

# ***From Rooftop to River***

*Tulsa's Approach  
to Floodplain  
and Stormwater  
Management*

***“In recent years, Tulsa has become one of the most progressive and far-sighted cities in the nation by promoting the protection of lives and property through the application of exemplary floodplain and stormwater management principles...***

***“This success is a direct result of the collective efforts and commitment of local government staff, elected officials, private sector organizations, and the citizens of Tulsa....”***

– Federal Emergency Management Agency, 1992



M. Susan Savage, Mayor

This booklet was prepared under the auspices of the City of Tulsa Stormwater Drainage Advisory Board and Public Works Department, Charles L. Hardt, Director.

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**May 1994**



*Tulsa Tribune photo*

▲ Looking east toward downtown: Tulsa's 1984 flood damaged nearly 7,000 buildings.

**Cover:** Tulsa's heart is on a high bank of the Arkansas River. *Bob McCormack photo.*

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Tulsa Park and Recreation Department photo

▲ The water's edge holds promise.

# Foreword: *Becoming Floodsafe*

Tulsa, Oklahoma, has been called America's most American city, because the age, race, income, and attitudes of our citizens reflect the United States as a whole. We're a test market for new products; if it works in Tulsa, it has a good chance of working elsewhere.

Tulsa's flooding problems also mirror many other towns. Our community was founded a hundred years ago on a major river and has a long history of floods, compounded by post-war growth, floodplain development, and frequent rainstorms.

By the 1980s, Tulsa's flooding had reached singular proportions. The federal government had declared Tulsa County a flood disaster area nine times in 15 years, more than any other community in the nation. Each flood was worse than the one before.

The most devastating flood in our history hit in the mid-night hours of Memorial Day 1984. Our City responded to the shock of this killer flash flood with community-wide commitment to end our recurring disasters. Determined leaders crafted a unified program to curb flood losses.

Today, Tulsa's floodplain and stormwater program is based on respect for the natural systems. It includes comprehensive watershed management, dedicated funds for maintenance and operation, a prototype alert system, and a \$200 million capital improvements program.

This program is more than flood control. We're building parks in the floodplains, sports fields in stormwater detention basins, and greenway trails on creekbanks.

We are forging strong partnerships with federal and state agencies.

And we've stopped creating new problems. Since the City adopted comprehensive drainage regulations 15 years ago, we have no record of flooding in any structure built in accord with those regulations.

Because the federal government gave our program its highest ranking, Tulsans enjoy the lowest flood insurance rates in the country. We are reaping benefits from national awards and favorable publicity.

We're still building our program, and we're still learning. We know our location in "tornado alley" guarantees that Tulsa will flood again, and we're working to prepare for that inevitability. But, without question, we've come a long way. Tulsa's progress has been called an example of what can happen when a community fully commits to solving urban problems.

Like many other U.S. communities, our experience didn't come easily. This booklet has been prepared in the hope that others may benefit from Tulsa's costly lessons on our long and continuing journey toward becoming floodsafe.

*M. Susan Savage*  
*Mayor, City of Tulsa*

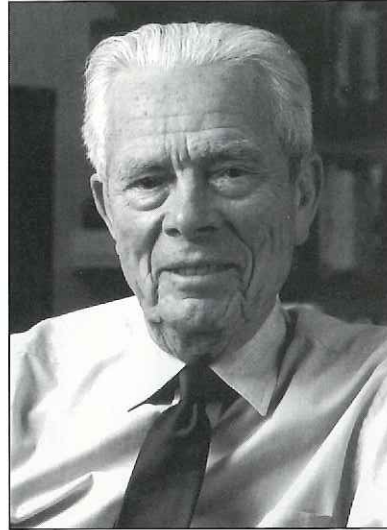
*May 1994*



# Dedication: *Leadership and Courage*

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*This report is dedicated to two gifted leaders in the field of floodplain and stormwater management — one national and one local. Both helped Tulsa develop its program. Both epitomize the many pioneers whose contributions leave the city and the nation immeasurably enriched.*



**Gilbert Fowler White** is the father of modern floodplain management. Mentor to many, Dr. White exemplifies the many national experts who have generously shared their vision, wisdom, and support with Tulsa. Gilbert White's sphere is global; but for 20 years, he has also been Tulsa's friend.



**Joseph Davis Metcalfe** led Tulsa's program during its formative years after the 1984 flood. A professional engineer and industrialist, J.D. Metcalfe has spearheaded community-improvement coalitions for decades and served as the city's elected street commissioner between 1984 and 1990. He is a patron for progress.

# Preface: Lessons Learned

As Tulsa's stormwater and floodplain management program evolved over many years, we learned from others, from our mistakes, and from our successes. The following are a few of the many lessons we have learned:



- Strong partnerships are essential; but local communities must accept responsibility and not expect the state or federal governments to solve all their flooding problems.
- Watersheds and drainage systems are interconnected units. Effective management demands drainage basins to be planned as integral units.
- The National Flood Insurance Program was instrumental in leading our community into floodplain management. But NFIP

regulations do not take into account future watershed urbanization and the resulting increase in flood depths. Tulsa's program is based on total basin urbanization.

