land area of the U.S. therefore may be viewed as a complex jigsaw puzzle in which each "piece" represents a watershed which may in turn be divided into smaller "pieces," and so on. A map of watersheds bears little resemblance to a map of political jurisdictions (Fig. 3).

Watersheds play a key role in the natural process of flooding. The physical capacity of a stream channel in terms of width and depth is directly related to the average or normal flow of surface runoff reaching the stream from its watershed. But runoff in any watershed in fact varies greatly according to changes in precipitation, temperature, and other factors. At times of little runoff, the stream channel can easily handle resulting flows. But when runoff increases above normal levels due to heavy rains or sudden snowmelt, the channel becomes inadequate. The action of moving water may scour the bottom and sides of the channel and increase its capacity somewhat, but when streamflow is much greater than normal, overbank flooding results.

3. What Is a Floodplain?

In a geological time scale, floods are routine. They happen with various magnitudes at irregular time intervals. Over time, the cumulative effects of flooding gradually create a "floodplain"—a natural overflow area adjoining each stream channel. Floodplains are as much a part of the hydrologic system as the channel iteself. Together, the channel and the floodplain make up the drainage pathway for each watershed (Fig. 4).

Floodplains vary greatly in width, depending upon the size of the watershed and its runoff characteristics, the erosion potential of the land next to the stream channel, and the geologic age of the valley in which the stream is located. In narrow mountain valleys or canyons, floodplains may be small or virtually nonexistent where the stream flows between rock walls. In more level or erodible terrain, streams characteristically lay out broader floodplains—sometimes several miles wide in the case of major rivers.

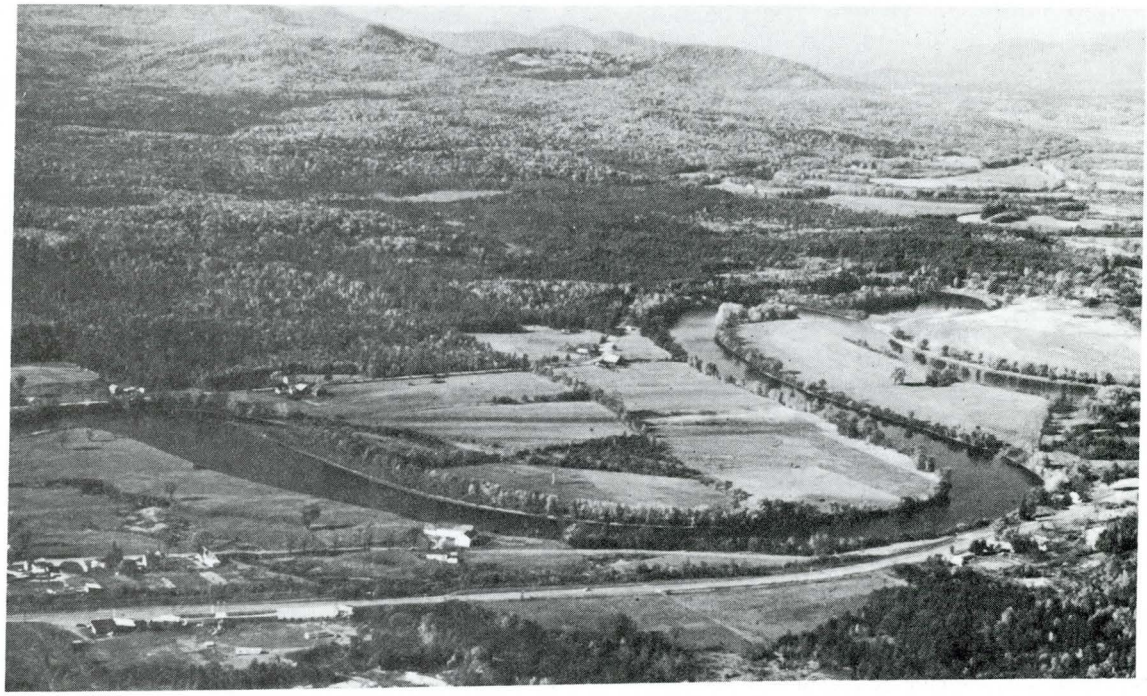


Figure 5. One Floodplain Shared by Two States: The Connecticut River Serves as the Boundary Between Vermont and New Hampshire. (Photo: Sandra Hauptman)

Figure 6. Big Thompson Creek, Colorado, May, 1977 - Nine Months After Flash Flood that Took 139 Lives. (Photo: R. Platt).

Stream channels seldom follow the centerline of a floodplain. Even in constricted mountain valleys, the channel veers from side to side, leaving a floodplain first on one side and then on the other. In broader floodplains, rivers meander, developing loops which wander back and forth like an undulating snake (Fig. 5). This is the result of energy being exerted at times of high flow, scouring and eroding material on the outer side of each curve where the current moves faster, while simultaneously, sediment is being deposited on the inner side where the current is slower. Over time, this action causes the stream channel to shift drastically within the overall floodplain, which remains relatively static. This shifting of the channel plays havoc with property boundaries and political jurisdictions which are drawn with reference to its centerline. Furthermore, the common use of stream channel centerlines as political boundaries leads to the split of floodplain authority on opposite sides of the stream channel, which raises problems we will consider later.

4. Kinds of Floods

As noted above, floods are broadly classified as coastal or riverine, with coastal flooding normally being caused by an exceptionally high tide known as a storm surge, and riverine flooding being caused by excess surface drainage within a particular watershed. Flooding in coastal estuaries, at the mouths of rivers, may involve both coastal and riverine flooding.

Both coastal and riverine floods are classified in terms of magnitude according to their estimated periods of return. Thus, floods are referred to as "annual," "10-year," "50-year," "100-year," and so forth, according to how often a flood of a particular magnitude may be expected to recur—the greater the flood, the longer the recurrence interval. This of course does not mean that a "100-year" flood will not recur for a century. In any year there is a probability of one percent that a flood of that magnitude will happen. Some floodplain managers prefer the term "one percent flood" to

avoid public misconception. Houston, Texas in fact experienced one percent floods three times during 1979! Flood frequency determination is based on conditions as they exist at the time an engineer preforms an analysis. Increasing urbanization, channel modifications and similar changes will change flood frequencies and magnitudes. Thus, last year's "two percent" flood can be this year's "one percent" flood.

With riverine floods, another criterion is used as well: they are also classified according to the rapidity of their onset, known as "flashiness." Larger rivers flowing through valleys of gradual slope experience slow flooding. Residents of the lower Mississippi River Valley for instance, can receive warning several days in advance of an approaching flood crest and thereby can take necessary precautions. By contrast, narrow mountain canyons or valleys—of the Rockies or the Appalachians, for example—experience "flash floods" which crest within hours after a heavy rainfall (Fig. 6). These result from precipitation falling on rocky areas producing a high proportion of surface runoff, and also from the steep gradient of mountain streams. Flash floods also happen in arid regions where normally dry gullies become raging torrents within minutes due to thunderstorms, often a considerable distance away.

B. Uses of Floodplains

Floodplains are attractive for a variety of human uses—some compatible with flooding, others not. Historically, the most important human use of floodplains has been agriculture. Floodplains are inherently fertile due to the deposition of silt and nutrients by floodwaters. This fertility allowed the floodplains of the Nile and the Tigris and Euphrates Rivers to serve as "cradles of civilization." Similar roles have been played by the Yangtze in China, the Volga in the Soviet Union, and the Mississippi in the United States. Flooding in such areas was essential for agriculture because it renewed soil fertility. Although crops were sometimes destroyed by floods, the choice of grain and the timing of planting were adjusted to minimize this hazard. Traditional agriculture was in close harmony with the natural flooding process.

Figure 7. West Springfield, Massachusetts During Connecticut River Flood of March, 1936. (Photo: U.S. Army, Corps of Engineers).

A more troublesome use of floodplains has been human habitation. People farming on floodplains must live near their source of livelihood. This means that if no higher ground is available, people must dwell in the floodplain. Homes are often elevated on stilts to protect against moderate flooding, but occasional catastrophic floods continue to inflict great loss of life and property in heavily populated floodplains, especially in the monsoon regions of Northern India, China, and Southeast Asia.

The United States now has an estimated 6.4 million dwelling units in coastal and riverine flood hazard areas (Fig. 7). These are mostly unrelated to any productive use of the floodplain but have been so located out of ignorance or unconcern about the flood hazard or because flood-prone sites may be relatively cheap. Loss of life is relatively rare in U.S. floods today due to improved warning and evacuation systems as compared with a few decades ago. But disruption of communities, loss of personal property, and psychological harm are widespread results of flooding in residential neighborhoods.

Industry is another frequent occupant of floodplains. Industrial development of sites adjoining water was promoted during the 19th century by the doctrine of "riparian rights" which grants special privileges to owners of land adjoining a stream, lake, or coastline. Riparian ownership involves a right of access to water for navigation, including the right to build docks and wharves. Riparian owners may withdraw water for manufacturing or other needs, may impound water to yield energy, or may (subject to recent water pollution laws) dispose of wastes cheaply through outfalls to the common water body. The northeastern region of the U.S. is still characterized today by old mill towns with factories along with homes and businesses concentrated in low-lying areas next to streams and rivers. Many communities like Wilkes-Barre, Pennsylvania, have been repeatedly damaged by floods but continue to rebuild. In a few cases like Winsted, Connecticut, or Rapid City, South Dakota, damaged structures have been removed and their sites returned to the river as open floodplain.

Electrification freed industry from dependence upon mechanical water power, but many other factors have combined to encourage continued industrial and related development in floodplains. Access to navigation and shipping facilities is an important need. Floodplains have always been regarded as convenient and level routes for railroads and highways and as sites for airports. These in turn have promoted economic development of adjacent land which, as in the case of Jackson, Mississippi, sometimes proves to be highly vulnerable to flooding (See Case Study 1 below). Many communities have deliberately used their redevelopment and zoning powers to encourage growth on remaining open floodplains, viewing them as vacant land ripe for new construction and thereby adding to their local tax base (and often to the flood problems of their neighbors).

Federal investment in highways, sewers, waterlines, shore stabilization works, and flood control measures have indirectly promoted further development on floodplains throughout the U.S. Executive Order 11988 issued by President Carter on May 24, 1977, requires federal agencies to "avoid direct or indirect support of floodplain development wherever there is a practicable alternative." Some progress has been made towards incorporating flood considerations into agency decision-making.

C. Costs of Floods

Human use of floodplains for the various purposes listed above usually entails interference with natural conditions. The water itself may be diverted, impounded, and altered in chemistry, appearance, smell, and temperature. Land next to water becomes valuable for the location of human activities associated with riverine resources: agriculture, wharves and warehouses, power generating plants, recreation facilities, sewage treatment plants, etc. According to a study of 26 U.S. cities by the U.S. Geological Survey in 1974, the average proportion of their floodplain areas devoted to their development was 52%.

The inevitable result of human encroachment has been frequent and mounting flood losses. During the 19th century, flood disasters in the U.S. were confined to relatively limited areas and unusual circumstances. Failure of an earthen dam during a heavy thunder-

storm in 1889 caused 2,200 deaths in the last century's most famous flood at Johnstown, Pennsylvania. Spreading urban development in the early 20th century set the stage for a series of widespread flood disasters in 1927, 1936, and 1938. The Great Hurricane of 1938 killed 558 persons and caused 500 million dollars in property losses within New England. Subsequent major floods have occurred in the Northeast in 1954 (Carol, Edna) and 1955 (Diane); in the mid-Atlantic states in 1972 (Agnes) and 1975 (Eloise); along the Gulf coast of Mississippi and Louisiana in 1969 (Camille) and 1979 (Frederick). Localized floods of spectacular magnitude have occurred in Rapid City, South Dakota (1972), Big Thompson Canyon, Colorado (1976), Johnstown, Pennsylvania (1977), the Massachusetts coast (1978), and the Pearl River in Mississippi (1979).

While fatalities have been reduced or prevented entirely in more recent floods due to improved warning and evacuation procedures, levels of property damage and community disruption have been rising sharply. Jackson, Mississippi, for instance, in 1961 experienced a major flood which displaced 3,000 people and inflicted about 33 million dollars in property damage. In 1979, despite completion of a Corps of Engineers flood control project at Jackson, the city experienced displacement of 17,000 people and an estimated 500 million dollars in property damage from a similar, somewhat larger flood. Most of the structures affected in 1979 were built in floodplains subsequent to the 1961 flood. Jackson is typical of urbanizing floodplains throughout the United States, where, increasingly, property is being developed despite the flood risk. Often such development occurs in the wake of a federal flood control project which creates the illusion that such locations are forever safe from flooding.

Overall, the U.S. Water Resources Council has estimated average annual costs of floods to be on the order of $3.8 billion which was about what occurred in 1979. Estimates of national flood losses are, of course, inadequate as measures of the true cost of flooding upon the nation. They do not include any value for lives lost or bodily injury to victims. Nor do they account for such tangible but nonquantifiable losses as pain and suffering, mental anguish, loss of cherished possessions, pets, and so forth.

Floods also generate the need for massive federal outlays to assist victims and communities to recover (Fig. 8). Federal disaster assistance is normally tied to declaration of a "major disaster" by the President. In 1978, floods in 17 states accounted for 20 presidential disaster declarations. Between January 1 and October 1, 1979, 30 flood disasters were declared by the President, involving 18 states, 369 counties, and 2 territories. The dollar cost of federal response to these disasters has been high. Between 1972 and 1979, 2.2 billion dollars were spent by the Federal Emergency Management Agency and its predecessors in the disaster field, the Office of Emergency Preparedness and the Federal Disaster Assistance Administration, in the form of grants and loans to communities and individuals afflicted by floods. In 1978 and 1979 alone, outlays from the presidential disaster fund amounted to 243 million dollars and 445 million dollars, respectively. The U.S. Small Business Administration (SBA) extends low-interest loans to disaster victims. The dollar total of such loans over the period 1972-1979 was 6.7 billion dollars. (These loans are expected to be repaid; the federal subsidy is the difference between the market rate of interest and the rate charged by the SBA, plus any loans in which default occurs.)

The National Flood Insurance Program (NFIP) is an additional, increasingly important source of federal assistance to flood victims. NFIP provides flood insurance at federally subsidized rates to owners of existing flood-prone structures in participating communities. In order to participate, a community must adopt floodplain management ordinances consistent with regulations, studies and maps provided by the Federal Emergency Management Agency (FEMA). By the end of 1979, more than 16,000 communities were participating in NFIP, and over 1.7 million policies were in effect covering 70 billion dollars in flood-prone property. Payments between the creation of the NFIP in 1968 and February 1980 exceeded 890 million dollars, of which 482 million dollars related to floods in 1979 alone (Fig. 9).

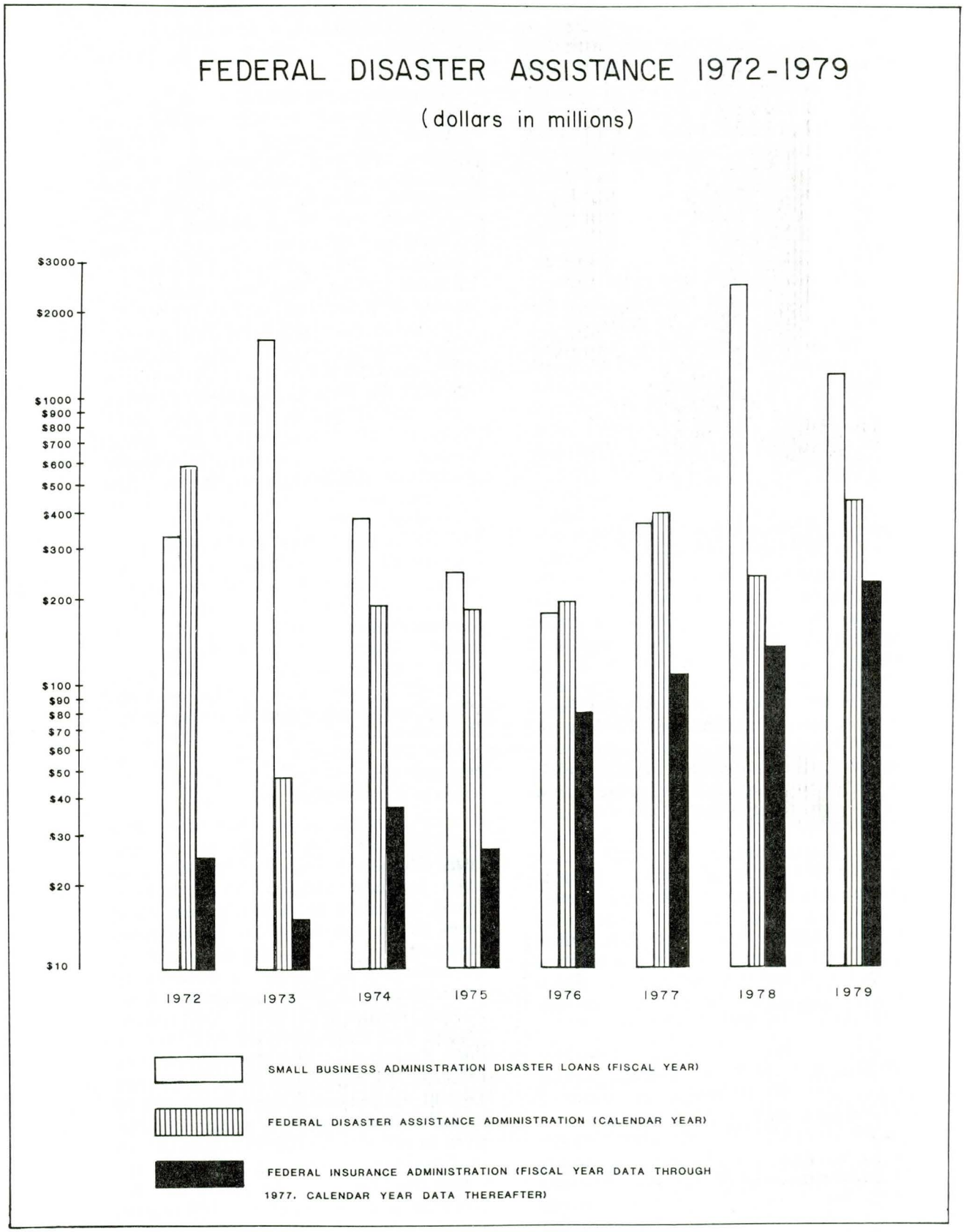


Figure 8. Federal Disaster Assistance 1972-1979. (Scale is Logarithmic).

Figure 9. Although 17,000 Communities Participate in the National Flood Insurance Program, There are Some Foot-Draggers. (Photo by R. Platt).