- In an urban area such as Tulsa, stormwater and flood programs should include multiple objectives, including recreation and environmental quality, and multiple techniques, including structural and nonstructural projects.
- Mitigation and flood-loss reduction should become the central focus of flood recovery efforts. Re-establishment of the pre-flood status quo only sets the stage for future disasters and losses.
- Pre-flood contingency and mitigation planning is the next local, state, and federal priority. We must plan in advance for our actions during and after the next floods – and there will be future floods, in Tulsa and elsewhere.

If this booklet helps us share our experiences with others, and if our lessons prove useful, it will have served its purpose well.

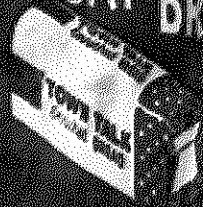
*Charles L. Hardt, P.E.  
City of Tulsa Public Works Director  
and Chief Operations Officer*



▲ Charles L. Hardt, center, leads a river sandbag crew, 1993.

ES  
MARKET

DON'T SAY BREAD



Town Talk

L.O. CHAPMAN  
FRUITS - VEGETABLES

TIRE REPAIR



14



◀ Floods haunt Tulsa history. Left: circa 1943.

# Setting and History

## *Learning the Hard Way*

Tulsa is a crossroads Midwest community with a long history of flooding that mirrors, in many respects, the nation as a whole.

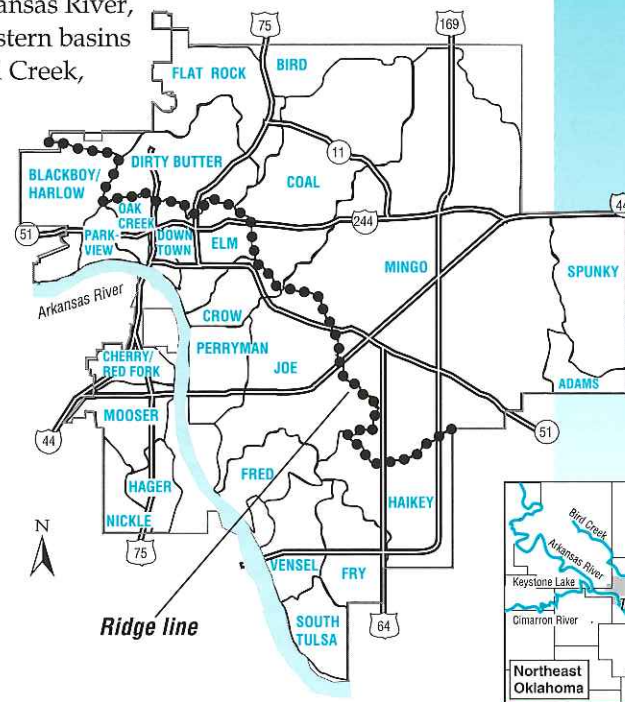
The city has 375,000 people and extends across 200 square miles of gently rolling terrain in northeastern Oklahoma's Osage Hills. The area is one of transition between the Ozark mountains to the east and the Great Plains to the west.

Tulsa is set on the Arkansas River, which rises in the Rocky Mountains and gathers across the Great Plains of Colorado, Kansas, and Oklahoma, thence to the Mississippi.

A ridge line divides the city. Southwestern creeks flow into the Arkansas River, and northeastern basins drain to Bird Creek, then to the Verdigris River east of Tulsa.

***The fundamental lesson that nature teaches, and will repeat patiently for the slow learner, is that the rivers and creeks own the floodplains.***

– Jim Sellars



**Tulsa's Watersheds**



Photo courtesy of the Bayl D. Ford Collection



**When a cool front meanders south to break a warm weather pattern, the results can be awesome. Occasionally, a cool front slows to a near-halt during a hot afternoon, and the moisture piled high above the city condenses into pounding thunderstorms. Creeks and streams swell rapidly as stormwater seeks out its natural course. Floods soon follow.**

### WEATHER: Tornado Alley

Tulsa's geographical crossroad is also a weather junction, an interchange amidst the hot, arid zone to the west, the temperate climate to the north, and the hot, humid zone to the south.

Warm, moist air from the Gulf of Mexico is pulled north by high-pressure systems and collides with cool northern fronts making their way south. This wide swath of convergence is known as tornado alley. When cool fronts clash with warm fronts, towering thunderheads can soar eight miles high and pack enormous energy and moisture.

The converging weather systems meet over Tulsa most often in the spring and fall, sometimes causing violent storms. Normal annual rainfall averages about 36 inches, but successive waves of thunderstorms occasionally can dump nearly half that in a few hours, with little warning.

### EARLY HISTORY: Indians and Oil

In search of water for transport and survival, early settlers were drawn to the Arkansas River in the low timbered hills that would become Indian Territory and, later, Oklahoma.