Figure 10. A Major Objective of Floodplain Management is to Warn the Uninformed Investor of Potential Hazards. (Photo: R. Platt).

Flood insurance *must* be purchased whenever a federal or federally-related institution extends a loan for the purchase or construction of structures in FEMA-designated special flood hazard areas within a participating community. The vast increase in coverage due to this requirement portends massive outlays during the 1980's under the NFIP. However, the quid pro quo for flood insurance availability in a community is the community's adoption and enforcement of the above-mentioned floodplain management ordinances, designed to mitigate flood damage and provide for prudent use of the floodplain.

In short, flood losses are rising drastically in the United States despite a long history of efforts to control floods through engineering structures. Flood losses are distributed widely throughout the nation. Many of these losses are in small watersheds or coastal areas which have experienced development only recently. Federal taxpayers are faced with ever-increasing outlays through grants and loans to flood victims and flood insurance subsidies to property owners in flood-prone areas. More effective efforts to deter additional floodplain development are urgently needed.

II. MULTI-GOVERNMENT MANAGEMENT OF FLOODPLAINS

A. Goals of Floodplain Management

Clearly, the primary goal of floodplain management is to *reduce the hazard of floods to life and property* (Fig. 10). This entails at least three factors: (1) avoiding unwise additional development on floodplains; (2) eliminating or relocating existing floodplain development where economically feasible; and (3) avoiding hydraulic changes in the watershed that will increase water flow at times of flooding. Achievement of the first two factors within a particular community may be undermined or nullified by failure to achieve the third—by failure to prevent increased flood flows elsewhere in the watershed due to adverse policies and actions.

Second, floodplain management should strive for *the beneficial use of floodplains.* Floodplains do not always need to be abandoned entirely. Agriculture, recreation, and low-intensity uses such as parking lots may be compatible with occasional flooding. Where floodplains are to be devoted to open space or conservation purposes, planning and management is necessary.

Third, floodplain management should seek to *treat property owners fairly.* The U.S. Constitution requires that property owners be ensured "due process of the law" and "equal protection of the law." This has been interpreted to mean that floodplain regulations, like other land use controls, must be based on sound data. It is not necessary to employ the most advanced or expensive methodology for this purpose, but a good-faith effort must be made to map the flood hazard area and to distinguish the levels of risk within it. In this manner, property owners can be treated like others with the same degree of risk. (Problems arise, of course, where properties that are similar in risk are separated by political boundaries.)

Fourth, floodplain management should be viewed as one element of a *comprehensive land and water resource management* effort. The goal of cutting flood losses must be viewed in the context of other public goals such as economic development, public safety, water quality improvement, agricultural land preservation, fish and wildlife protection, recreation, tax considerations, and so forth. Again, this suggests the need for floodplain management to be conducted in harmony with other public programs and policies applicable at various geographic scales: community, watershed, region, state, and nation.

B. Techniques of Floodplain Management

Much has been written on the subject of the techniques of floodplain management. For our purpose here, the major tools available are outlined in Table 1. These are listed in three categories: measures that control floodwaters directly; measures that reduce the vulnerability to flood damage; and measures that modify the impact of flood losses. More information on these techniques can be found in the references at the end of this paper, and some of the techniques are illustrated in the case histories discussed in Part II of this report.

Table 1. TECHNIQUES OF FLOODPLAIN MANAGEMENT

A. Control Flooding ("Structural")

1. Dams and Reservoirs
2. Dikes, Levees, and Floodwalls
3. Channel Alterations
4. High Flow Diversions and Spillways
5. Land Treatment Measures
6. On-Site Detention Measures

B. Reduce Vulnerability to Flood Damage and Disruption ("Nonstructural")

1. Floodplain Regulations

   a. State Regulations for Flood Hazard Areas
   b. Local Regulations for Flood Hazard Areas

      (1) Zoning
      (2) Subdivision Regulations
      (3) Building Codes
      (4) Housing Codes
      (5) Sanitary and Well Codes
      (6) Wetlands Regulations (Coastal, Inland)

2. Development, Redevelopment, and Reallocation Policies

   a. Design and Location of Services and Utilities
   b. Land Rights Acquisition and Open Space Use
   c. Redevelopment
   d. Permanent Evacuation

3. Disaster Preparedness and Assistance: All Levels of Government

4. Floodproofing of Buildings

5. Flood Forecasting and Warning Systems, Emergency Plans

C. Modify the Impact of Flooding on Individuals and the Community

1. Information and Education
2. Flood Insurance
3. Tax Adjustments
4. Flood Emergency Measures

Adapted from: U.S. Water Resources Council, *A Unified National Plan for Floodplain Management*, January, 1979.

C. Floodplain Managers

Most floodplain management literature addresses the question of "how" more than "who." Responsibility is vaguely assigned to "the public" for carrying out floodplain management measures. But this conveniently overlooks the complex nature of private and public environmental decision-making in the United States. To paraphrase Pogo, "The public is us."

As noted earlier, rivers form boundaries between many units of private ownership and public jurisdiction. Rivers also flow across boundaries from one unit into another. All of these various entities—national, state, county, municipal, and private—collectively are the public. Authority to manage floodplains is shared by all of them. Viewed another way, *no single private or public entity has complete authority to cope with its own flood problem. Coordination among management units is essential.*

Before turning to the ways in which coordination may be achieved, let us briefly review the powers and characteristics of each type of manager.

1. The Private Owner

In the United States, the private landowner is a key figure in the floodplain management process. Owners have great discretion over the use of their land. Furthermore, under the riparian doctrine, owners of land next to surface waters have certain rights as to the use of the shore line and water. Landowners have great freedom to determine whether, how, and when to develop their properties. The owner's free will is constrained only by public health, safety, and welfare considerations. This freedom of the private landowner is, of course, a major concern in the floodplain context.

Floodplain management is most effective when the landowner is cooperative; prolonged disputes or litigation to uphold floodplain management objectives are expensive. Probably the best way to encourage private responsibility is to fully inform the owner about the nature and extent of the flood hazard. Thus, floodplain management to a great extent involves education and public awareness. The property owner or private investor must realize respect for floods or other natural hazards is essential to wise decision-making.

2. Municipalities

The municipality (city, town, incorporated village) is the workhorse of land use regulation in the United States. Through state enabling acts, municipalities have the authority to plan and regulate land use within their jurisdictions. They also are vested with authority to acquire land through purchase, gift, or eminent domain for a variety of uses—parks, conservation areas, school sites, etc., provided that such acquisition is for a public purpose. Municipalities thus have the power to guide development away from floodplains. Until recently, however, few had used this power effectively. Too often, floodplains were regarded as convenient sites for industry, housing, or shopping centers. The short-run gains in employment and taxes have dictated these choices, and the long-run costs of catastrophic flood losses were often ignored.

Most municipalities are not set up to assume major responsibility in floodplain management by themselves. Typically, they are small in area and exercise authority only over a small portion of a total watershed or floodplain. Their boundaries are likely to be shaped erratically and may be altered by land annexation (other than in certain northeastern states, where municipal boundaries are static). Municipalities often allocate little or no money for planning services. Finally, the politics of local governments can often work against floodplain management.

Nevertheless, about 17,000 local governments (including counties) have enrolled in the National Flood Insurance Program. Of these, about 12,000 are in the "emergency program," which does not yet require significant management regulations. The remainder, however, have entered the "regular program," which requires adoption and enforcement of floodplain zoning and related measures based on technical engineering data provided by the Federal Emergency Management Agency.

Progress in local floodplain management is less than one would desire. A small watershed typically includes communities with different levels of regula-

Figure 11. Regional Special Districts Such as This One Play Important Roles in Flood Control and Water Allocation. (Photo: R. Platt).

tion and some with no regulations at all. A higher degree of consistency among communities sharing a common watershed or floodplain should continue to be pursued as a matter of public policy.

3. Special Districts

The management of floodplains is only one of many public concerns that transcend local, county, and state boundaries. Among other concerns are education, public safety, pollution abatement, solid waste management, parks and recreation, transportation, health, and housing. Others that directly relate to water include navigation, water supply, sewage treatment, drainage, irrigation, and fire fighting. In each case the political and geographic fragmentation of general purpose governments poses a substantial barrier to fulfilling public policies and programs. A widespread response to this dilemma has been the formation of special districts whose powers and territories are tailored to a particular public mission. The basic criterion of a special district is that it be a "municipal corporation"—that is, an autonomous legal entity created in accordance with state law and having specified legal powers to be exercised within a definite geographical territory. As with municipalities, special districts are legal persons: they can sue and be sued, they may enter into contracts, and they may exercise other powers necessary to carry out their duties. Unlike municipalities, they are limited to one or more specified purposes and may overlap the territory of general purpose governments and other types of special districts (Fig. 11).

Special districts may be either a cause of or a remedy for fragmentation of floodplain authority. Thousands of special districts have been formed to promote urban redevelopment, navigation, flood control—all of which may directly or indirectly contribute to development in floodplains. By their very nature, special districts do not usually engage in comprehensive planning, nor do they participate widely in regional or basin-wide planning programs. Furthermore, many special districts operate in relative obscurity, with little scrutiny by the public or the press.

On the other hand, special districts may be used creatively to overcome fragmentation at other levels of government. They can be drawn specifically to embrace a territory relevant to the purpose

of a district. For instance, a watershed management district may correspond to the watershed with which it is concerned. This means that its authority can extend throughout its area regardless of municipal boundaries. Also, the costs of district activities may be allocated to those who primarily benefit through a tax levy on property within the district territory.

The special district is thus a two-edged sword for floodplain management. On the one hand, its territorial, fiscal, and legal flexibility obviously recommends it as a means for overcoming the fragmentation of general purpose governments. On the other hand, the proliferation of special districts of disparate type, function, size, and outlook can greatly aggravate this fragmentation. To the extent that localism is the main reason for forming such districts, they may be even greater obstacles to the wise management of floodplains than general purpose governments. Once formed, special districts are practically impossible to dissolve or reorganize. There are promising examples, however, of special districts (such as the Du Page County Forest Reserve District—see Case Study 3 in Part II) whose powers are redefined by statute or administrative interpretation to encompass floodplain management activities. In other cases, a brand new special district like the San Francisco Bay Conservation and Development Commission may be created specifically to manage a resource that overlaps many political jurisdictions.

4. Counties

All land within the continental United States lies within some county (except Connecticut, where they have been abolished). Counties normally are vested with the powers to plan and zone land in "unincorporated areas" (outside incorporated municipalities). The actual powers and functions of counties vary widely. Rural counties usually do not engage in planning or zoning of any land use, let alone floodplain management. Large metropolitan counties such as Du Page County, Illinois, and Ramsey County, Minnesota (see Case Studies 3 and 5) undertake elaborate programs for the management of land including floodplains within their jurisdiction. In part, this may take the form of collaboration with local governments and special districts to promote coordination through consensus. In other cases, counties may be authorized to exercise direct power over floodplain development even within incorporated areas. Much depends upon the statutory and political context in which a county functions. In their size and general authority, however, counties are in a position to play a more important role in floodplain management than they have to date.

5. States

States traditionally have played little role in land use management in the U.S. Although they are vested with sovereign powers under our federal system of government, states have generally delegated their land use authority to local governments. In so doing, most states abdicated any interest in the substantive results of local planning and zoning. This was particularly true in the case of floodplains.

In recent years, however, several states have begun to assert a statewide interest in flood loss reduction, preservation of wetlands, coastal zone management, and related objectives. Legislative measures can take many forms: for example, they can include the licensing of obstructions to navigation and flood control works, regulations to protect "critical areas" (which are often defined to include floodplains), and coastal and inland wetland programs. In some states—notably Minnesota, Wisconsin, and New York—local governments are required to adopt floodplain zoning consistent with state criteria. Failure to do so results in direct state adoption of regulations for that community.

The National Flood Insurance Program has recognized the potential role of states in floodplain management. "State assistance grants" are being made to facilitate development of programs in each state. It is unlikely in most cases that states will entirely take over floodplain authority from local governments. Rather, their role is usually viewed as facilitating improved management by local governments, with increasing emphasis on the need for cooperation between sub-state units in the management of common watersheds and floodplains.

6. Federal

Detailed review of the many federal activities relating to floods and floodplains is beyond the scope of this report (see reference list). We may note, however, certain key federal agencies which play important roles (which in some cases may be discontinued or restricted due to funding reallocations) in the development of multi-governmental approaches to floodplain management.

a. Federal Emergency Management Agency (FEMA)

With its establishment by executive order in 1978, FEMA became the lead federal agency for flood hazard mitigation. Two components of FEMA are closely involved in both pre- and post-flood planning and recovery. FEMA administers the National Flood Insurance Program discussed earlier and administers federal assistance to disaster victims pursuant to a Presidential declaration of a "major disaster." Both of these activities are conducted through FEMA regional offices in the ten federal regions. Obviously, FEMA's floodplain management efforts must be closely coordinated with its disaster recovery efforts to accomplish their common objectives.

b. Army Corps of Engineers

For more than a century, the Corps of Engineers has served as the principal federal agency for flood control. Its structural activities include dams, reservoirs, levees, channel modification, shore protection works, and other projects to restrain or redirect floods. With a national policy shift towards nonstructural measures during the 1970's, the role of the Corps has diminished somewhat in relation to FEMA and other agencies. Beginning in 1961, however, the Corps conducted its own program of "Flood Plain Information Reports." Floodplain maps and flood profiles were developed for approximately 4,000 communities until this program was discontinued in the mid-1970's in favor of the flood insurance studies performed by the Federal Insurance Administration (FIA), now part of FEMA. The Corps continues, however, to assist local communities with the development of floodplain regulations through its Flood Plain Management Services Office. The Corps has also conducted many studies in specific urban areas and watersheds under various authorities. In the Charles River watershed in Massachusetts, the New England division of the Corps is implementing a novel approach to basinwide management in cooperation with the state and local governments (see Case Study 6 in Part II).

c. Soil Conservation Service (SCS)

The Soil Conservation Service of the U.S. Department of Agriculture is concerned with flood problems principally in "small watershed" areas of fewer than 250,000 acres, under authority of Public Law 83-566 (1954). In such areas, SCS may construct small flood control dams and acquire land in cooperation with state and local authorities. Like the Corps, SCS also may facilitate or directly conduct planning studies in specific watersheds for communities.

d. Tennessee Valley Authority (TVA)

TVA is a unique federal entity created in 1933 and given wide-ranging authority within the Tennessee River Basin. It was established to improve social and economic conditions in the Tennessee Valley through flood control, better river navigability, rural electrification, soil erosion control, and related measures. It is best known for the series of nine large, multi-purpose dams it built on the Tennessee River. Despite this massive structural investment, much of the Tennessee Basin has remained subject to flash flooding along tributaries. As early as 1953, TVA initiated a local Flood Relations Program to assist states and local governments in developing nonstructural measures for managing their floodplains. This program, which pioneered the concept of federal technical assistance to non-federal authorities, continues to the present time under TVA. It has inspired comparable efforts elsewhere under the Corps and FEMA.

Figure 12. Interstate and International Boundary Rivers of the United States.

e. Water Resources Council (WRC)

The U.S. Water Resources Council is an interagency forum for study of water resource issues. WRC has contributed to the management of floodplains in several ways. First, WRC funds and monitors river basin studies throughout the country that are done under the auspices of federal-state river basin commissions, interstate compact commissions, and other basinwide entities. Second, WRC has established a standard statistical method for estimating flood discharges. Third, WRC has developed "Principles and Standards" to evaluate water resource projects proposed by federal agencies. Lastly, WRC provides a means for agencies to consider together specific policy issues, such as coordinating their response to flood disasters.

f. Executive Office of the President

Various Presidents of the United States have sought to influence federal flood policy through executive orders. President Johnson in 1966 issued E.O. 11296, which directed the heads of federal agencies to "provide leadership in encouraging a broad and unified effort to prevent uneconomic use and development of the nation's floodplains. . . ." This order was superseded in 1977 by E.O. 11988, issued by President Carter to establish a process under which federal agencies must consider the flood implications of their actions and avoid direct or indirect contribution to future flood losses. E.O. 11988 also recognized the role of floodplains as natural phenomena providing benefits to the riverine system and its surrounding region.

D. Conflicts Among Floodplain Managers

The nation's floodplains are thus a mosaic of private and public managers, differing in geographic scale and legal authority while collectively sharing the benefits and burdens of being located next to water. These managers differ widely in their objectives, policies, and actions relating to floodplains, but each generally attempts to promote its own interests, often without regard for neighboring jurisdictions. Nevertheless, the very nature of rivers and streams signifies that the action or non-action of one authority may affect its neighboring areas, for better or for worse.

We may readily identify two situations in which multi-governmental conflict may arise. The first situation involves the river serving as a political boundary. The second involves rivers and streams flowing across political boundaries from one jurisdiction into another.

Most inland streams of any significance serve as boundaries between jurisdictions. At the international scale, the United States faces Canada across rivers in Maine, New York, Michigan, and Minnesota, and it faces Mexico across the Rio Grande. Forty-one states are bordered in part by inland rivers or lakes. The total length of interstate river boundaries is estimated at about 10,000 miles (Fig. 12). Rivers that bound states necessarily also border smaller units of jurisdiction: counties, special districts, municipalities, and private property holdings. This role of inland streams as boundaries can cause conflict between jurisdictions. Where floods are concerned, one jurisdiction may permit haphazard filling, diking, or other forms of encroachment, which may increase flooding in jurisdictions across the stream. Such alteration of flood patterns may wreak havoc if one community has developed on or near the floodplain on its side, assuming from past flooding patterns that they will not be engulfed (See Jackson, Mississippi case study in Part II).

Streams that flow *through* political jurisdictions also can cause conflicts of an upstream-downstream nature. A major problem of this type in small watersheds is upstream development, which raises flood levels downstream. Covering the land with buildings, pavement, and lawns increases surface runoff to streams, a phenomenon which is further aggravated if storm sewers are constructed without a stormwater detention mechanism. Under such conditions, drastically more severe floods will be experienced in downstream jurisdictions (See Haikey Creek case study in Part II). Another form of upstream-downstream conflict is the "bottleneck": if jurisdictions on opposite sides

of a stream both obstruct their floodplains through levees or other means, the resulting constriction inflicts "backwatering" upon areas immediately upstream. This effect is pronounced on major rivers such as the Mississippi upstream from St. Louis.

The effects of multi-governmental fragmentation in floodplains are cumulative. Most watercourses of any significance involve both cross-stream and upstream-downstream conflicts. Furthermore, alteration of flooding patterns in *tributary* watersheds likely will make flooding on mainstream rivers worse. The cumulative effects of specific actions, however, is not always obvious because a flood may not occur for years. Unlike questions of water quality and supply, the multi-governmental implications of flooding are too often seen only in the aftermath of a flood. Certainly not all flood damage can be blamed upon the actions of neighboring areas. But just as certainly, even the most responsible floodplain management unit is to some extent at the mercy of its neighbors. Ultimately, there is a need for multi-governmental arrangements to promote mutually responsible and enforceable floodplain management policies.