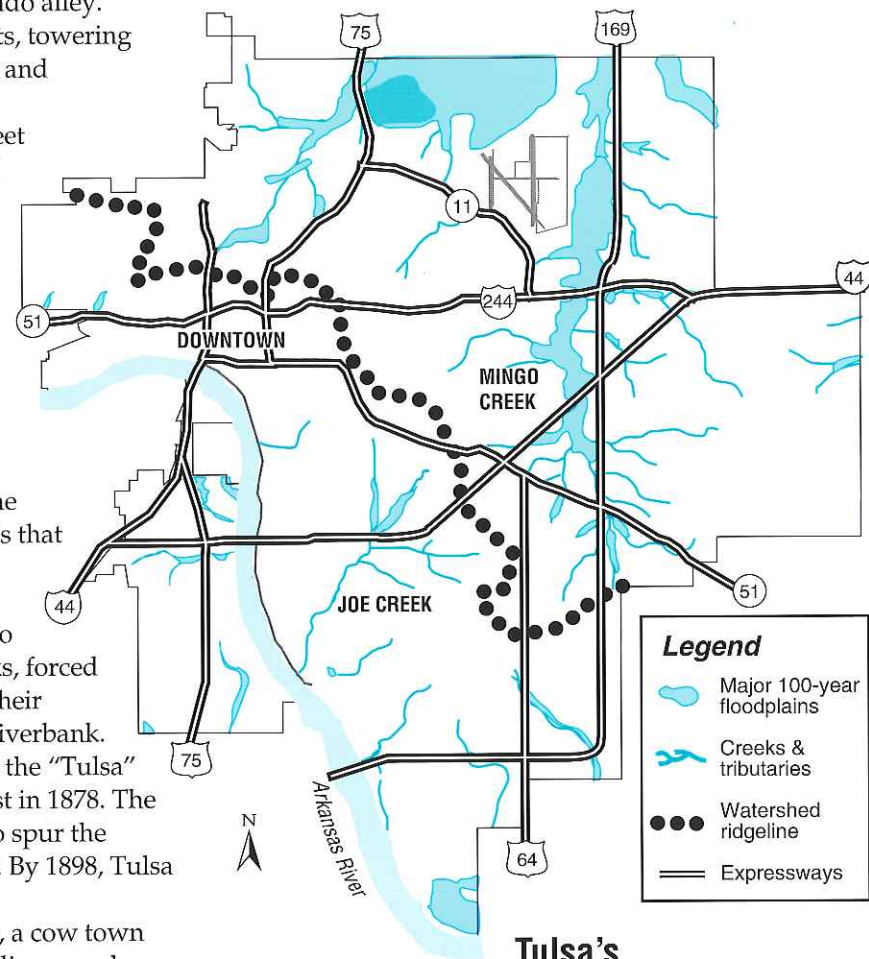
Tulsa can trace its beginnings back to the early 1800s, when Lockapoka Creeks, forced from their Southern homes, rekindled their council fires beneath an oak on a high riverbank.

A Creek Indian rancher established the "Tulsa" post office at the Perryman Trading Post in 1878. The Frisco Railroad came through in 1882 to spur the shipping of Texas herds to Kansas City. By 1898, Tulsa had incorporated as a town.

What was, in more than one respect, a cow town changed dramatically in 1901. Oil was discovered on the west side of the Arkansas River at Red Fork. The boom began in earnest in 1905, when the Glenn Pool, then called the world's largest oil field, was discovered

south of Tulsa. Indian Territory became the center of oil exploration and speculation.

In the wake of Oklahoma statehood in 1907, Tulsa's population grew 100 percent a year. The city gained worldwide prominence as a petroleum center and dubbed itself the "Oil Capital of the World."



**Tulsa's Major Creeks**

## FLOODING HISTORY: Pathways to Progress

Tulsa has grown up with flooding. Many of the causes are locational: The city is based on a wide river, in a zone of violent storms, and on a frontier where a man had a right to do as he wished with his land.

Flood records are sparse before 1900. In 1908, only a year after statehood, Arkansas River flooding at Tulsa caused \$250,000 in damages (\$13.15 million in 1994 dollars).

By 1920, the town had outgrown its raw, boom-town image. As riches mounted and investors and speculators poured in, Tulsa grew to a wealthy city of 72,000. Development edged closer and closer toward the river.

On June 13, 1923, the river flooded Tulsa's waterworks, caused \$500,000 in damages (\$11.94 million in 1994 dollars), and left 4,000 homeless. City fathers responded with Tulsa's first land-use plan, which envisioned upland boulevards and housing. In the lowlands, such as Mingo Creek east of town, would be generous parks and recreational trails.

The waterworks moved to higher ground, near a band of Bird Creek bottoms that became one of the nation's largest city parks. That far-sighted preservation of Tulsa's 2,800-acre Mohawk Park was destined to save the city innumerable future flood losses.

### The Structural Era of Flood Control

Meanwhile, around the nation, the 1920s ushered in what has been called the Structural Era of Flood Control, generally 1928 to 1968.

In response to the Great Mississippi River Flood of 1927, Congress in 1928 passed the Lower Mississippi Flood Control Act, authorizing the U.S. Army Corps of Engineers to construct dams and levees to control flooding.