E. Techniques for Multi-Government Coordination in Floodplains

Floodplain management is just one of many public concerns that transcend political boundaries. Much has been written on techniques for "intergovernmental coordination." (See particularly various reports by the Advisory Commission on Intergovernmental Relations.) Much of this literature, however, deals with "vertical" relationships among federal, state, and local entities. While that dimension is important to floodplain management, the emphasis here is upon "horizontal" cooperation between adjoining units of government—thus we use the term "multi-governmental coordination." Techniques to be summarized below include:

1. Interstate compacts
2. Comprehensive river basin planning
3. Statewide regulations
4. Counties
5. Special districts
6. Intergovernmental agreements
7. Extraterritorial powers
8. Litigation

1. Interstate Compacts

Article 1, section 10 of the U.S. Constitution states: "No state shall without consent of Congress, . . .enter into any agreement or compact *with* another state." Interstate compacts with the consent of Congress have long been an important vehicle for establishing formal agreements and arrangements among states. Compacts deal with a wide range of concerns: transportation, pollution, navigation, and port development, fisheries and wildlife, power, water supply, and flood control. Most water-related compacts have been achieved in western river basins, where allocation of scarce water resources is of primary concern. In the East, the principal water-related compacts are those established for the Delaware and Susquehanna River basins. These in fact are the only compact commissions with comprehensive planning authority within their respective watersheds, including the power to review and approve local floodplain zoning regulations. (This power has been used sparingly in the Delaware and not used at all in the Susquehanna basin.)

Interstate compacts are formal legal instruments that establish the rights and duties of each state party and that are enforceable through the courts. Potentially, compacts offer a way to promote consistent floodplain management policies and practices along interstate rivers. Compacts, however, are difficult to achieve due to reluctance of states to delegate their powers. On the average, it takes eight years for a compact to be ratified; none have been established since 1975.

2. Comprehensive River Basin Planning

Comprehensive river basin planning (whether or not leading to an interstate compact) has been a goal of planners in the United States since at least the 1930's. The Water Resources Planning Act of 1965 authorized the establishment of federal-state river basin commissions to:

> Serve as the principal agency for the coordination of federal, state,

interstate, local and nongovernmental plans for the development of water and related land resources in its area, river basin, or group of river basins. (P.L. 89-90, section 201)

Six basin commissions have been established under this act: New England, Ohio, Great Lakes, Missouri, Upper Mississippi, and Pacific Northwest (See fig. 3). These commissions are not compacts and lack their authority. Instead, their function is to perform planning studies and to recommend consistent policies and practices to the various public authorities within their basin. Each commission has performed diverse studies with funding and policy guidance from the U.S. Water Resources Council. The foremost of these studies to address floodplain management issues is "The River's Reach," prepared for the Connecticut River Basin by the New England River Basins Commission in 1975.

For smaller watersheds in metropolitan areas, an analogous role may be served by regional planning agencies or councils of government. In many cases, such advisory agencies have addressed the need for consistent management of urbanizing watersheds. The role of these agencies is strengthened when they serve as an "A-95 regional clearinghouse" for federal assistance applications within their region, for in this capacity they may disapprove federal investment in any project that conflicts with a regional floodplain management policy.

Although a regional advisory board of a different sort, the Tennessee Valley Authority perhaps best illustrates how regional advice and resources can help local governments with their floodplain management. While TVA has been criticized for high-handedness in its structural flood control efforts, for 20 years it has sought to promote nonstructural measures through technical assistance and encouragement of states and local communities. (See Case Study of Maryville and Alcoa, Tennessee, in Part II.)

3. Statewide Regulations

According to the 1979 Annual Report of the U.S. Council on Environmental Quality, 24 states had adopted some form of state permit requirements covering riverine floodplains. Twelve of these, notably including the strong state programs in Minnesota, Wisconsin, New York, and New Jersey require local governments to adopt floodplain regulations at least as strong as state criteria, or the state will adopt them directly. In some cases, states may adopt floodplain regulations for a particular stream or watershed (See Salt Creek case study in Part II). State authority may thus be applied selectively to overcome special problems of intercommunity conflict.

4. Counties and Special Districts

Substate regional coordination is critical to a resolution of many local conflicts about floodplain use. Both county governments and regional special districts may be useful in filling the gap between states and local governments. Each is broader in its geographic jurisdiction than individual municipalities, yet they are closer to the local scene than state or federal authorities. Unfortunately, as mentioned above, counties and special districts often belong more to the problem than to the solution of multigovernmental fragmentation. The case studies in Part II on Lilydale, Minnesota, and the Salt Creek watershed in Illinois indicate that counties and existing districts may play important new roles in floodplain management. In some cases this will require new legislation; elsewhere, existing powers may be expanded through reinterpretation of existing authority. And in other cases, a brand new special district will be needed to remedy an impasse at the local level.

The use of counties or special districts to resolve interlocal floodplain conflicts must be applied cautiously. Municipalities are loathe to give up authority over land within their boundaries. Unincorporated land, of course, is directly under county authority, but such areas may involve only a dwindling fraction of an urbanizing watershed. To promote regional harmony, counties and special districts should, where possible, complement rather than countermand the role of local governments. As the Lilydale and Salt Creek case histories suggest, the most appropriate role of the extramunicipal entity may be land acquisition rather than regulation.

5. Informal Communication Between Governments

Local autonomy in planning and zoning is an article of faith in the United States, yet this does not need to mean that communities should ignore the actions or interests of their neighbors. Although now little used, there are many interlocal communication channels available to promote rational floodplain management as well as other mutual objectives. Such communication may occur through a "council of government" or other regional organization, or it may simply take the form of letters, telephone calls, or street corner conversation between officials of neighboring communities. Local news media play an important role in reporting pending local actions and policies. Where floodplains are concerned, communities should be vigilant in looking over the shoulders of their neighbors.

6. Zoning Testimony

The American approach to zoning has substantially hindered municipal participation in the zoning and planning decisions of neighboring localities. Most state laws do not require notice of proposed zoning changes to be circulated beyond the immediate municipality. (Massachusetts, however, now requires notice of any amendment, variance, or special permit to be sent to the planning boards of abutting municipalities as well as the state, regional planning agency, and adjoining property owners.) In any case, though, there is no constitutional barrier to the submission of verbal or written testimony to the zoning authorities of a neighboring jurisdiction. The New Jersey Supreme Court, in a 1949 decision, recognized the standing of municipalities to participate in and challenge the zoning decisions of their neighbors:

> What may be the most appropriate use of any particular property depends not only on all conditions, physical, economic, and social, prevailing within a municipality, . . . but also on the nature of an entire region in which the municipality is located. . . . The effective development of a region should not and cannot be made to depend upon the adventitious location of municipal boundaries, often prescribed decades or even centuries ago and based in many instances on considerations of geography, commerce, or politics that are no longer significant with respect to zoning and the use of property. (*Duffcon Concrete Products, Inc.* v. *Cresskill*, 64 A.2d 347 [1949])

In a subsequent case, the same court recognized that a municipality

> owes a duty to hear any residents and taxpayers of adjoining municipalities who may be adversely affected by proposed zoning changes and to give as much consideration to their rights as they would to those of [their own] residents and taxpayers. . . . To do less would be to make a fetish out of invisible municipal boundary lines and a mockery of the principles of zoning. (*Cresskill* v. *Dumont*, 104 A.2d 441 [1954])

These cases and more recent decisions from New Jersey, New York and Illinois support the right of municipalities to participate in zoning decisions affecting land within a short distance of their borders. While the issue of flooding was not involved in these or other reported decisions, the threat of litigation has undoubtedly lent force to the protests by one community as to pending actions by others. (See Part II, Haikey Creek case study.)

7. Intergovernmental Agreements

Municipalities, special districts, counties and states are all "legal persons" and therefore may enter into contracts and agreements with each other. Intergovernmental contracts are formal legal instruments which specify the duties and rights of each party thereto. Failure to perform duties specified in a contract subjects a party to legal liability. Governmental bodies may also enter into less formal agreements which lack the specific character of contracts. In "memoranda of understanding," they may express mutual policies and intentions without creating legal obligations. Even a mere exchange of letters may serve to provide mutual reassurance as

to common purposes. Such informal agreements, however, are not legally enforceable.

Intergovernmental agreements are presently used for various public purposes such as coordination of police and fire protection, water and sewage facilities, solid waste disposal, and so forth. Depending upon state law, agreements may also involve different levels of government, such as federal-local, state-special district-local, etc.

Intergovernmental contracts frequently are used in the development of structural flood control projects. Channelization and flood control measures along the Upper Salt Creek in Cook County, Illinois, for instance, involves an agreement between the federal government, the state, and several municipalities and special districts. Such contracts or agreements are more unusual in the nonstructural floodplain management context. Several are discussed in the case studies in Part II (see particularly the Charles River and Maryville cases).

An important unanswered question is whether intergovernmental contracts or agreements may create mutually enforceable policies regarding floodplain management regulations. Certainly communities may agree through a memorandum of understanding to adopt comparable sets of regulations. It is not clear, however, whether this gives either community rights against the other in the event that such regulations are not adopted or enforced. In many Corps of Engineers projects, nonfederal entities agreed to implement land use regulations. Presumably, failure to perform would be actionable in a court of law. By analogy, there would seem to be no reason why communities could not bind themselves to adopt and enforce regulations. This would be a powerful tool for multi-governmental management of floodplains.

8. Extraterritorial Powers

A final technique to be considered is the possible use of extraterritorial powers by a county or local government. The rules on extraterritorial power vary greatly from one state to another. Some states allow local governments to adopt zoning for areas within a specified distance outside their boundaries. Land acquisition outside the corporate limits may be authorized, although usually not through the use of eminent domain. Normally, the consent of the jurisdiction in which the land is located must be obtained. This may in turn require an intergovernmental agreement, as in the Lilydale case study in Part II.

Conclusion

Part I has reviewed the nature of flood hazards and forms of response by which flood damages may be avoided or mitigated. We have noted that the management of floodplains is shared by countless units of government: national, state, county, and local—as well as millions of property owners. Any strategy to reduce flood losses therefore depends upon coordinated action by multiple units of government—none can do the job alone. We have summarized a variety of techniques available for achieving multigovernmental action in floodplains. Now we may turn to some real life examples of how public authorities can work with—or against—each other in coping with their mutual flood problems.

PART II: CASE HISTORIES OF MULTI-GOVERNMENT FLOODPLAIN MANAGEMENT

Introduction

The case studies which follow illustrate a variety of problems and approaches in the management of floodplains by multiple governments. The studies concern small urbanizing watersheds located in six diverse regions and states: Mississippi, Oklahoma, Illinois, Tennessee, Minnesota, and Massachusetts. While the nature of the flood problem, the extent of urban development, and the laws and customs of each area differ, there is much of value to be learned from each case history which may be applied elsewhere in the U.S.

The first two cases—the Pearl River in Mississippi and Haikey Creek in Oklahoma—depict "horror stories" of the results of lack of intergovernmental planning and coordination in floodplains. While each is complex in its facts, the Pearl River case involves principally a conflict between cross-stream jurisdictions while Haikey Creek presents upstream-downstream issues.

The next four cases illustrate various approaches to multi-governmental coordination, with differing degrees of success. In the Salt Creek case, a county forest preserve district served as catalyst to an intercommunity floodplain acquisition program. Maryville and Alcoa, Tennessee, under the benevolent encouragement of TVA agreed to coordinate their floodplain policies through an intergovernmental agreement. Lilydale, Minnesota, was relieved of a chronic flood problem through extraterritorial action by Ramsey County which acquired the Lilydale floodplain and relocated its residents. Finally, the Charles River case indicates the opportunities for coordinating federal, state, and local actions—both structural and nonstructural—to relieve flooding on a basinwide basis.

1. JACKSON, MISSISSIPPI—PERIL ON THE PEARL

This is the story of wishful thinking in Jackson, Mississippi—by the local authorities, the local citizens, and the federal government—all of whom ignored the possibility of disaster until it struck on Easter, 1979.

The Setting: At the River's Edge

The Pearl River rises in central Mississippi and flows south for 240 miles until it reaches the Gulf of Mexico at the boundary between Mississippi and Louisiana. Its watershed is about 8,760 square miles—usually drained in a leisurely fashion, for the Pearl is in most places, at most times, a shallow, meandering stream (average gradient, approximately one foot per mile).

About halfway down the Pearl—with 3,110 square miles of drainage area above it—lies Mississippi's capital city, Jackson, on the west bank of the river. The natural floodplain at Jackson is around two miles wide, through which the Pearl plods sluggishly. However, neither the floodplain nor the river's course are still natural there: the Ross Barnett Dam just upstream, extensive channelization, and levees on the east and west banks (all constructed during the 1960's) have caused substantial riverine changes.

Nor has the city and its environs stayed the same. Between 1960 and 1976, Jackson grew from 144,422 to 205,100 in population (partly through annexation). Across the river, the city of Pearl's population has more than tripled, going from 5,081 in 1960 to 15,750 in 1976 (although the small town of Flowood has largely held to its 1960 level of 500 due to a lack of bridge access to Jackson. In addition, the wholly new city of Richland with a population of more than 3,000 has grown up on the east bank since 1960 (Fig. 13).

Why all this growth? To some extent, it can be attributed to normal population change, but it is also due to other

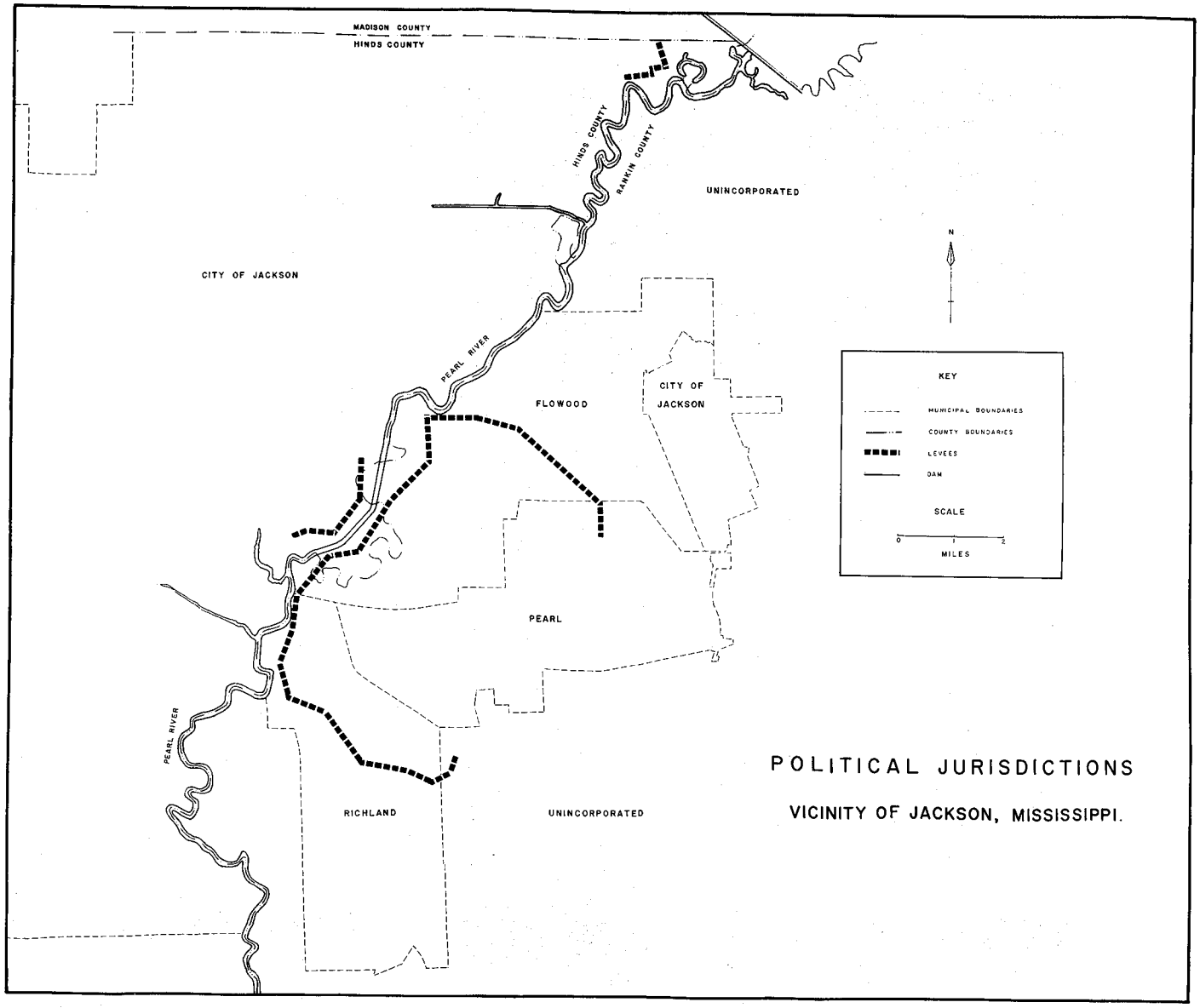


Figure 13. Political Jurisdictions Along the Pearl River at Jackson, Mississippi.

Figure 14. Flooding Behind the Corps Levee at Jackson Mississippi, April, 1979, Showing State Fairgrounds, Ramada Inn (Upper Right) and Industrial Buildings. (Photo: R. Platt).

changes that took place in the 1960's—public improvements such as two new interstate highways and a state highway (including a new bridge across the river), new water and sewage treatment plants, several additional electrical substations, expansion of the airport on the east side, and several other new public facilities. Furthermore, and of particular importance here, there were the 1960's river projects, all of which helped direct growth in the Jackson area onto the Pearl's floodplain.

Prior Flooding and a False Sense of Security

Floods were no strangers to the Pearl. The highest at Jackson before 1979 occurred in 1902 when the river crested at 37.5 ft. with a discharge of 85,000 cubic feet per second (cfs). There were more, but the next really bad one was in 1961, this time with a discharge of only 66,000 cfs but again with a crest of more than 37 ft.—with urban encroachments, the river had less floodplain over which to spread. Indeed, the 1961 flood would have been even higher but for the Ross Barnett Dam, then in the process of completion. But even so, the 1961 flood caused damages of more than $33 million, and everyone was determined that it shouldn't happen again.