The major impact first came to Tulsa during World War II. As an emergency national defense project, and in response to 1943 flooding, the Corps built levees around Tulsa's oil refineries along the Arkansas River.

By 1950, in the post-war building boom, housing was fanning out, onto the floodplains to the south and east. Land that had periodically flooded with little harm now was awash in wave after wave of urban flooding.

By the late 1950s, flooding of newly developed subdivisions along the river spurred calls for flood control. In 1964, the Corps completed Keystone Dam 15 miles upstream from Tulsa. For years to come, Tulsans would believe that the Arkansas River was forever tamed.

Tulsa enjoyed another boom in the 1960s, when the

***Early settlers took to the high ground, following the paths of Native Americans who honored natural laws.***



city's population grew 25 percent. Tulsa's rapid growth required pastures and meadows to be piped and paved, as new buildings continued to spill into the lowlands of the the creeks and streams that etch the area. The rapidly urbanizing Mingo watershed was annexed to the city in 1966.

▲ Keystone Dam was built upstream from Tulsa in 1964.

▼ Firemen rig a rescue line on Little Joe Creek, 1968.



***The argument that floodplain dwellers should have known better stood exposed for what it was: cynical disregard for community welfare. City-wide responsibility for flood problems would eventually become conventional wisdom.***

Floods struck every two to four years during the 1960s and early 1970s. The response was classic: emergency response and recovery, reconstruction as quickly as possible, and denial of the possibility that floods could reoccur.

Victims petitioned for neighborhood flood control, with limited success.

### **The Regulatory Era of Floodplain Management**

Nationally, flood losses continued to rise despite billions of dollars in federal flood-control projects. The dilemma prompted a decade of actions that could be called the Regulatory Era of Floodplain Management, generally from 1968 to 1978.

Flood control structures offered spot protection but sometimes caused offsite problems. They also could produce a false sense of security that lured more development into floodplains, flirting with catastrophe. To compound this problem, the value of the induced growth was counted as a benefit in project evaluations.

In the 1960s, this problem was illuminated in the

landmark House Document 465, *A Unified National Program for Managing Flood Losses*. In response, the late 1960s brought Presidential Executive Order 11296 espousing floodplain management and the National Flood Insurance Act of 1968, which made federally subsidized flood insurance available to communities that agreed to adopt minimum floodplain regulations to stem future losses.

**The Mother's Day flood of 1970** in Tulsa caused \$163,000 in damages (\$340,000 in 1994 dollars) on rapidly developing Mingo and Joe creeks.

The City responded by joining the National Flood Insurance Program's "emergency program" and promising to adopt federal floodplain regulations. In August 1971, the NFIP issued its block rate maps. A month later, Labor Day floods hit Flat Rock, Bird and Haikey creeks, and many suburban communities. In December, Bird Creek flooded again. Tulsa joined the NFIP's "regular" program, adopted a new 100-year flood standard, and promised to regulate floodplain land use.

**The Year of the Floods, 1974**, brought April and May floods that left \$744,000 in damages (\$2.11 million in 1994 dollars) on Bird Creek. Violent storms June 8 caused widespread flooding on Joe, Fry, Haikey and Mingo creeks, with more than \$18 million in damages (\$40.24 million in 1994 dollars). On September 19, Mingo Creek flooded again; for some citizens, it was the third flood in a year.

Angry, drenched victims waded out of the floods to demand help. They contended the city wasn't enforcing NFIP regulations. They tried to halt development, to avoid deeper flooding until existing problems could be solved. Developers objected strenuously.

Thus began a community debate over floodplain management, locally called "Tulsa's great drainage war," destined to last years.

The city responded with a plan to widen part of Mingo Creek, including clearance of 33 houses in the

right of way. The houses were removed just before the next flood.

**The 1976 Memorial Day flood** marked a milestone in Tulsa's search for flood solutions. A three-hour, 10-inch deluge was centered over the headwaters of Mingo, Joe and Haikey creeks. The resulting flood killed three and caused \$40 million in damages (\$75 million in 1994 dollars) to more than 3,000 buildings.

By this time, the victims were becoming skilled lobbyists and gathering sympathizers city-wide. They stormed City Hall.

Newly elected city commissioners responded with a wave of actions. They enacted a floodplain building moratorium; hired the city's first full-time hydrologist; developed comprehensive floodplain management policies, regulations and drainage criteria; enacted stormwater detention regulations for new developments; instituted a fledgling alert and warning system; and began master drainage planning for major creeks.

In 1978, an earth change ordinance was also adopted, giving the city control over alterations to Tulsa's landscape, including floodplains and stream channels.

### **The Nonstructural Era of Stormwater Management**

The Nonstructural Era, a third major phase of stormwater management, began with the President's 1978 Water Policy Initiative. It recognized the need to place nonstructural techniques on a par with flood-control structures and to preserve the natural values of floodplains and wetlands.

To curb continuing losses, in the early 1980s the federal government developed the Federal Inter-agency Hazard Mitigation process. In the days after disasters, federal teams were dispatched to identify hazard mitigation opportunities – basically ways to make the response to each disaster reduce the scope of the next one. The mitigation concept focused on correcting the *causes* of losses, including removing, raising, or floodproofing the most vulnerable of the damaged buildings.