Pursuant to enabling legislation adopted by the Mississippi Legislature in March of 1962, the Rankin-Hinds Flood and Drainage Control District was established, named for the two counties facing each other across the Pearl River at Jackson. The purpose of this district was to serve as the local sponsor for a flood control project authorized for this reach of the Pearl by the U.S. Congress in its 1960 Flood Control Act. Like its counterparts across the nation, the district was required to provide land and easements to permit federal construction of levees and channel improvements. Thereafter, the local district would operate and maintain the levees. The Pearl project consisted of a 1.5-mile

levee on the west bank, a 10.3-mile levee on the east bank, and a 5-mile channel improvement with a 2.3-mile cutoff to lead the river between the levees. It was begun by the U.S. Army Corps of Engineers in 1964, completed in 1968, and cost $8 million in federal funds and $1 million in local dollars. It was intended to accommodate a flood of a magnitude that hypothetically would occur only once in every 175 years.

It didn't, as time soon told. But meanwhile, everyone was very optimistic that it would: the Flood Control District's president said, "This project will make many, many acres of valuable land secure for home, business, and industrial use"; a Major General of the Army Corps of Engineers said, "There is no reason why the project should not give indefinite protection from flooding to the area"; and the people started building, feeling secure in the protection of the recent flood control project combined with the dam upstream (Fig. 14).

The local authorities did nothing to stop them. Far from seeking to prevent floodplain encroachment, each local jurisdiction—Jackson on the west bank and Flowood, Richland, Pearl, and Rankin County to the east—did its utmost to attract new development regardless of flood hazard. An example: *all* of the land bordering the Pearl in Jackson was zoned residential or commercial; the Pearl and its local tributaries were not identified as constraining land use, nor was there any distinction between lands inside or outside the levee. On the east side of the river, land use management of the floodplain was lacking altogether. There, development both within and outside the levee proceeded without any zoning at all.

There were a few minor cautions about floodplain development: (1) in its 1973 Flood Plain Report, the Corps of Engineers did note that several northern Jackson subdivisions infringed on flood lands, but it did not go on to criticize Jackson's zoning law, and its tone about the unlikelihood of a major flood was generally complacent; (2) the Jackson city council did adopt a 1974 resolution that building permit applications should be reviewed for their consistency with the need to minimize flood damage and for recommended construction changes in flood hazard locations, but this resolution was passed primarily to qualify Jackson for the "emergency phase" of the National Flood Insurance Program, and enforcement was by visual inspection only; and (3) in 1978, the Central Mississippi Planning and Development District—the A-95 review agency for the region—did include in its general land plan for Rankin County the advice that the county should adopt zoning to restrict inappropriate floodplain development, but the advice came late, has not been followed even yet, and was not similarly directed to municipalities of Pearl, Richland, and Flowood, who also needed it. All three acknowledgments of flood danger were simply token gestures: pebbles in the path of a surging tide.

The Ross Barnett Dam likewise proved no defense against the '79 flood. Completed in the early 1960's, this dam at the northeast corner of Jackson was built by the then newly-organized five-county Water Supply District using local taxes and land sale revenues. It was intended mainly for water supply and recreation, although an ancillary purpose was to reduce downstream flooding by providing a modest storage capacity. It was not, however, a flood control project—to have served as such, its reservoir would have to have been kept at a level too low for maximum recreation use and shoreline development. With adequate flood warning, the level could have been dropped by phased releases to accommodate arriving floodwaters. But three federal agencies—the Corps, National Weather Service, and the U.S. Geological Survey—all gave different predictions of flood conditions, and all were too low. As a result, releases from the dam were too delayed to reduce the flood crest at Jackson very much.

The 1979 Flood: Inundation and Mitigation

The week before Easter in 1979 it started to rain. And it rained. By Thursday, April 12, Jackson was disrupted by local flash floods and the Pearl was rising ominously. By Sunday, they knew it was going way past the 1961 level, and the water continued to rise. It finally crested on Tuesday, April 17, at 43.25 ft., with a

Figure 15. Emergency Dike Erected Around Vital Electrical Facility in Jackson, Mississippi, April, 1979. (Photo: R. Platt).

discharge of 130,000 cfs. The Mayor of Jackson estimated $500 million in damage to the city with 17,000 people driven from their homes—the 1979 flood was thus far costlier and more disruptive than the one in 1961, despite the Corps flood control project completed in 1968. A new sewage treatment plant was destroyed, and many other vital services were threatened with collapse (Fig. 15).

Apart from the seventeen-year prelude setting the scene for this disaster, two points were notable during the flood:

- Many people thought the city might have been saved or the flood at least lessened if the Ross Barnett Dam had been operated to maximize its flood holding capacity by having periodic and well-publicized releases before the crisis began to peak. (Releases did increase gradually beginning April 11, but at a pace less than inflow to the reservoir from upstream.) The U.S. General Accounting Office has criticized lack of coordination among federal, state, and local officials regarding the operation of the dam.
- The floodfight was heroic but fragmented, with the levee in Jackson prematurely abandoned and massive resources devoted to the east side levee surrounding much natural floodplain.

The above two points indicate the need for emergency plans that are coordinated among the various public authorities and jurisdictions and well-established *prior to* the portent of any disaster. It is not enough to rise to the occasion; you must know which way to turn. And equally, mitigation *after* a flood must, while meeting urgent needs, be done with an eye to the future.

How was relief brought to the Jackson area? Again, heroically, and again, in a rather hasty and unplanned fashion. Within two days, six federal disaster centers were set up, and over the next year $145 million was allocated to help Mississippi recover. This money was not given unconditionally; in 1974, Congress passed an act (P.L. 93-288) requiring that federal disaster relief money be accompanied with actions by the state and local governments to mitigate the causal

Figure 16. Flooding in Haikey Creek Watershed, May 1976.

hazards, including actions such as "safe land use and construction practices." But between the idea and the response can fall a great gulf. Have these required mitigating actions been taken?

Not to any great extent. A bit has been done at the federal level: the Federal Insurance Administration (FIA) surveyed flood victims for willingness to relocate, conducted seminars on floodproofing, and negotiated an agreement with the Small Business Administration (SBA) whereby the latter would extend relocation assistance when the FIA recommended that no reconstruction take place. But except for the FIA and SBA, no other federal agency has taken direct action to avoid losses in future floods.

And even less has been done at the state and local level. In compliance with P.L. 93-288, a State Hazard Mitigation Coordinator was appointed five weeks after the flood, but because the preeminent need was to get things back to normal, little farsighted planning was done at that time. And paradoxically, that is the time when farsighted planning must occur, for otherwise the old patterns will repeat themselves. But only a few modest changes have been made: a plan was developed by Jackson to relocate 29 chronically flooded homes, and a floodplain zoning law which qualifies it for participation in the regular phase of NFIP was adopted 10 months after the flood (an unfortunate delay due to lack of data, for in this instance delay means adverse construction). On the east side of the river, floodplain management is still largely nonexistent for example, in Flowood, construction of an office park *outside* the levee was even being continued despite the Easter flood. This continuing disregard by the east bank communities for floodplain management may be due partly to the fact that they weren't as seriously inundated: the east levee held but the west levee did not, and the west side experienced much higher flooding (two clearly interrelated circumstances, for the standing east levee would raise the flood level on the other bank).

In any case, the main response of officials in almost *all* the local jurisdictions has been to join the Mississippi Congressional Delegation in urging the Corps to expedite a $500,000 study to evaluate the need in the Jackson area for more dams, more local protection works, and a better flood warning system. In other words, more structural control, by and large.

Summary: Lessons to Be Learned

The Jackson case history points to a number of lessons that can be learned, although not all of them have taken hold there. Briefly stated, these involve:

1) the danger of overconfidence in structural flood control;
2) the importance of preventing floodplain encroachment;
3) the importance of locating vital public facilities outside the possible flood zone;
4) the need for pre-disaster contingency planning;
5) the need for post-disaster hazard mitigation, including appropriate relocation and prevention of adverse future development; and
6) the need for improved cooperation among public authorities.

All of these six points are important, but the first two are especially so. For finally, the question comes down to this: Why *did* the 1979 Jackson disaster happen? Why did a flood whose discharge was only two-thirds that of a 175-year flood, against which the area was supposed to be protected by the 1960's improvements—why did that real flood crest *above* the hypothetical, larger flood? The answer doesn't lie in a miscalculation of the theoretical flood levels. It lies instead with the fact that the real flood had to contend with a myriad of encroachments, planned and unplanned, each one seemingly innocent (as with the homes in the floodplain) and well-intended (as with the levees), yet each one constricting the river and raising its level—and the level of potential disaster.

2. HAIKEY CREEK—UPSTREAM/ DOWNSTREAM CONFLICTS

No one wants floodwater—but where should it go? The Haikey Creek case history is an example of the conflicts that can arise between upstream and downstream neighbors over this issue.

The Setting: Highlands to Lowlands; City to Suburb

Haikey Creek is one of several prairie creeks that rise within the city limits of Tulsa, Oklahoma, and flow outward to the Arkansas River. Its 37 square mile basin lies within the fast-developing southeast section of the Tulsa metropolitan area. The creek rises in the Ozark highlands—rolling hills now becoming houses, streets, and shopping centers. But from these busy hills it drops to the still-pastoral bottom lands of the Arkansas River. Barns and farmhouses dot the "Bixby Bottoms" and only scattered subdivisions can be seen in this area of rich agricultural soils.

However, those scattered lowland subdivisions are a portent of things to come, and the portent does not bode well. At present there are about 400 structures (most of them single-family homes) in the 100-year floodplain of the Haikey basin (which covers about one-fifth of the basin). There is still plenty of room for development. Today, a 100-year flood would cause an estimated $5.4 million in damages. Who knows what it could cause ten years from now?

The Creek and Its Flood Experience

Haikey Creek drops about 275 feet in its total twelve-mile length, partly through channelized and straightened courses but otherwise meandering. The occasional flooding usually found with abrupt elevation drops is made worse in Haikey's case by several factors: (1) the basin's geological underpinnings are mainly an impermeable strata of shale and limestone, preventing ground water absorption; (2) this naturally high surface water runoff is increased by the urbanization upstream; and (3) in the Haikey area, rain comes erratically, intensively, often in cloudbursts or torrential downfalls. All this means *floods*—more and more of them and with increasingly severe consequences as urbanization marches on.

Before 1960, the Haikey basin housed fewer than 6,000 people, most of them in the upland area, and flood damage was largely confined to agricultural crops. By 1974, the population had *tripled*, and this meant two things: more surface runoff and more property to be damaged. Floods in 1957 and 1959 had each caused $100,000 in damages; floods in 1974 and 1976 caused damages of $650,000 and $783,000, respectively (Fig. 16). So again the question arises:

What will happen if this urbanization is allowed to go unchecked, with no thought to flooding? And who is going to do something about it?

Public Jurisdictions: A Jumble of Conflicts

Like its flood water, the distribution of public authority in the Haikey basin is chaotic. Basically, the watershed is divided among four jurisdictions (Fig. 17): the City of Tulsa, at the northwest corner of the watershed; the City of Broken Arrow, scattered in a jumble of annexations across much of the upper and middle parts of the watershed; the lowland Town of Bixby, straddling the Arkansas River; and Tulsa County, which has primary responsibility for the unincorporated balance.

Tulsa, incorporated in 1898 on a high bluff of the Arkansas River, already had urban problems by 1960, with a population of 182,000. But by 1970, its population had nearly doubled, and its problems were proportionately bigger. An especially ominous one was the threat of flooding—a threat which was borne out with the 1974 and 1976 floods, the latter being the most costly disaster in the city's history. The 1976 flood gave impetus to the city's previously half-hearted floodplain management policies, concocted at least partly in compliance with the National Flood Insurance Program, which Tulsa joined in 1970. As the 1976 floodwaters subsided, Tulsa declared a moratorium on all construction exposed to flash floods. This moratorium lasted until the city commission adopted new floodplain ordinances in late 1977 whose general goal was to allow only development that would not be flooded or aggravate flooding for others. Flooding concern also inspired related planning efforts: a growth guidance program for the city, of which floodplain management was an important part; and, as described further on, the Army Corps of Engineers' Tulsa Urban Study.

Meanwhile, in other parts of the watershed, Broken Arrow was rushing to other remedies in the face of the 1976 flood. Their solution was structural: a floodplain policy committee of developers, engineers, and citizens recommended channelizing all streams in new developments throughout Broken Arrow, to carry stormwater efficiently out of its jurisdiction. Fine, perhaps, for Broken Arrow (although rather costly)—not so fine for downstream Bixby (Fig. 18).

Bixby, on getting word of Broken Arrow's intention, threatened a court suit to compel that city to control its runoff, which Bixby maintained would substantially increase—to the downstream town's detriment—if Broken Arrow went ahead with its proposed channelization. Bixby's charges were borne out by preliminary findings in the Corps of Engineers' Tulsa Urban Study, which further found that channelization would be far more expensive than a suggested alternative: preserving the floodplains as open space rather than developing them at all. This finding, combined with maintenance costs to be passed on to water users, persuaded Broken Arrow's voters to reject channelization.

Broken Arrow then abandoned the scheme and switched to a more benign approach: it adopted ordinances prohibiting new construction on the 100-year floodplain and also prohibiting major stream channel alteration where the contributing drainage area exceeded one square mile. It also started looking for ways to finance stormwater detention and construction and floodplain open space compensation. Concurrently, Bixby—trying to put its own house in order—was considering putting them on stilts or higher ground: after a brief floodplain development moratorium, the town adopted requirements that new house floor levels be at least one foot above the 100-year flood level. It also required that large construction allow floodwaters to pass underneath, and that development on higher ground have stormwater detention measures.

All this took place in the two years following the 1976 inundation. Meanwhile, what was the *fourth* actor, Tulsa County, doing? Very little. Although unincorporated areas remain under its jurisdiction, Oklahoma law does not give it the prerequisites of home rule, and it would have to formally seek zoning authority. It has not done so yet, although to qualify for federal flood insurance, it did, in 1975, adopt a building code.

Forums for Coordination

And who has been there to reconcile

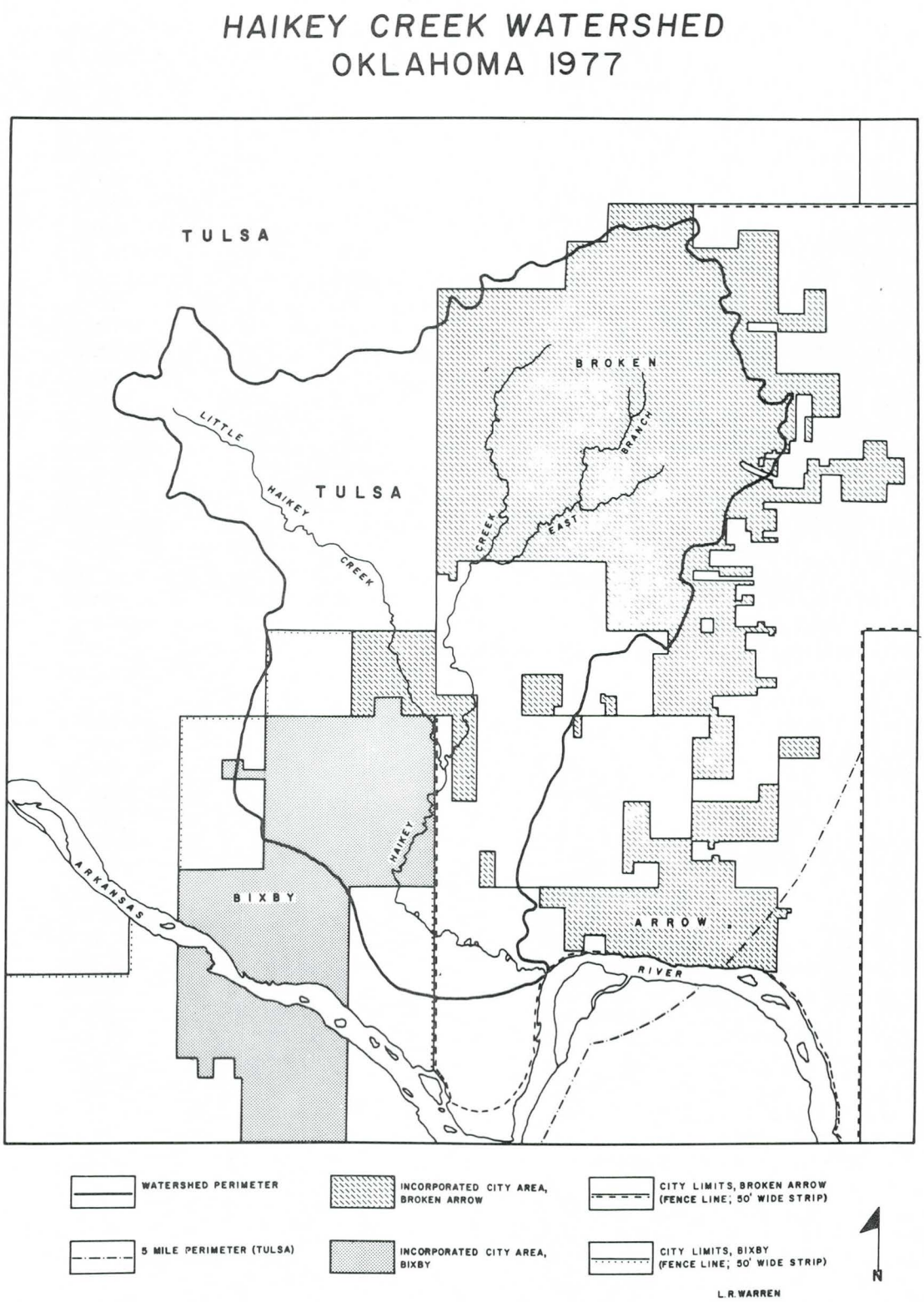


Figure 17. Political Jurisdictions Sharing the Watershed of Haikey Creek, Vicinity of Tulsa, Oklahoma, 1978.

Figure 18. New Construction Next to Haikey Creek, Broken Arrow, Oklahoma, July, 1977.

Figure 19. Homemade Dike Erected by Residents of Hickory Hills Subdivision (Shown in Figure 16) in Response to Increased Flooding Due to Upstream Development. (Photo: R. Platt).

conflicts and nudge the recalcitrant into action? There are several multi-government forums for coordination in the Haikey watershed, all of mixed usefulness:

- The Tulsa Metropolitan Planning Commission, organized in the 1950's in part to deal with the intergovernmental stormwater question but with largely a planning function (although it can regulate subdivisions), and with its existence dependent on diplomatic relations with its member jurisdictions.

- The Indian Nations Council of Governments (INCOG), organized in the late 1960's with constituent members including all the Haikey basin jurisdictions except the county, which withdrew in 1977. As the A-95 review agency for the Tulsa region and the clearinghouse for floodplain regulations done in compliance with the federal flood insurance program (both federally designated roles), INCOG has potential clout, but its ambitions as a coordinator are still undefined.

- The Regional Metropolitan Utility Authority (RMUA), created by Tulsa and Broken Arrow in 1972 to improve the sewage systems in those jurisdictions, and with members now including most other municipalities in the area. RMUA has the scope to help coordinate multi-governmental floodplain management, but so far its streamlined wastewater systems have simply encouraged development on those floodplains (and so further improvement of those systems is now in question).

- The Tulsa Urban Study, which, although a one-shot deal rather than an ongoing forum, has already shown its usefulness in helping to resolve the Broken Arrow-Bixby battle. Done by the Army Corps of Engineers, the Haikey component of the study includes 100-year floodplain regulation, stormwater detention provisions in the Tulsa and Broken Arrow uplands, channelizing the last mile of the creek, building a levee around one subdivision, and floodproofing some floodplain structures. If implemented, it would represent a big step towards coordinated floodplain management in the Haikey basin.

But will it or any other coordinated floodplain management effort be carried out? Despite some coercive measures that could be externally imposed, that depends mainly on the principal actors: the four jurisdictions and their constituents.

Summary: Hang Together or Hang Separately

What is a 100-year flood? It is no static mark, no infallible line above which you'll be safe. Instead, it can be changed by anyone's action along any part of the stream. As one storm-harassed Haikey Creek resident put it:

> They're diking and damming downstream, piping and paving upstream, and who's to help us here in the middle?

The Haikey Creek case history is not unique. It could happen anywhere. And as it shows, each jurisdiction adopting its own floodplain measures is not enough; the effects along *all* the stream must be considered, either formally or informally. For the more the upstream areas urbanize and the more they simply hasten on their stormwater, the greater the potential disaster downstream. And the same can happen in reverse by adverse downstream measures—blockage below will mean backwater above. No one is safe, acting alone (Fig. 19).

3. SALT CREEK—THE CLASSIC INTERGOVERNMENTAL CASE

Sometimes direct coordination doesn't work—you need someone else to pull things together. In the Salt Creek watershed, the Du Page County Forest Preserve District did that with mixed success.

The Setting: A Headstrong Stream, a Patchwork of Jurisdictions, and a Flooding Problem

The Salt Creek has a mind of its own; it goes where it wants regardless of political boundaries. Located northwest of Chicago, it begins in Lake County but quickly passes into Cook County. From there, it cuts through the northeast section of Du Page County and finally returns to Cook County again before ending its 40-mile journey at the Des Plaines River, which in turn flows to the Illinois and then to the Mississippi (Fig. 20).

Along its way, Salt Creek and its tributaries drain part or all of 32 municipalities, 17 in Cook and 15 in Du Page (Fig. 21). The municipalities in Cook County close to Chicago and O'Hare Airport have been heavily developed for some time; the rest in the Salt Creek basin are fast on their way to becoming so. Municipalities sharing the Salt Creek watershed in Du Page County grew from 101,787 in 1960 to 158,340 in 1970 (constituting 60% of the County's total population); those in the upper Salt Creek's Cook County area grew from 38,273 to 112,232.

The Salt Creek is prone to frequent flooding, not usually of a disastrous nature, but enough to be a big nuisance. There are several contributing factors: (1) the stream has a low gradient, resulting in low velocity; (2) with this slight gradient, construction such as highways and railroad embankments have an especially significant effect on drainage and floodplain characteristics; and (3) the Salt Creek basin is a youthful, poorly drained system with numerous stagnant swamps and natural depressions. But these swampy complexes are an important part of the Creek's hydraulic system: as they become filled or eliminated, their holding capacity lessens, surface water runoff increases, and so does the potential level of flood damage.

The upper Salt Creek basin in Cook County developed a multi-government approach to flood control in the early 1970's through a study by the U.S. Department of Agriculture's Soil Conservation Service. However, the area to be considered in this case history will be limited to Du Page County, for it too is headstrong in its own way: though sandwiched within Cook County, Du Page has remained steadfastly independent in its flood planning.

Flood Planning in Du Page: A Plan Rejected; A Plan Adopted

Spurred by an August 1972 flood which caused $5 million damages throughout the Salt Creek watershed, Du Page County undertook to develop a coordinated set of policies towards floodplain management—policies which previously had been determined by each municipality individually. But the state acted faster. A plan released by the State Division of Water Resources in February 1973 proposed a number of structural measures costing $14 million along Salt Creek in Du Page County. It specifically rejected as infeasible an "open land concept" under which all flood-prone land would be acquired and used for recreation.

However, Du Page was beginning to formulate its own, quite different approach. In 1972, the recently formed Du Page County Regional Planning Commission (RPC)* adopted a set of development policies for the county, many of which related to flood hazards:

- natural resource conservation was to be the principal determinant of urban development;
- such development was to avoid flood and drainage hazard areas, which were to be devoted to open space use;
- lands adjoining streams and other water bodies were to be preserved in their natural state;
- surface water resources and groundwater recharge areas were to be protected from pollution and encroachment; and
- natural drainage patterns, water retention areas, and floodplains were to be preserved so as to minimize flood hazards and preclude the need for structural remedies.

On the basis of all these points, especially the last, the RPC objected to the state plan, as did Du Page representatives to the state legislature, and that plan

*The Du Page County RPC was formed in 1970 to provide planning and zoning services for the county's unincorporated areas and to coordinate the incorporated municipalities.

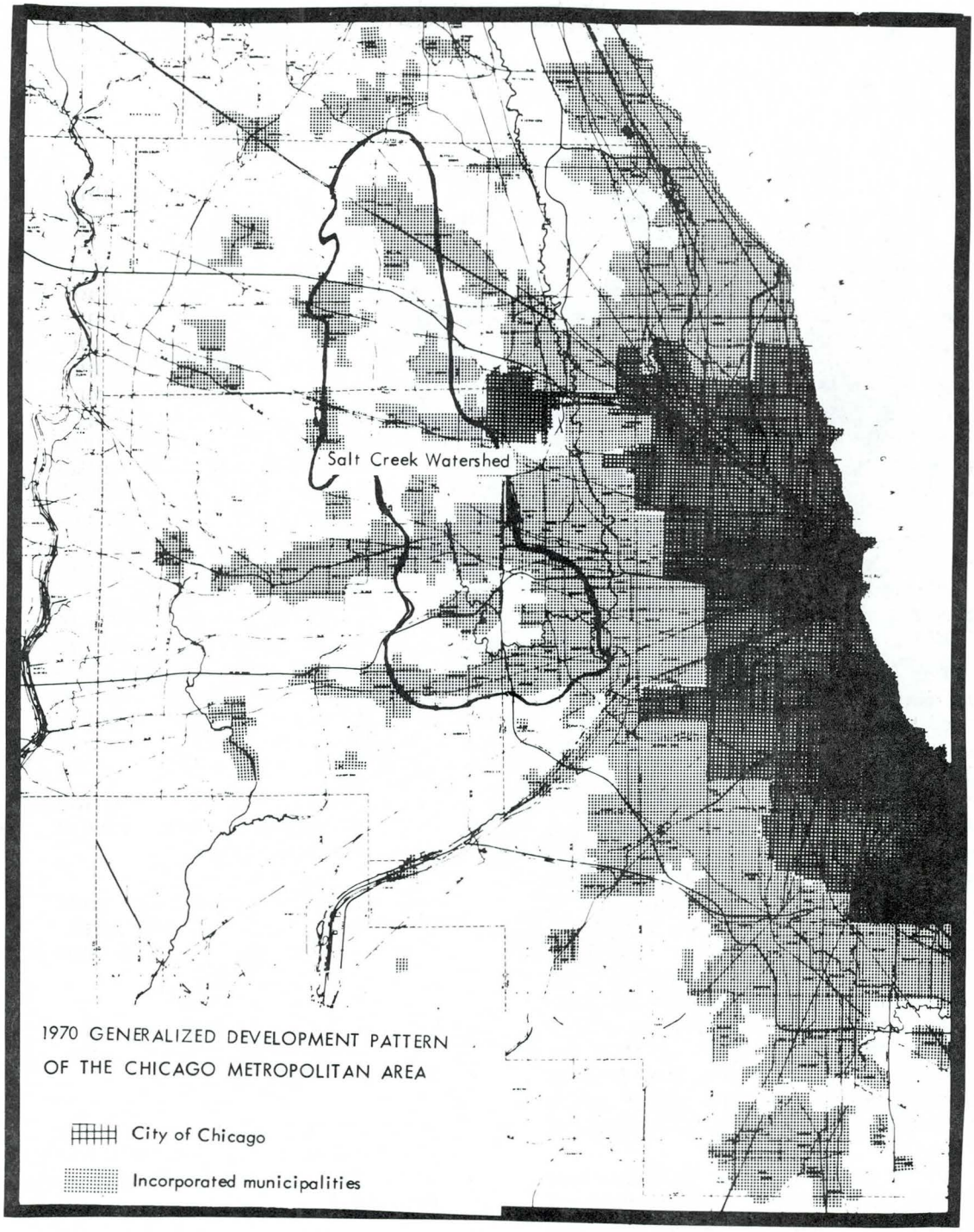


Figure 20. Salt Creek Watershed and Chicago Metropolitan Area.

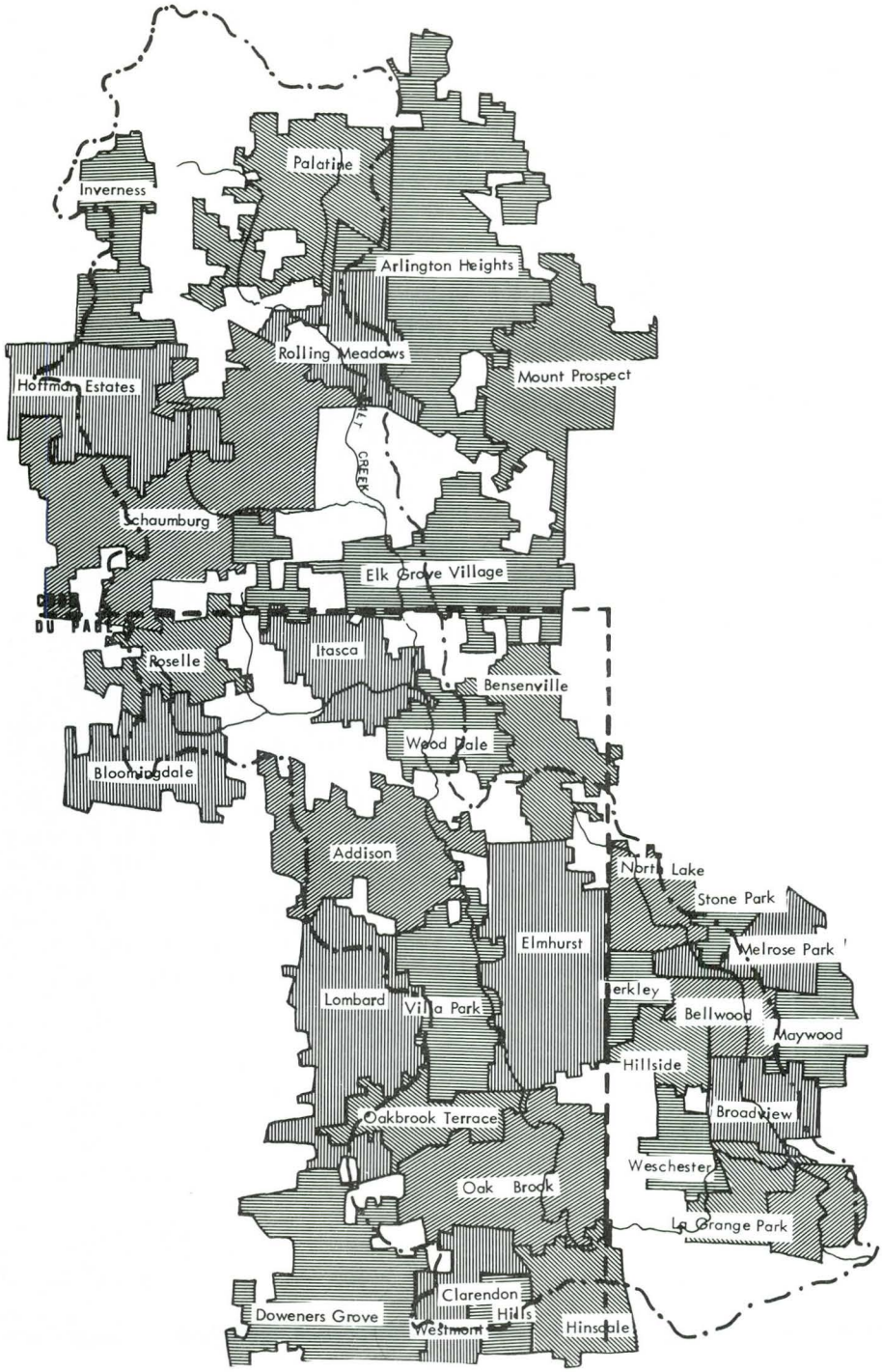


Figure 21. Municipal Jurisdictions of the Salt Creek Watershed, 1977.

stalled.

The RPC then proposed to do its own flood management study in conjunction with the Du Page County Forest Preserve District. (By Illinois law, this district constitutes an independent corporation with power to acquire and manage forests and related lands within the county's territory.) The proposal to do a study was well received, and the firm of Bauer Engineering was retained, serving as consultant to the RPC and the Forest Preserve District.

Diametrically opposite to the state plan, the crux of the Bauer plan was public acquisition of key flood-prone areas: 15 sites totaling almost 3,000 acres (Fig. 22). This acquisition program, which was to help realize the purposes of the development policies and constraints previously set forth, was estimated at that time to cost $8 million and was to be done by the Forest Preserve District. The plan was formally adopted by the RPC—presumably with at least the tacit support of the RPC's constituent municipalities—and its implementation was under way.

Meanwhile, a sidenote: a group appropriately called FLAC (Flood Land Action Committee) made up of disgruntled Du Page property owners was putting pressure on county and local officials to adopt floodplain regulations, which were notably lacking in the Bauer plan. Either in response to or in spite of FLAC pressure, the Du Page County RPC adopted a comprehensive ordinance to prevent floodplain or wetland alteration in unincorporated areas without a special use permit from the County Planning and Zoning Department.

But the distinctive feature of the Du Page County approach—and the one on which much of its potential value rests—is the acquisition program of the Forest Preserve District. By 1978, more than one-third of the area proposed for acquisition either had been purchased or was in the process of condemnation. During the early years of this program, there was one especially notable success; one notable failure.

Success at Kingery West

Kingery West is a 300-acre area straddling Salt Creek for about 1.5 miles in Du Page County. Although mostly unincorporated, Kingery West includes small portions of Elmhurst, Addison, and Villa Park (Fig. 23). By 1970, Kingery West contained over 200 houses, a 204-unit apartment complex, six commercial buildings, and a wastewater treatment facility. Many of these had experienced frequent flooding: damaging floods had occurred there in *ten* of the years between 1960 and 1974, and in the August 1972 flood, ninety homes were inundated, many with sewage-laden waters. Wells were so contaminated by septic tank flooding that drinking water had to be imported by tanker truck for two years thereafter. Despite its flooding history, a massive development was proposed for the southern part of Kingery West in Elmhurst, but this project was aborted by financial setbacks.

This set the scene for the Bauer plan, which listed in its proposed acquisition program 146 acres of Kingery West, including eighty-two homes. Seventy-five families were to be relocated, and the area was to become permanent open space for flood protection, recreation, and aquifer recharge purposes. Instead of the channel and cement dike proposed earlier by the state, an "undulating land form" was to be built to protect adjoining areas from flooding. This form would be built using fill from the floodplain, thereby simultaneously creating small lagoons and flood storage reservoirs. A bike path and other recreation was to be the responsibility of the Forest Preserve District, as was the whole responsibility for the Kingery West acquisition: acquisition costs were estimated at $3.5 million, including relocation expenses.

To cover the acquisition costs, the state legislature increased the District's permissible debt ceiling by 2% of the county assessed value, with this bonus earmarked for flood control. Kingery West residents, some vehemently opposed to the project, were mollified by the $15,000 above fair market value that was given each family to cover relocation expenses. By late 1980, the project was nearing completion, with 139 acres owned by the District and all occupants relocated. Construction of the protective land form and related improvements was scheduled to be done with funds from the State Division of Water Resource

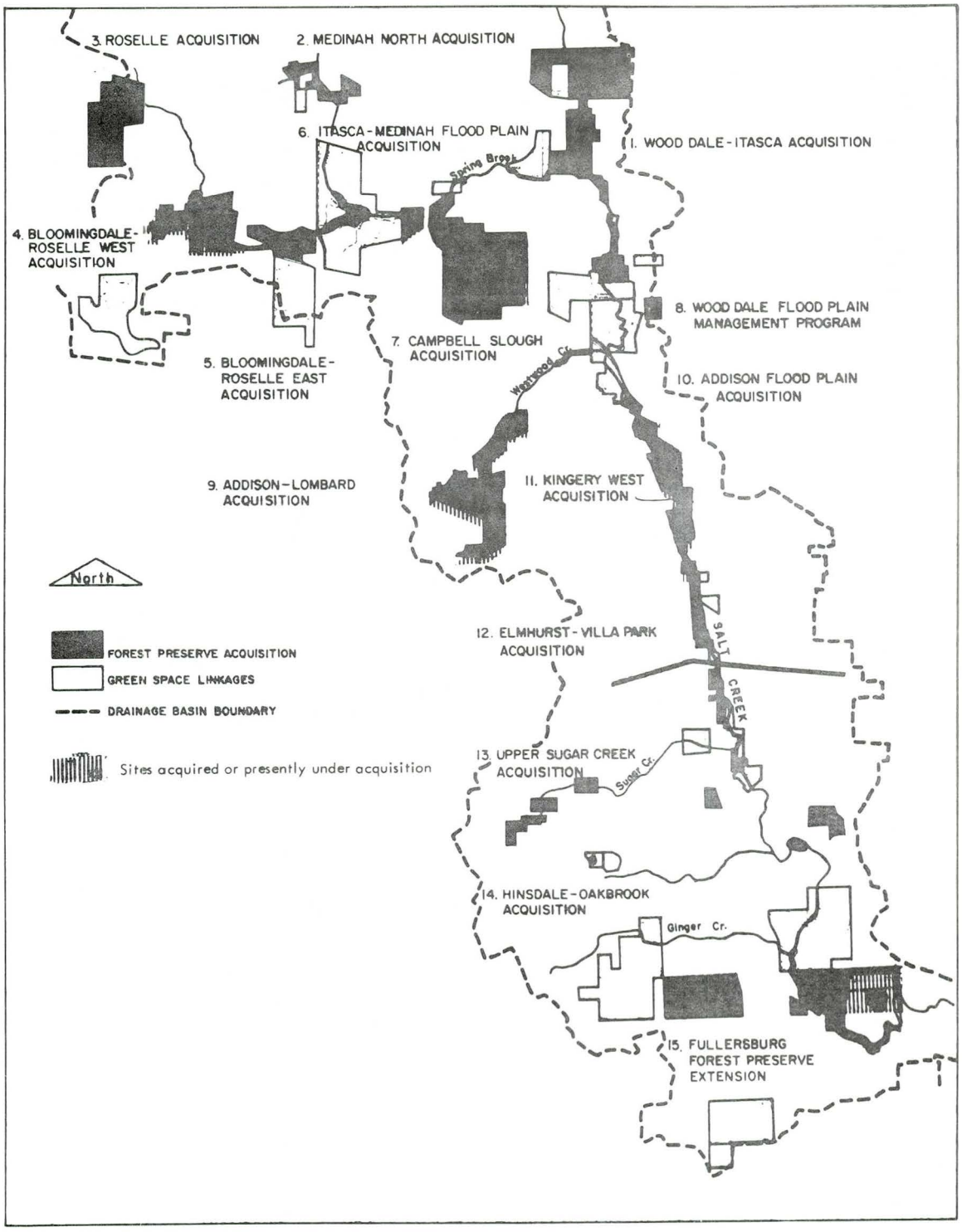


Figure 22. Salt Creek Watershed: Sites Proposed for Acquisition by Du Page Forest Preserve District (Courtesy Bauer Engineering Co.).