Tulsans worked with the Federal Emergency

Management Agency to develop the process. Tulsa's early exposure to the new FEMA mitigation program was to have a significant impact on the city's response to future floods.

**The 1984 Memorial Day Flood**, the worst in the city's history, was Tulsa's watershed point.

After a muggy Sunday afternoon, a stalled cool front produced some 15 inches of mid-night rain, centered over Mingo Creek but also extending across most of the city. The results were disastrous.

The 1984 Memorial Day Flood killed 14, injured 288, damaged or destroyed nearly 7,000 buildings, and left \$180 million in damages (\$257 million in 1994 dollars). Mingo Creek alone accounted for \$125 million of the damages.



© Jim Wolf

The newly elected mayor and street commissioner had been in office for only 19 days, but both knew the issues well. In the darkest hours of the city's worst disaster, they pledged to make their response reduce the likelihood that such a disaster would ever be repeated.

***Tulsa's 1984 flood response focused on mitigation and flood loss reduction, rather than re-establishment of the pre-flood status quo.***

▲ The 1984 flood routed thousands, killed 14, injured 288, and caused \$180 million in damages to nearly 7,000 buildings.

**By the 1990s, Tulsa's stormwater program was institutionalized and broadly accepted.**

Before daylight, they had assembled the city's first Flood Hazard Mitigation Team to develop the city's strategy.

Within days, a new approach to Tulsa flood response and recovery was born.

As ultimately completed, the program included relocation of 300 flooded homes and a 228-pad mobile home park, \$10.5 million in flood control works, and \$2.1 million for master drainage plans. The total capital program topped \$30 million, mostly from local capital sources, flood insurance claim checks, and federal funds.

It was only the beginning.



▲ Volunteers sandbag on the Arkansas River, 1986 flood.

**A Unified Program** was created after the 1984 flood.

The work didn't end with the initial flood response and recovery. In fact, it was only the first step in a long and continuing journey to make Tulsa floodsafe.

The 1984 flood also persuaded Tulsans that a coordinated, comprehensive stormwater management program was needed – from the rooftop to the river.

The Department of Stormwater Management in 1985 centralized responsibility for all city flood, drainage, and stormwater programs.

A stormwater utility fee was established by ordinance in 1986 to operate the program. The utility fee ensures stable funds for maintenance and management, independent of fickle political winds. The ordinance allots the entire fee exclusively for floodplain and stormwater management activities.

**The 1986 Arkansas River Flood** was a first test of the new stormwater management program. It also served as a reminder of the finite protection of Keystone Dam.

Between September and October 1986, Keystone Reservoir filled to capacity, forcing the Corps to release water at the rate of 310,000 cubic feet per second. Downstream flooding was inevitable.

At Tulsa, a private westbank levee failed, causing \$1.3 million in damages to 64 buildings. The city fielded its hazard-mitigation team and cleared 13 substantially damaged structures.

**Institutionalization and acceptance** came in the 1990s, after Tulsans approved a change in city government from the mayor-commission to the mayor-council form.

A new Department of Public Works consolidated all public works services. Stormwater management was reintegrated and finally institutionalized into the city structure.

Today, storm drainage management is generally an accepted part of the city's services.

Tulsa's system has not been tested by a catastrophic rainfall since 1986, but the system has handled smaller rains well. Leaders believe improved maintenance, continuing capital projects, stringent regulations, and aggressive citizen awareness programs will reduce – but cannot entirely eliminate – future flood losses.

The greatest testimony to the program is that, since comprehensive regulations were adopted in 1977, the city has no record of flood damages to any building that complies with those regulations.

In the early 1990s, FEMA ranked Tulsa first in the

nation for its floodplain management program, allowing Tulsans to enjoy the nation's lowest flood insurance rates. The program was also honored with FEMA's 1992 Outstanding Public Service Award; and the Association of State Floodplain Managers has twice given Tulsa its Local Award for Excellence.

Leaders consider the Tulsa program still in progress. They know that much remains to be done, and that there is an inevitable next flood ahead. The program continues to evolve.

### The Watershed Era of Comprehensive Management

The Great Midwest Floods on the Mississippi and other heartland rivers in 1993 caused more than \$10 billion in damages to 72,000 structures and, in some cases, entire communities.

The 1993 Midwest floods spurred national leaders to re-examine their programs. Although Tulsa was not directly affected, local leaders also took advantage of the lessons that the nation was learning.

The 1993 floods served as a catalyst to launch a fourth era in the nation's attempts to stem disaster losses, according to Dr. Gilbert F. White, a leader in national floodplain management for the past 50 years, and Larry Larson, Executive Director of the Association of State Floodplain Managers.

That new era looks above and beyond the floodplains, beyond response to a specific disaster, and takes a longer and broader view.

"It examines in an integrated fashion the whole regional floodplain environment," White says. "It is a program which takes into account the human values, the local resource decisions, the whole pattern of local community management as it is related to flood-hazard and the floodplain."