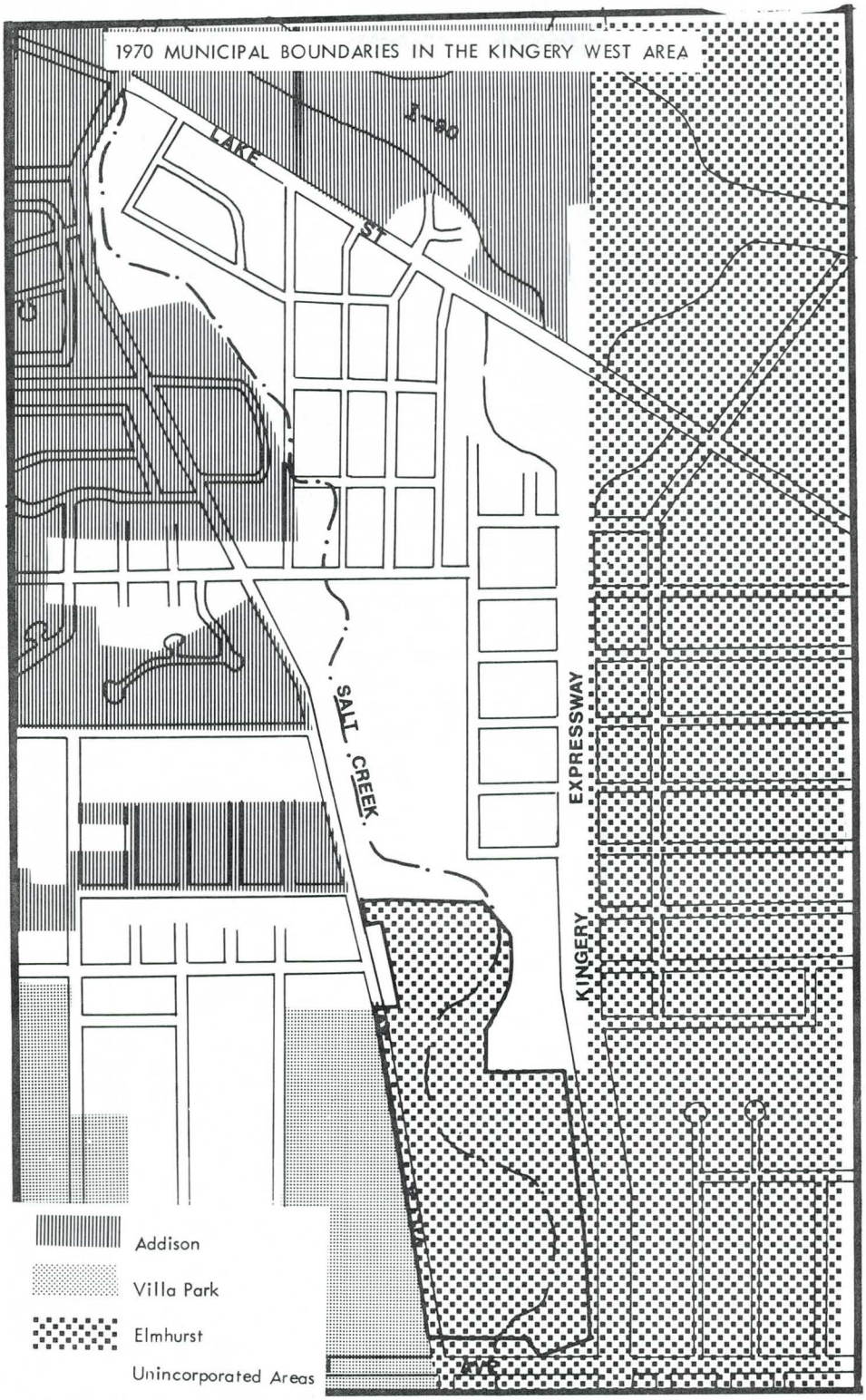


Figure 23. Municipalities Surrounding Kingery West Subdivision at Time of its Acquisition by Du Page County Forest Preserve District.

Management. So the Kingery West acquisition has been a fairly resounding success. But then there was the failure at Campbell's Slough.

Failure at Campbell's Slough

Campbell's Slough is a small marsh in the middle of a 715-acre tract of farmland. Stormwater will collect there, with some of it being stored by the marsh and seeping into the ground; the rest—during especially bad storms—is carried off to the east as sheet flow. The latter phenomenon, aggravated by an interstate highway which bisects the tract, brings flooding to the adjoining communities of Wood Dale and Itasca.

But the flood problem would be much worse if the Campbell's Slough area were developed, so in a token display of intergovernmental cooperation, the mayors of Itasca, Wood Dale, and Addison agreed that this should be discouraged. Theirs was not a legally binding commitment, however. Because of its weakness, the Bauer plan instead recommended that the Forest Preserve District acquire the entire Campbell's Slough. The plan's rationale was that (1) the slough's flood storage and natural recharge functions would be protected; (2) the site would be a permanent open space and wildlife sanctuary; (3) portions of the land could be retained for farming and recreation; and (4) the site could be used for spray irrigation of wastewater (also called "land treatment").

The last point was especially significant because it would enable 85% of the site's acquisition cost to be covered by the U.S. Environmental Protection Agency. A proposal was made with the Du Page RPC, the Forest Preserve District, and Itasca in support, but the proposal was opposed by some neighboring homeowners, the Du Page County Department of Public Works, and Addison. (The latter, Addison, had a vested interest in the existing, conventional sewage treatment approach because it had been named the lead agency for the three-community wastewater planning area of which it was a part, giving it an edge in that area's growth control.)

The land treatment debate lasted three years and came to a head over a 120-acre planned unit development (PUD) proposed for Campbell's Slough. Since the PUD was to be located on unincorporated land, the developer applied to Addison for annexation and appropriate zoning. The wrath of Wood Dale and Itasca was provoked; they saw the PUD as threatening to increase flooding in their communities by increasing runoff from Campbell's Slough. It also threatened the land treatment concept there: when Addison went ahead anyway with its annexation and zoning and began granting building permits, the wastewater irrigation project was shelved. Without it, there was no prospect of 85% federal funding, and the Campbell's Slough acquisition plan was drastically reduced. Legal recourse against Addison's peremptory action regarding the PUD was possible, either through a condemnation suit by the Forest Preserve District or through civil suits by Wood Dale and Itasca (or their residents), but these were never filed. And so by defection and default, an imaginative flood control program for Campbell's Slough was never to be tried.

Summary: How Viable Is the Forest Preserve District Approach?

That depends on how you look at it. The Forest Preserve District of Du Page County, with its special function, special powers, and countywide jurisdiction, was better able than any one of its constituents to address a regional flood problem along Salt Creek. However, as the Kingery West and Campbell's Slough situations showed, the Forest Preserve District could only be as strong as those constituents' commitment. Lacking that commitment—and barring strong-arm tactics that might negate its future acceptance—the Forest Preserve District was unable to realize fully its floodplain management capabilities. In the end, when more and more homeowners are standing waist-deep in sewage-laden floodwaters, this fact may sink home.

A further limitation of the Forest Preserve District approach was the absence of any coordination across *county* lines, specifically with regard to the rest of the Salt Creek watershed upstream and downstream in Cook County. This need was finally addressed in 1979 through state floodplain regulations for all of Salt Creek. It is too early to assess the effect of these state regulations, but they bode well.

4. MARYVILLE AND ALCOA, TENNESSEE—TOWARDS A PISTOL CREEK SOLUTION

No one loves Big Brother, but sometimes he can help out. This is a case history of how Maryville and Alcoa, working with the Tennessee Valley Authority and the Tennessee State Planning Office, started solving their Pistol Creek flooding problem.

The Setting: A Small River and Two Small Cities

Pistol Creek is just a little gun, but it can be fierce. It rises in the foothills of the Smokies in eastern Tennessee, flows north through the farms, houses, businesses, and industrial developments of Maryville and Alcoa, and then joins the Little River, which in turn joins the Tennessee (Fig. 24). While not a big stream normally, Pistol Creek has a steep gradient with low banks in places. One of those places is downtown Maryville. High waters often arrive in the form of flash flooding—increasingly so as Maryville and Alcoa have become urbanized and hastened surface water runoff.

Although incorporated as cities, these two municipalities are small by most standards: Maryville's population was 13,808 in 1970; Alcoa's was 7,739. Though side by side, the two cities are nonetheless quite different. Maryville is a traditional place—county seat since the 1790's and home of Maryville College since the mid-1800's. More recently it has also become a bedroom community for the Knoxville area, but its aura of tradition remains. Alcoa, on the other hand, is a one-industry town, and that industry is the Aluminum Corporation of America—founder of the town in the early 1900's and still its principal employer and largest landholder. Besides sharing a border, the two cities share the distinction of being the two principal municipalities in Blount County (not a very great distinction, since Blount County's 1970 population was only 63,744 and the county is still predominantly rural)—otherwise Maryville and Alcoa have little in common. Nevertheless, with help from outside, they have developed a certain rough cooperation in the face of their mutual flooding problem.

Floods and a Joint Response

Pistol Creek has flooded a number of times in the Maryville-Alcoa area. An 1875 flood with damages estimated *at that time* to be $150,000 was the biggest flood of record, but others have caused substantial damage, including a 1963 one with losses of about $75,000. It has been estimated that a $3 million flood is theoretically possible.

Prior to 1963, Maryville and Alcoa had already made some moves toward floodplain management: in 1958, Maryville turned to the Tennessee Valley Authority (TVA) for information and technical assistance from TVA's Local Flood Relations Program, a program started by TVA in 1953 to provide flood problem assistance to communities on request. Maryville's request was followed by a joint request from the Alcoa and Maryville Planning Commissions and the regional branch of the Tennessee State Planning Office (TSPO), which was assisting the two local commissions. The result was a hydrological report released in 1959 by TVA which prompted further local studies that in turn led to the adoption of floodplain provisions in Maryville and Alcoa's zoning and subdivision controls.

All this happened before the 1963 flood. But that flood, together with continuing technical aid from TVA and TSPO, spurred the municipalities on to more extensive and planned flood precautions. One approach was quickly put aside: a study initiated in 1962 and done by the Army Corps of Engineers and the U.S. Soil Conservation Service found structural control infeasible because of its cost (an estimated $750,000) and because of the difficulty of locating a dam or channel when the flooding problem was coming from more than one source (the Pistol has several tributaries). With the structural approach abandoned, TVA offered its technical assistance at a meeting of Maryville, Alcoa, and Blount County officials—a meeting which led to the establishment of the Joint Flood Study Committee. This committee, made up of representatives of the three local governments (the county, which has jurisdiction over unincorporated land, and the two municipalities), was to explore possible solutions to the flood problem with the

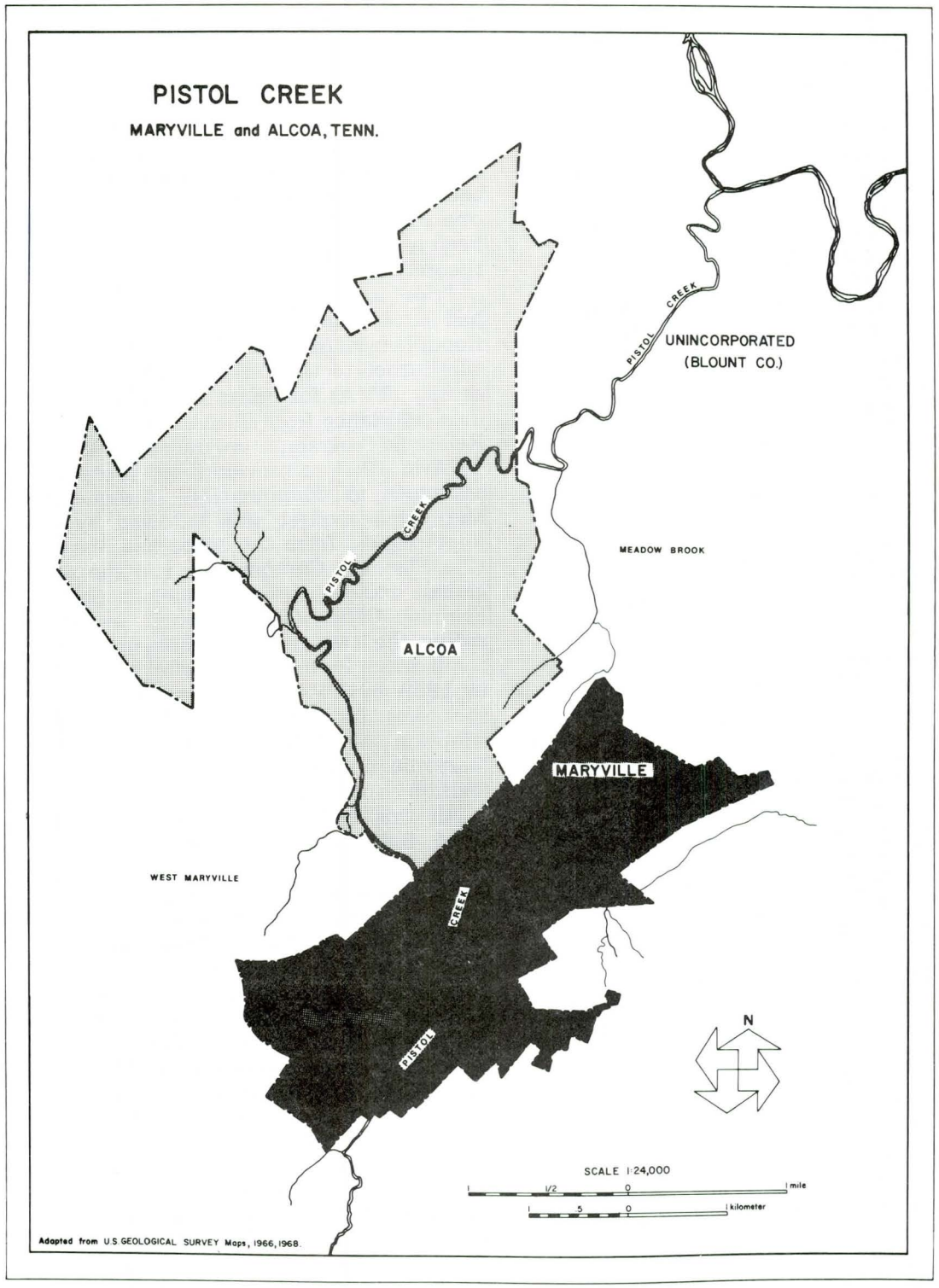


Figure 24. Maryville and Alcoa, Tennessee in Relation to Pistol Creek.

help of TVA and TSPO and make recommendations to the cities and county.

The Joint Committee was divided into four work groups: Flood Control, Flood Plain Regulations, Flood Proofing, and Urban Renewal. They had outside help from interested citizens and especially from TVA, which designated one of its employees as a liaison to the committee, gave it engineering assistance on the physical and economic feasibility of alternate flood control measures, and supplied background data and other general advice (with advice on zoning and subdivision controls from TSPO). The result was the committee's 1965 "Plan for Flood Damage Prevention at Maryville, Alcoa, and Blount County."

The 1965 Plan and Its Outcome

The 1965 plan was a success in terms of the scope of its recommendations, but not all of those recommendations have been carried out. Listed below are six key elements of the 1965 plan and their outcomes over the subsequent twelve years.

- *Stream widening and clearance.* Recommended widening in Maryville not done; it would have required buying easements, and Maryville lacked the funds. Some channel clearance was done, mostly using Comprehensive Employment and Training Act (CETA) employees.

- *Coordinated channel improvement below Maryville sewage treatment plant.* Not done, but the plant was replaced by a regional sewage treatment plant downstream on the Little River.

- *Floodproofing of public buildings.* Three county buildings were within the Maryville floodplain, but floodproofing was not done on them.

- *Encouragement of private floodproofing.* Done, insofar as possible, by a program of public information and technical assistance shortly after the 1965 plan came out. However, it seems that there was little response, and the program was not ongoing.

- *Revision of zoning and subdivision controls.* Done, so that Maryville and Alcoa's floodplain provisions have become more compatible. They are also more extensive in their geographic scope—both cities' subdivision review powers now include unincorporated areas within five miles of their boundaries. However, other unincorporated parts of Blount County still lack substantive land use controls.

- *Incorporation of flood damage provisions in urban renewal projects.* Done, especially in Maryville, whose downtown underwent a major facelift during the late 1960's and early 1970's. Funded mainly by federal money, which was then flowing freely for urban projects, the Maryville project was generated by several other objectives but did include flood management as a need and an outcome: a key feature of the project was the relocation of a number of families and businesses, replaced by a greenbelt park along the creek in the areas likely to receive the most severe flooding (Fig. 25).