"Until this year," says Larson, "the government mostly helped people rebuild at risk of the next flood. A monumental change has occurred in federal attitudes and programs that assist people and communities in flood recovery. That change will result in relocation of structures out of flood hazard areas or elevation above flood levels with government

assistance."

This new direction – a comprehensive, regional approach to long-term solutions, based on collaborative partnerships – mirrors the best of Tulsa's local goals and priorities.

The long journey and hard lessons continue. In the words of a former Tulsa mayor, "We're all learning – together."

***The newest national era of floodplain management mirrors the best of Tulsa's local goals and priorities.***



▲ Creekbank maintenance trails make excellent playgrounds.







◀ Tulsa policies encourage use of stormwater as an amenity, as in this private project at Warren Place.

# Policy Framework

## *Watershed Management*

Tulsa's program works because it is based on a unified, logical philosophy.

The philosophy evolved as Tulsa realized that management systems must take into account two key factors: the timing of flood peaks and the availability of flood storage. This awareness led Tulsa to its watershed-wide management approach to time and space allocation of stormwater.\*

It is the foundation on which the program rests.

This section highlights excerpts from Tulsa's floodplain and stormwater management philosophy and policy framework.

### PRINCIPLES

- The urban environment and each watershed within it form a single, interacting system. Actions have consequences.
- Floodplain and stormwater management is a matter of time and space allocation. Water requires space and must be stored and conveyed, in either appropriate or inappropriate places.
- Floodplains and stormwater are resources. If they can become recreation or beautification assets, so much the better.
- Floodplain and stormwater management programs should include multiple purposes and multiple means.
- Changes in the natural balance require compensations. Nature bats last.

\*Tulsa's policies were gleaned from the work of many others, including the National Flood Insurance Program, Gilbert F. White, Jim Goddard, Jon Kusler, Rutherford Platt, Jack Sheaffer, Ken Wright, and FEMA's *Unified National Program for Floodplain Management*.

***Floodplains are natural storage and conveyance facilities, and all stormwater management efforts should be directed toward helping them serve that function.***

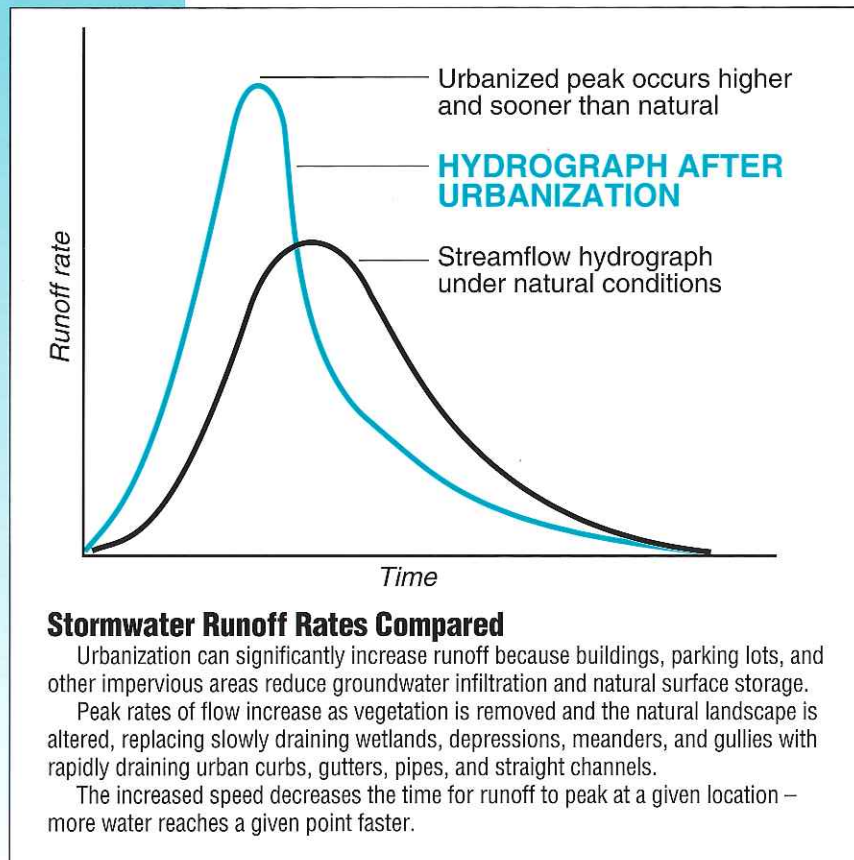
**Structural and non-structural approaches are both weapons in the arsenal of flood management when appropriately applied in accordance with a basin-wide plan.**

## CORRECTIVE POLICIES

- Flood control works include channel modifications and stormwater detention storage.

Under certain circumstances, structural projects are necessary to correct past mistakes and provide spot protection. But they must be used with care, because they tend to transfer problems elsewhere, create a false sense of security, and encourage unwise use of the floodplain.

Flood control projects should consider the entire watershed, based on master drainage plans.



▲ Detention storage, such as this Mingo basin, can include amenities.

Proper, routine maintenance is essential to keep the stormwater systems working.