Summary: No Panacea, But a Good Approach

Thus, as noted above, Maryville, Alcoa, and especially Blount County did not fulfill all aspects of their 1965 plan—just some of them. However, to the extent that floodplain management *was* accomplished there, it was due to a set of fortunate circumstances: (1) a geographic setting wherein Maryville, the upstream city, was also the one with the greater potential flood damage and could not simply pass its problem on downstream to Alcoa—the problem had to be solved closer to the source; (2) a committed local government and an enthusiastic citizenry, especially in Maryville's case (due perhaps to its more severe flood problem); (3) a well-conceived program for flood management in the form of the 1965 plan; (4) an ample supply of federal money to overhaul Maryville's downtown area, including flood-prone sites; and (5) an ongoing outside source of technical assistance, offered by TSPO and especially TVA.

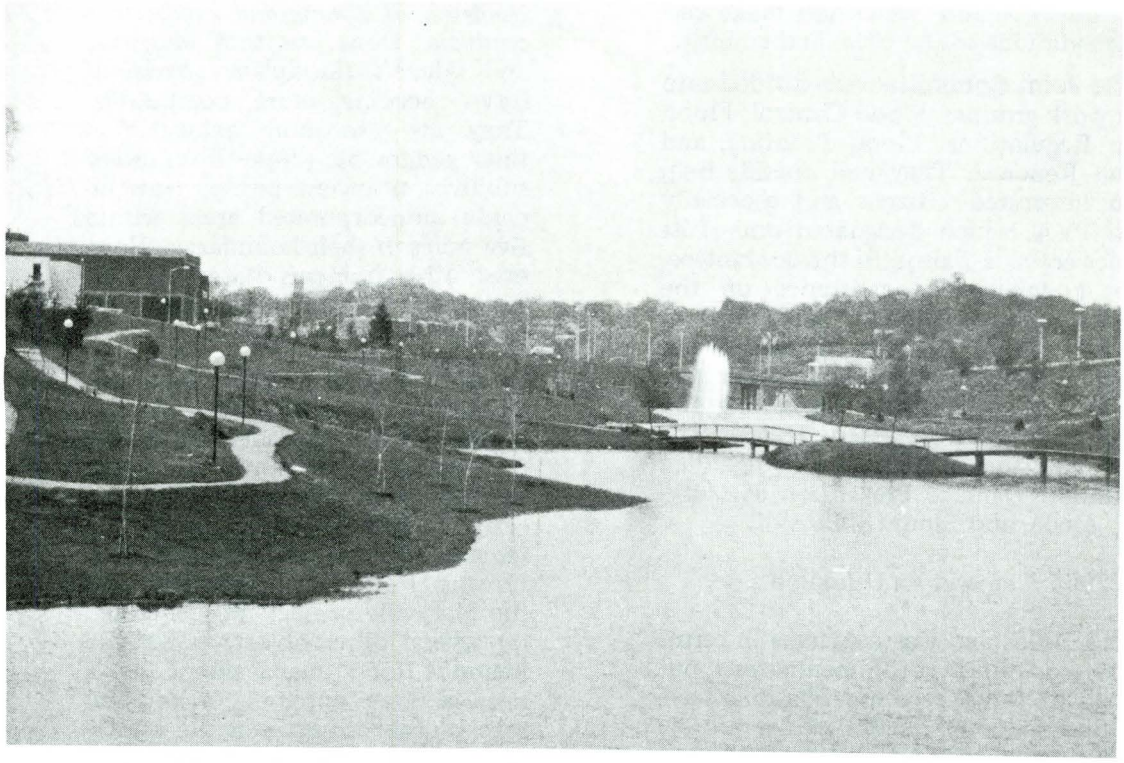


Figure 25. Reflecting Pool and Park Created by Urban Renewal Along Pistol Creek.

The last point is particularly important. Without the outside assistance of TVA and TSPO, which at times helped to generate discussions and coordinate them, the 1965 plan might never have been done, and flood management in the Maryville/Alcoa area would have proceeded haphazardly.

TVA and TSPO were not coercive forces, but cohesive ones. In the United States, where land use control—including floodplain management—traditionally has been a local affair, there can still be a role for regional, state, and interstate agencies, even if they lack specific authority over the land in question. That role is one of *guidance* and *assistance*, using the greater technical resources and broad expertise at their disposal to help local governments individually and collectively, bringing them into better accord with each other.

5. LILYDALE: FLOODPLAIN ACQUISITION BY EXTRATERRITORIAL POWERS

Can interference to help a neighbor in distress be justified? Sometimes, as shown in this case history.

The Setting: A Small City with a Big Flooding Problem and a Helpful Neighbor

This is a tale of two cities and two counties divided by the Mississippi River. Lilydale, Minnesota (1970 population of 426), in Dakota County faces the City of St. Paul (population 304,651) in Ramsey County across the "Father of Waters" (Fig. 26). Although near its headwaters, the Mississippi is already sizeable, and so are its bluffs—rising to 200 feet or more of loess and limestone. Lilydale straddles these bluffs and contains two very different communities: Upper Lilydale on the crest of the bluffs, home of tidy suburban houses, condominiums, businesses; and Lower Lilydale down on the riverfront, by the late 1960's

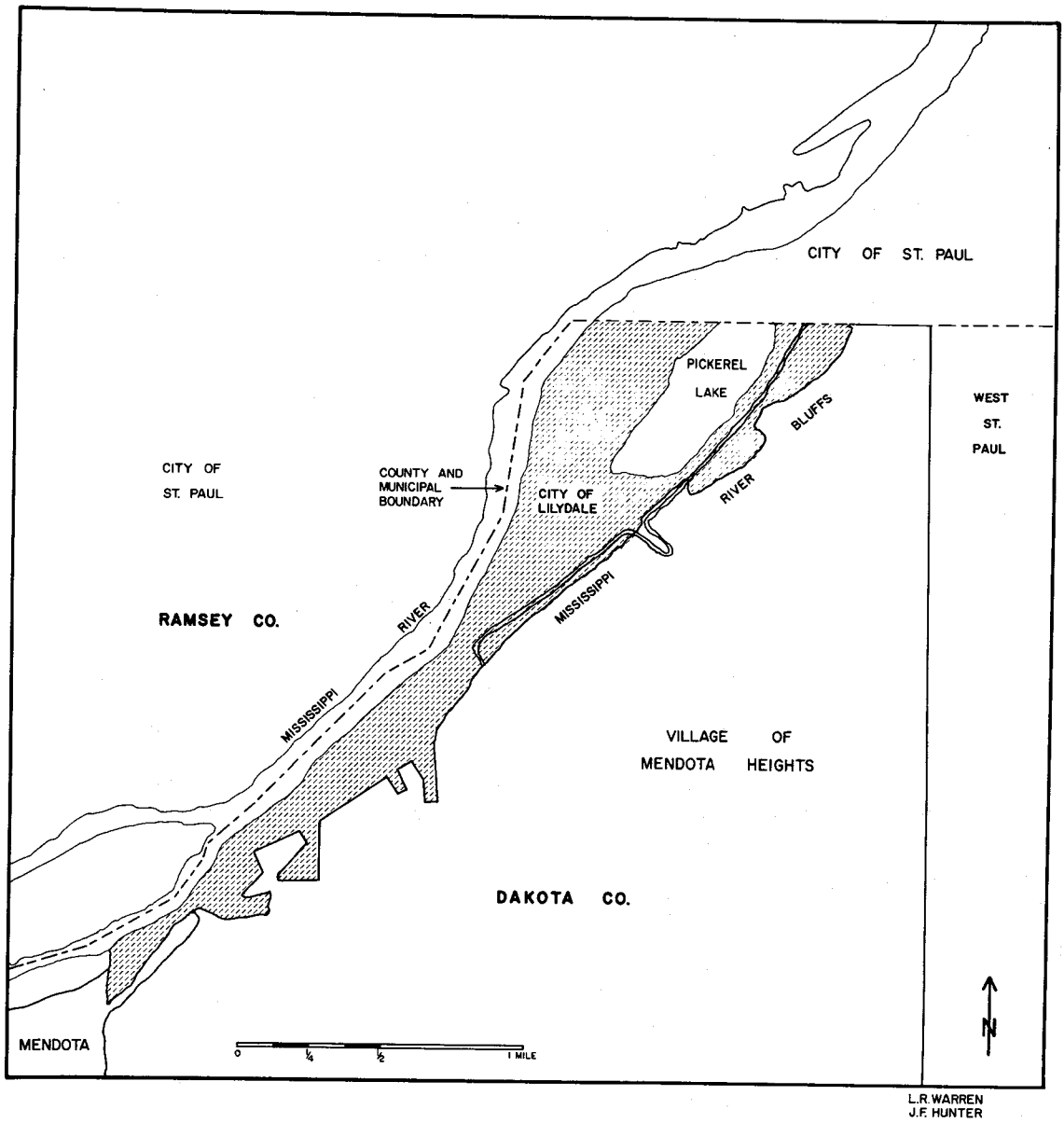


Figure 26. Political Jurisdictions in Vicinity of Lilydale, Minnesota, 1977.

a nesting of mobile homes with a boat marina as its sole commercial facility.

Lower Lilydale has known many floods. Located on a constricted inside bend of the Mississippi, lower Lilydale is right by the river—in it when it floods. And that can happen often, with disastrous results. In 1965, floodwaters destroyed all 13 permanent homes still remaining in lower Lilydale, and 104 people were evacuated. Total damages in Lilydale: $1,033,000. Subsequently, building permits—even for reconstruction—were prohibited by the city; lower Lilydale residents put mobile homes on the lots they owned. In 1969, flooding came again, but this time, people hauled their homes to safety. Total damages: $245,000.

Obviously the only permanent solution would be to relocate the lower Lilydale residents and convert the site to public open space, but two factors impeded this: (1) the resistance of lower Lilydale residents, who would then have no place to put their mobile homes (the Lilydale floodplain was the only spot in the region whose zoning allowed mobile homes on individually owned lots); and (2) the indifference of upper Lilydale and Dakota County in general, neither of which was interested in paying for the creation of a park that would probably be used mainly by St. Paul's residents. Of the two factors, the second was the more potent, for upper Lilydale had political control of the city government.

However, others in the Minneapolis-St. Paul metropolitan region were very interested in the idea of a relocation/open space solution to the lower Lilydale flooding problem, especially Ramsey County, which lies both upstream and cross-stream from Lilydale. The land right next to the Lilydale floodplain in St. Paul* was maintained as a city park, and the 1969 Ramsey County open space plan called for acquisition of lower Lilydale, as did the 1973 open space plan of the Twin Cities Metropolitan Council (or "Metro Council"). But neither of these had jurisdiction in Lilydale, so how could they acquire the land? Elsewhere, the matter might have been dropped. In Minnesota, however, there is a strong tradition of floodplain management which was challenged by the dangerous and economically costly perpetuation of lower Lilydale as a residential community. Also, with the statehouse only a mile and a half away in St. Paul, there was interest in the state government to remedy this repugnant situation.

The Joint Powers Agreement

Minnesota has a number of floodplain management tools at its disposal, but one that is particularly applicable in intergovernmental situations is the joint powers agreement. Under this legal mechanism, any number of local governments, counties, special districts, or the state itself may contract with each other to achieve a common purpose. In this instance, the common purpose was the relocation/open space acquisition of lower Lilydale. The contracting parties were Ramsey County—the prime mover—and Lilydale and Dakota County, acquiescent as long as the costs fell elsewhere. Specifically, their 1972 agreement said that (1) Ramsey County would make purchase offers to all the lower Lilydale landowners within two years; and (2) Ramsey County could exercise any of the powers which the other two contractors had (e.g., ownership and management of the acquired floodplain) except the power of eminent domain. But the agreement was hampered by two uncertainties: one legal, the other financial.

Legal and Financial Obstacles

On the legal side, the issue was whether Ramsey County *could* buy land outside its borders. (The joint powers agreement presumed it could, but the agreement could not in itself grant that authority.) The legal issue came to a head in 1973 when new members of the Ramsey County Board refused to sanction spending their county's money on the Lilydale acquisition, maintaining Dakota County would still retain jurisdiction over the purchased land. Things looked even bleaker when the state's attorney general ruled that—apart from who would have jurisdiction over the site—Ramsey County lacked authority to *buy* it, since it was outside the county's borders. The day was saved—legally at least—when a pro-acquisition coalition successfully lobbied through a special act amending Ramsey County's Open Space

Act by allowing the county to engage in extraterritorial acquisition.

Summary: In the Best Interests of All?

There are two questions here. One is whether even a good intention is a justifiable reason for extraterritorial intervention, where the issue at stake is—on the surface, at least—local in nature. In the Lilydale case, the continued existence of its floodplain as a residential area was hurting chiefly the residents—who didn't want to move. This is an argument against extraterritorial intervention. However, three factors argued *for* extraterritorial intervention in this case: (1) the lower Lilydale flooding was placing an economic burden on the region as a whole because of necessary disaster recovery efforts; (2) the formal powers of the local government *voluntarily* agreed to the relocation/open space proposal, their only stipulation being that they didn't want to pay for it; and (3) the region needed open space, and this was a logical component of a regional open space plan. Thus, in this instance at least, the regional interest justifiably overrode a narrowly-viewed local interest (which in any case might not have been hostile if they'd been sure of an equitable recompense from the beginning).

But that brings up the second question: if the relocation/open space proposal was really in the *regional* interest, who should pay? Not Lilydale, not Dakota County, not even Ramsey County, but the *region*, and reasonably so. For this solution represents the logical strategy of allocating the cost of an action to the level of government that encompasses both the costs and the benefits of the action. There are problems with this—neither the costs nor the benefits can be evenly distributed across the region, and furthermore, few metropolitan areas have as strong a regional government as the Twin Cities area has. But even with those constraints, it would still behoove other metropolitan areas to consider whether the Lilydale solution might be a way to solve seemingly intractable floodplain management problems in their own region.

*As shown in Fig. 26, the boundary between Lilydale and St. Paul (as well as Dakota and Ramsey Counties) crosses the river at the downstream end of Lilydale.

But the battle was not over. There was still the money issue, which came down to this: there was not enough of it. Ramsey County lacked sufficient funds to acquire the lower Lilydale land; state money was unavailable; and Minnesota's share of the federal Land and Water Conservation Fund had already been divided up. Finally, Ramsey County was able to get a state commitment for $825,000, with the county to make up the difference through a bond issue. But then another setback, and this one seemed fatal: the state balked at releasing any money without evidence that the landowners whose property was to be bought were in financial distress. It finally relented, but only to the tune of $625,000—$200,000 less than their presumed share. This was not enough for the entire project, and the Ramsey County Board of Commissioners refused to allow *any* acquisition without full funding. What was to be done?

The Final Answer: The Metro Council Fund

Ramsey County's inability to start acquisition was fuel for the fire of a "committee of seven" then coalescing: the seven county park commissioners in the Twin Cities region, who saw urban open space rapidly disappearing and felt Lilydale was yet another example of the problem of relying on the counties individually to meet the region's open space needs. This group was able to persuade the state legislature to create a Metropolitan Parks and Open Space Commission with a revolving (renewable) $40 million treasury to make 100%-funded grants for open space acquisition. Through this program, Ramsey County was funded in 1975 to carry out the Lilydale project at a total cost of $4 million. Altogether, 113 families have been relocated from lower Lilydale.

6. CHARLES RIVER—MANAGING THE ENTIRE WATERSHED

"Everything is related to everything else"—and on the Charles River they have an idea about how to protect some crucial links in this natural system of flood management. Can it work?

The Setting: A Benign River with Several Faces

Like the Boston Marathon, the Charles River begins in Hopkinton, Massachusetts, and ends in Boston, but its course is less direct: it takes 80 miles rather than 26 to reach its destination. The entire watercourse may be divided into three distinct reaches (Fig. 27). The Upper Charles, extending 32 miles, drops somewhat in its first stretches, then flattens out, meandering through farms and wetlands. The next reach—the Middle Charles—takes the river 17 miles through outlying bedroom communities to the edge of the intown suburbs, where the Lower Charles begins and broad lawns and golf courses give way to old factories, warehouses, urban parks, and the well-known Boston Esplanade. The Charles watershed altogether encompasses 307 square miles, crossing or bounding twenty-one towns and cities and draining portions of thirteen others. (In Massachusetts, all land has been allocated to one municipality or another; there is no unincorporated land.)

The Charles is an expansive, leisurely river, made more so by two major dams near its Boston Harbor mouth and by vestiges of old mill dams upstream. Wide, flat plains of sand and gravel (products of glacial deposition) in its middle and upper reaches have made the upstream Charles in its natural state a flood manager's dream. Along its course are dotted a series of swamps, marshes, and other damp places collectively called wetlands. In hydrological parlance, these are, literally, natural valley storage (NVS) areas—natural sponges which capture and store surface runoff from upland areas, slowly releasing it over several days at a rate that eases flooding downstream.

Flood Experience, Population Pressures, and the 1972 Plan

The Charles can thus easily absorb brief but intense rain—extraordinary storms still cause trouble, however. And despite the famed fickle New England climate, rainfall in the Charles River area is fairly consistent: an average of 44 inches annually, usually distributed uniformly through the year—but not always, as the Floods of '36, '38, '55, '68, and '69 attest. Caused in most cases by summer hurricanes or heavy spring rains combined with snow melt, these floods wrought substantial damage upon downstream urban areas—for example, the 1955 flood entailed $5.5 million in losses, of which $3.5 million occurred along the river's lower reach. It is estimated that a recurrence of that flood today would cause $12.4 million in damages on the Lower Charles—nearly four times as much as before.

In total, flood losses on the Charles are expected to increase 3.2% annually, even assuming that physical conditions—the natural wetlands upstream—remain unchanged. This is a big assumption, since population in the watershed of the Upper and Middle Charles nearly doubled between 1950 and 1970 due to both improved highway links to Boston and an exurban business boom. This population pressure is likely to continue even despite economic recessions and energy crises.

Recognizing all this and responding to a 1965 resolution of the U.S. Congress, the New England Division of the Army Corps of Engineers developed a plan for the Charles in the late 1960's and early 1970's. A 1968 interim report recommended construction of a new dam on the Lower Charles, a project which was completed in 1978. More to the point here, however, was the Corps' 1972 plan, which also called for:

1) *Acquisition* of certain wetlands to protect NVS areas in the middle and upper watershed; and
2) *Regulation* of additional wetlands and flood-prone areas.

The first was to be done by the Corps using federal money; the second was to be done at the state and local level.