- Acquisition and relocation should be used to reduce, over time, the occupancy and value of exposed property in flood-hazard areas.

Any proposal for corrective actions should include a careful analysis of acquisition and relocation alternatives. The value of floodplain lands for urbanization should not be used to justify structural projects. The value of floodplain land for park, recreation and open-space purposes and other natural values should be used to evaluate nonstructural alternatives.

Relocation may be more cost-effective after a flood. Post-flood acquisition should be evaluated and, if possible, pre-planned.

- Other essential corrective measures include flood insurance and floodproofing.

## PREVENTIVE POLICIES

- Public park, recreation, and open space use of the floodplain is the best policy.
- Regulatory systems are based on the “100-year flood” under fully urbanized watershed conditions.
- Floodplain alterations should be avoided unless they are based on a basin master drainage plan and it can be shown that they will not cause off-site problems.
- Regulation of floodplain uses is based on the recognition that:

Flooding is a public threat.

Floodplain uses should be compatible with the natural functions of conveyance and storage.

Floodplain uses should not reduce, restrict, or impede channel conveyance capacity, or increase downstream velocities.

No changes can take place in the floodplain that decrease or reduce storage. If filling is allowed, compensatory storage must be provided in the floodplain.

Development should be directed to areas free from flooding.

All development within the regulatory floodplain requires a permit.

- Stormwater runoff control is necessary because development on higher ground can increase flooding, siltation, and erosion.

Excess stormwater runoff caused by new development should be detained and released at a rate that will not increase peak discharges above that which occurred before development. Generally, regional detention basins are more effective than on-site facilities, unless a specific problem is being addressed.

- Public facilities located in the floodplain require special attention.
- Other preventive actions include:
  - Public acquisition of floodplain lands.
  - Disclosure of flood-hazard information to purchasers and renters.
  - Flood alert, warning and emergency management systems.
  - Public information, education and awareness programs.
  - Development of a post-flood recovery plan, including acquisition of frequently damaged properties; relocation of occupants from floodprone areas; and preservation of floodplain lands for park, recreation and open-space purposes.

***Waterways can be channeled, concrete-lined, or even buried. But the floodplain carved over centuries is the gathering point for runoff from higher lands.***

***Regardless of our schemes, water will continue, from time to time, to reclaim its routes.***



Tulsa World photo

▲ Neighbors now stroll where homes once flooded.





◀ Before (inset) and after flood channels and detention storage were added to McClure Park.

# Rooftop to River

## The Tulsa Program

Tulsa's floodplain and stormwater program includes three key goals:

- Prevent new problems.
- Correct existing problems.
- Enhance the community's safety, environment, and quality of life.

This section highlights major program elements used to achieve those goals.

### REGULATION

In general, Tulsa growth is welcomed – so long as it will not flood or cause flooding elsewhere.

### Beyond the 100-year standard\*

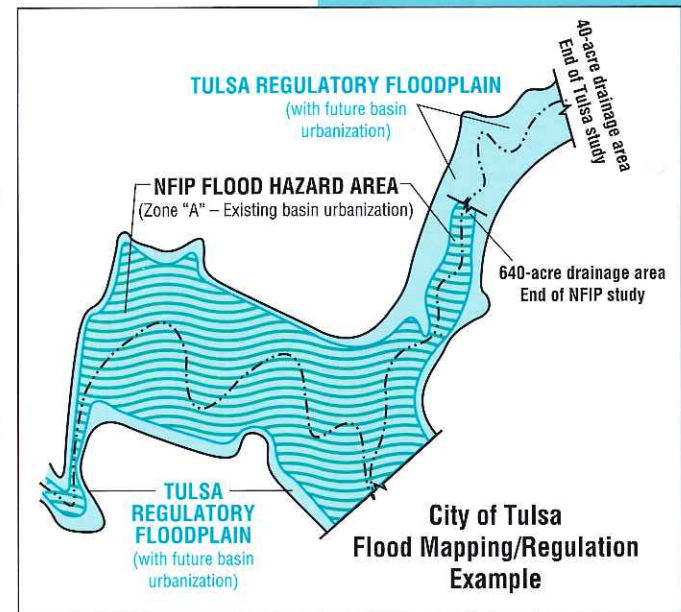
Experience showed that the National Flood Insurance Program's minimum standard is insufficient for Tulsa. Therefore, the city's regulations exceed NFIP's standard in several important ways, highlighted below.

\*Two terms need to be defined.

**Base flood:** The National Flood Insurance Program is based on the so-called "100-year flood," which has a 1 percent chance of occurring or being exceeded in any given year. This standard is also called the "base flood." It is based on watershed development as it exists at the time of the mapping.

**Regulatory flood:** The city's more extensive and restrictive system is based on the "regulatory flood," a 100-year flood calculated as it will occur when the basin is fully developed.

**A city can overcome its flood hazards while still encouraging responsible growth.**



### Floodplain Maps

For greater protection, Tulsa's regulatory floodplains generally exceed those mapped by the National Flood Insurance Program. Tulsa's broader floodplains are based on full future urbanization of watersheds.