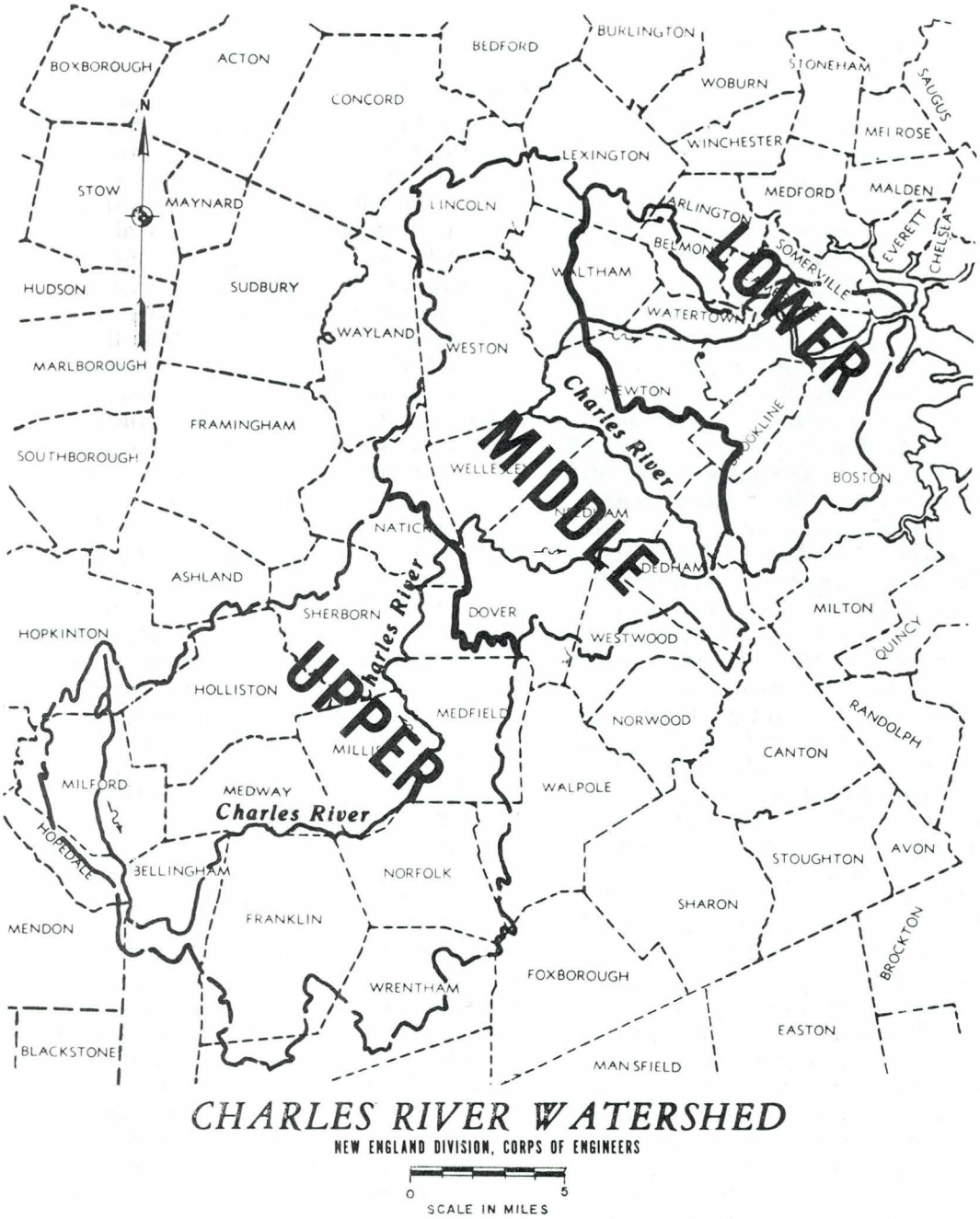


Figure 27. The Charles River Watershed and its Planning Reaches, Vicinity of Boston, Massachusetts

Implementation of the Plan

How well has the plan worked? That remains to be seen, but a prognosis is possible now.

The Corps' rejection—for both environmental and economic reasons—of a structural approach for the Middle and Upper Charles was a big first step, recognizing as it did the value of the wetlands as natural floodwater retention areas. Feasibility demanded that only major, undeveloped wetlands be acquired, to keep costs and the number of landowners to a reasonable level. So, out of the watershed's 20,000 acres of wetlands, 17 areas located in 16 different municipalities and totaling 8,422 acres were targeted for acquisition, in fee simple or through conservation easement (Fig. 28). (A taking by eminent domain was also possible as a last resort.) The owners of these wetlands included nonprofit land trusts, municipalities and the state, but about three-quarters of the area was in private hands—in all, a total of more than 500 owners.

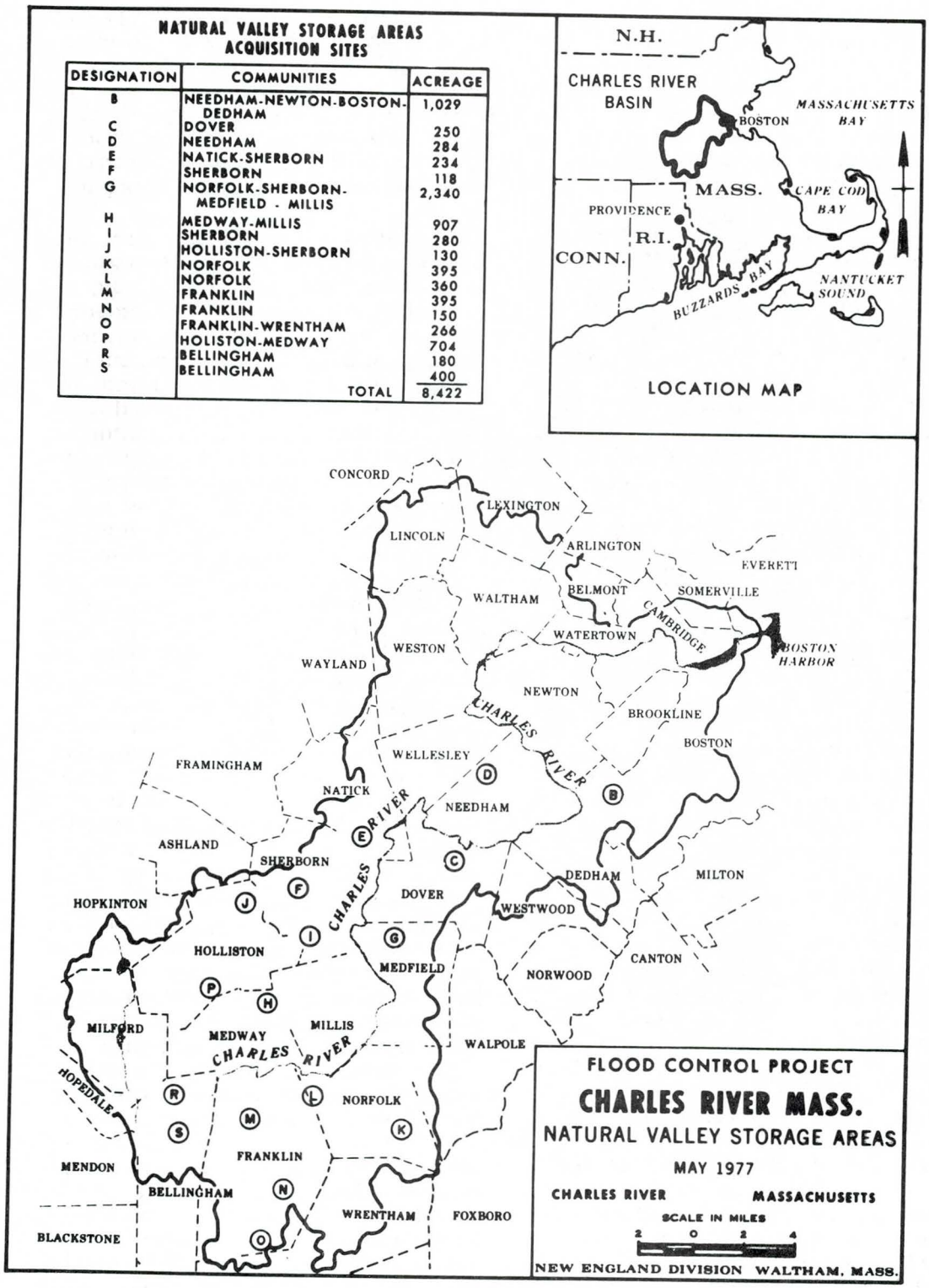
The acquisition of the wetlands entailed massive effort, but one that has been systematically pursued by the Corps, which developed an acquisition priority list based on imminence of development and hydrologic merit. The total project was estimated to cost $11 million. Astonishingly, this may prove to be more money than is actually needed, since the Corps has found it possible to acquire more tracts than expected through easements rather than fee simple. The total acquisition program included about 700 parcels in 17 sites amounting to approximately 8,500 acres. As of December 1980, some 400 parcels totaling 5,100 acres have been acquired. Of this acreage, 3,300 have been acquired by easement and 1,800 in fee simple.

The Corps' job has been made easier by enthusiastic private support: instrumental in the development of the 1972 plan was a Citizens Advisory Committee (CAC) organized as part of the Corps' study and composed of municipal, industrial, educational, recreational and real estate representatives. During the plan's development, the CAC reviewed plans, made recommendations and organized information meetings in the watershed. A more ongoing role has been played by other private groups such as the Charles River Watershed Association (CRWA), organized in 1965 to serve as an advocate for the Charles' natural resources and recreation possibilities. The CRWA has also become an advocate for the 1972 plan and has contracted with the Corps to help inform the public about it.

The second part of the plan, regulation of wetlands not protected by acquisition, has not been going so smoothly. At the time of its proposal, the plan had been informally supported by the Massachusetts legislature, but that support was not made formal until late 1977 when the legislature passed a bill which, among other things, authorized the Massachusetts Water Resources Commission to establish floodplain encroachment lines in the Charles River watershed and prohibited construction within those lines without a special state permit. This, together with other wetland controls available in Massachusetts—(1) the 1972 Wetlands Protection Act, which regulates wetlands alterations and is administered locally by municipal conservation commissions although with procedures for appeal to the Massachusetts Department of Environmental Management (DEM); (2) the 1968 Inland Wetlands Act, which, if backed by adequate data, has the power to restrict or prohibit the use of identified wetlands and is administered directly by DEM; and (3) local zoning powers (municipal floodplain zoning was upheld in a 1972 Massachusetts Supreme Judicial Court decision*)—meant that the state and local governments had a full armory of regulatory powers at their disposal to protect the Charles River watershed.

The municipal governments largely supported the 1972 plan and since then have been at work: between 1973 and 1978, ten towns in the watershed adopted floodplain/wetland zoning ordinances, bringing the watershed total to twenty-three; municipal conservation commissions have been tightening their administration of the Wetland Protection Act's permit system. Two factors have helped make the local climate favorable: through the 1977 legislative bill, municipalities were assured that they would be compensated for taxes lost on lands taken for flood control purposes; in addition, the land being taken was mostly

**Turnpike Realty Co.* v. *Town of Dedham*, 284 N.E. 2d 891.



DESIGNATION	COMMUNITIES	ACREAGE
B	NEEDHAM-NEWTON-BOSTON-DEDHAM	1,029
C	DOVER	250
D	NEEDHAM	284
E	NATICK-SHERBORN	234
F	SHERBORN	118
G	NORFOLK-SHERBORN-MEDFIELD - MILLIS	2,340
H	MEDWAY-MILLIS	907
I	SHERBORN	280
J	HOLLISTON-SHERBORN	130
K	NORFOLK	395
L	NORFOLK	360
M	FRANKLIN	395
N	FRANKLIN	150
O	FRANKLIN-WRENTHAM	266
P	HOLISTON-MEDWAY	704
R	BELLINGHAM	180
S	BELLINGHAM	400
	TOTAL	8,422

Figure 28. Charles River Watershed: Sites Planned for Acquisition for Natural Valley Storage by the Corps of Engineers.

undevelopable and so not prime investment land. But in any case, many of the towns in the Middle and Upper Charles had already begun to see the merits of open space and recreation over a burgeoning population and were ready to cooperate with the 1972 plan's implementation.

The Corps' 1972 plan for the Charles recognized this interdependence both in its selection of the sites to be protected by acquisition—those 8,422 acres, although less than one-half of the watershed's wetlands, comprise 75% of its natural storage capacity—and in its call for state and local restriction of the remaining wetlands. If just part of the latter were to be developed, the project's whole benefit/cost ratio (i.e., its flood control capacity) would be considerably lessened.

So the protection of the hydrologic chain has become dependent on the human chain, and again, the strength of the links individually is crucial to the strength of the whole. If the 1972 Charles River plan is to succeed, the participants must move with equal fervor, and with all possible speed. For with land acquisition or regulation, the stakes almost always get higher—the land more expensive or the buildings already built where they shouldn't be.

The Charles River watershed has everything going for it: a fortutious natural system of water storage areas, a good plan to protect those areas, federal money and interest, an array of land use controls, and a generally enthusiastic citizenry. It would be unfortunate if, out of bureaucratic negligence, this rare opportunity to help a watershed help its people was diminished.

The state's performance has been somewhat less zealous. Under an intergovernmental agreement with the federal government, dated March 7, 1977, the state agreed to:

- prevent modification or alteration of existing roadways, utilities, bridges, culverts [so as not to increase discharge to downstream areas];
- adopt and enforce regulations to restrict development of floodplain lands; and
- operate and maintain the existing dams along the Charles River.

Of these commitments, the second has been most problematic. Authority to set encroachment lines along the Charles was specifically granted to the Massachusetts Water Resources Commission by act of the legislature (Laws of 1977, Ch. 858), but no such lines have yet been established. (With most flood hazard areas on the Charles now mapped by the National Flood Insurance Program, the state role may not be needed.) Some progress has been made in restricting 6,000 acres of wetlands under the Inland Wetlands Act, but some of these areas are already protected through Corps acquisition or other means. The role of the state as middleman can be awkward, stepping in where others fail but trying not to step on any toes. However, it is also a good cause for procrastination, which may have been the case here. The state may prove to be the weak link in the chain—the federal-state-local-private effort to protect the Charles.

Summary: The Virtues of Speed and Diligence

But the real chain in question here is the hydrologic chain—that linked series of natural water retention areas which, besides aiding the environmental quality and beauty of the Charles, also can help residents along the river by reducing the effects of flooding. And no link can be considered independently of the others—losing one to development diminishes the effectiveness of the whole.

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GLOSSARY*

Building Code—A collection of regulations adopted by a local governing body setting forth standards for the construction of buildings and other structures for the purpose of protecting the health, safety, and general welfare of the public.

Channel—A natural or artificial watercourse of perceptible extent, with definite bed and banks to confine and conduct continuously or periodically flowing water. The top of the banks form the dividing lines between the channel and the floodplain.

Design Flood—The selected flood against which protection is provided, or eventually will be provided, by means of flood protective or control works. It is the basis for design and operation of a particular project after full consideration of flood characteristics, frequencies and potentials, and economic and other practical considerations.

Encroachment Lines—Lateral limits or lines beyond which, in the direction of the stream or body of water, no structure or fill may be added without permission from the regulatory agency that established them. Their purpose is to preserve the flood-carrying capacity of the stream or body of water and its floodplain. Their location should be such that the design floodway between them, including the channel, will handle a designated flood flow or condition.

Flood—An overflow of lands not normally covered by water and that are used or usable by man. Floods have two essential characteristics: the inundation of land is temporary; and the land is adjacent to and inundated by overflow from a river or stream or an ocean, lake, or other body of standing water.

Normally a "flood" is considered as any temporary rise in stream flow or stage, but not the ponding of surface water, that results in significant adverse effects in the vicinity. Adverse effects may include damages from overflow of land areas, temporary backwater effects in sewers and local drainage channels, creation of unsanitary conditions or other unfavorable situations by deposition of materials in stream channels during flood recessions, rise of ground water coincident with increased stream flow, and other problems.

Flood of Record—Any flood for which there is a gage record or other systematic or reliable record useful for technical analysis. Included are USGS and other official gage records; records documented in diaries, newspapers, and other reports; known high water marks; eyewitness accounts; and other data that are reliable and complete enough to be useful to the hydrologist.

Generally, this term infers it is the highest such flood.

Flood Control—The elimination or reduction of flood losses by the construction of flood storage reservoirs, channel improvements, dikes and levees, bypass channels, or other engineering works.

Flood Crest—The maximum stage or elevation reached by the waters of a flood at a given location.

Flood Frequency—The average interval of time, based on the period of record, between floods equal to or greater than a specified discharge or stage. It is generally expressed in years.

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*Adapted from Glenn R. Wall, ***Establishing an Engineering Basis for Flood Plain Regulations.*** Knoxville· Tennessee Valley Authority, 1969.

Flood Peak—The maximum instantaneous discharge of a flood at a given location. It usually occurs at or near the time of the flood crest.

Floodplain—The relatively flat area or low lands adjoining the channel of a river, stream or watercourse, or ocean, lake, or other body of standing water, which has been or may be covered by flood water.

Floodplain Regulations—A general term applied to the full range of codes, ordinances, and other regulations relating to the use of land and construction within the channel and floodplain areas. The term encompasses zoning ordinances, subdivision regulations, building and housing codes, encroachment line statutes, open-area regulations, and other similar methods of control affecting the use and development of the areas.

Flood Probability—The percentage chance of a flood equal to or greater than a specified discharge or height occurring during any one year.

Flood Proofing—A combination of structural changes and adjustments to properties subject to flooding, primarily for the reduction of flood damages.

Flood Stage—The stage or elevation at which overflow of the natural banks of a stream or body of water begins in the reach or area in which the elevation is measured.

Floodway—The channel of a stream and that portion of the adjoining floodplains designated to provide reasonably for passage of flood flows.

Floodway Fringe—The portion of floodplain between the limits of the designated floodway and the limits of the flood selected for controlling elevations.

Historical Flood—Any known flood for which there is no gage record or other systematic or usable technical record.

Mean Annual Flood—The arithmetic mean of the highest peak discharge experienced during each year of record at a given location. This flood is equaled or exceeded, on the average, once every 2.33 years.

Standard Project Flood—The flood that may be expected from the most severe combination of meteorological and hydrological conditions that are considered reasonably characteristic of the geographical area in which the drainage is located, excluding extremely rare combinations. Peak discharge for these floods are generally about 40 percent to 60 percent of the Maximum Probable Floods for the same basins. Such floods as used by the Corps of Engineers are intended as practicable expressions of the degree of protection that should be sought in the design of flood control works, the failure of which might be disastrous.

Subdivision Regulations—Regulations and standards established by a local authority, generally the local planning agency, with authority from a state enabling law, for the subdivision of land in order to secure coordinated land development, including adequate building sites and land for vital community services and facilities such as streets, utilities, schools, and parks.

Zoning Ordinance—An ordinance adopted by a local governing body, with authority from a state zoning enabling law, which under the police power divides an entire local governmental area into districts and, within each district, regulates the use of land, the height, bulk, and use of buildings or other structures, and the density of population.