**NFIP standards are inadequate for urbanizing watersheds. Many developments permitted today under less restrictive NFIP standards will flood tomorrow as upstream urbanization increases runoff.**

**Ultimate watershed urbanization.** Runoff generally becomes deeper and faster, and floods become more frequent, as watersheds develop. Water that once lingered in hollows, meandered around oxbows, and soaked into the ground now speeds downhill, shoots through pipes, and sheets off rooftops and paving.

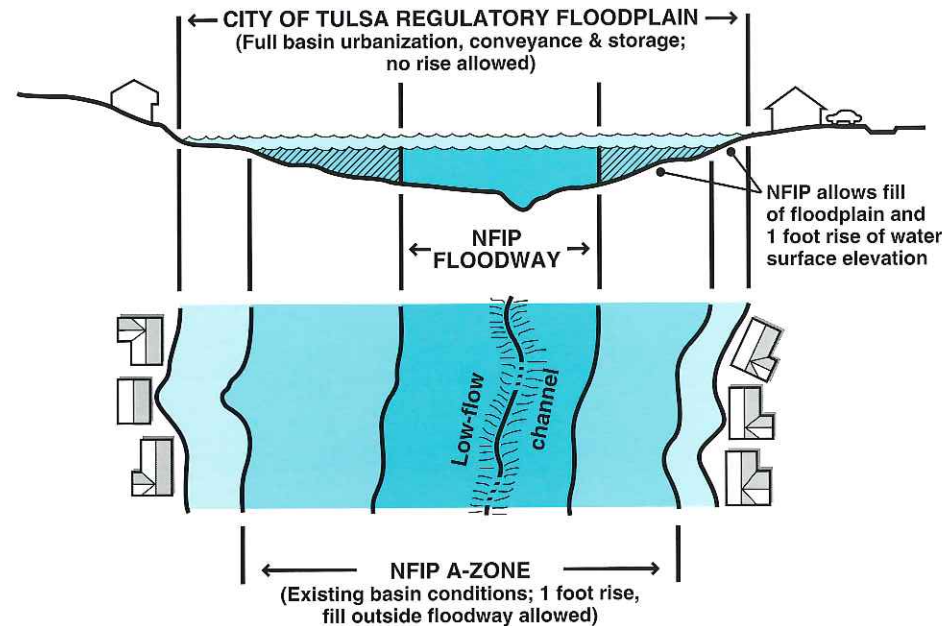
Insurance purposes require the NFIP floodplain maps to be based on *existing* watershed development.

But unless plans and regulations are based on future watershed urbanization, development permitted today may well flood tomorrow as uphill urbanization increases runoff. Tulsa enforces the NFIP minimum regulations and maps, to retain eligibility for federal flood insurance.

In addition, the city enforces its own more extensive maps and regulations, which are based on *ultimate watershed urbanization* as forecast in the comprehensive plan.

**Watershed-wide regulation.** Floodplains are only part of flood-management considerations. Water gathers and drains throughout entire watersheds, from uplands to lowlands. Each watershed is an interactive element of the whole. A change at one place can cause changes elsewhere, whether planned or inadvertent. Therefore, Tulsa goes above and beyond the floodplain in its regulatory program, extending its regulations watershed-wide.

**Stormwater detention.** One way to avoid increased flooding downstream from new development is to provide stormwater detention



### Regulatory Floodplains

Tulsa's floodplain regulations are more stringent than the National Flood Insurance Program's, because Tulsa regulations are based on full urbanization of the watershed and do not allow any rise in the water surface elevation.

basins throughout watersheds.

New or substantially improved developments must detain the excess stormwater on site – unless they are exempted in master plans or allowed to pay a fee in lieu of on-site detention. Water from detention basins is released slowly downstream.

In-lieu fees are allocated for regional detention facilities. In most instances, the city has found regional detention basins to function more satisfactorily than smaller, scattered on-site facilities.

**Valley storage.** Flood water cannot be compressed. It requires space. Encroachments into a channel or floodplain can dam, divert, or displace flood waters. So Tulsa requires compensatory excavation if a development – including a flood control project – would reduce valley storage. Preserving or recreating floodplain valley storage is a keystone of the city's program.

**Freeboard.** NFIP regulations require finished floors of new development to be at or above the base flood elevation, based on existing watershed conditions. Tulsa includes freeboard as another margin of safety, requiring finished floors to be at least 1 foot above the regulatory flood elevation, based on ultimate watershed urbanization.

**Erosion and sedimentation.** Erosion and sedimentation rob hillsides of valuable topsoil, dam lowlands, clog streams, and pollute rivers. Builders must control site erosion from new development.

### Permits and performance standards

Tulsa requires a watershed development permit to be issued before developing, redeveloping, building, excavating, grading, regrading, paving, landfilling, berming, or diking of any property within the city. There are five types of watershed development permits: floodway, floodplain, stormwater drainage, stormwater connection, and earth change permits. Individual residential lots outside the floodplain are exempted.

Tulsa's regulations are based on adopted floodplain maps (both Tulsa and NFIP), watershed-wide master drainage plans, and development permits based on specific performance standards.

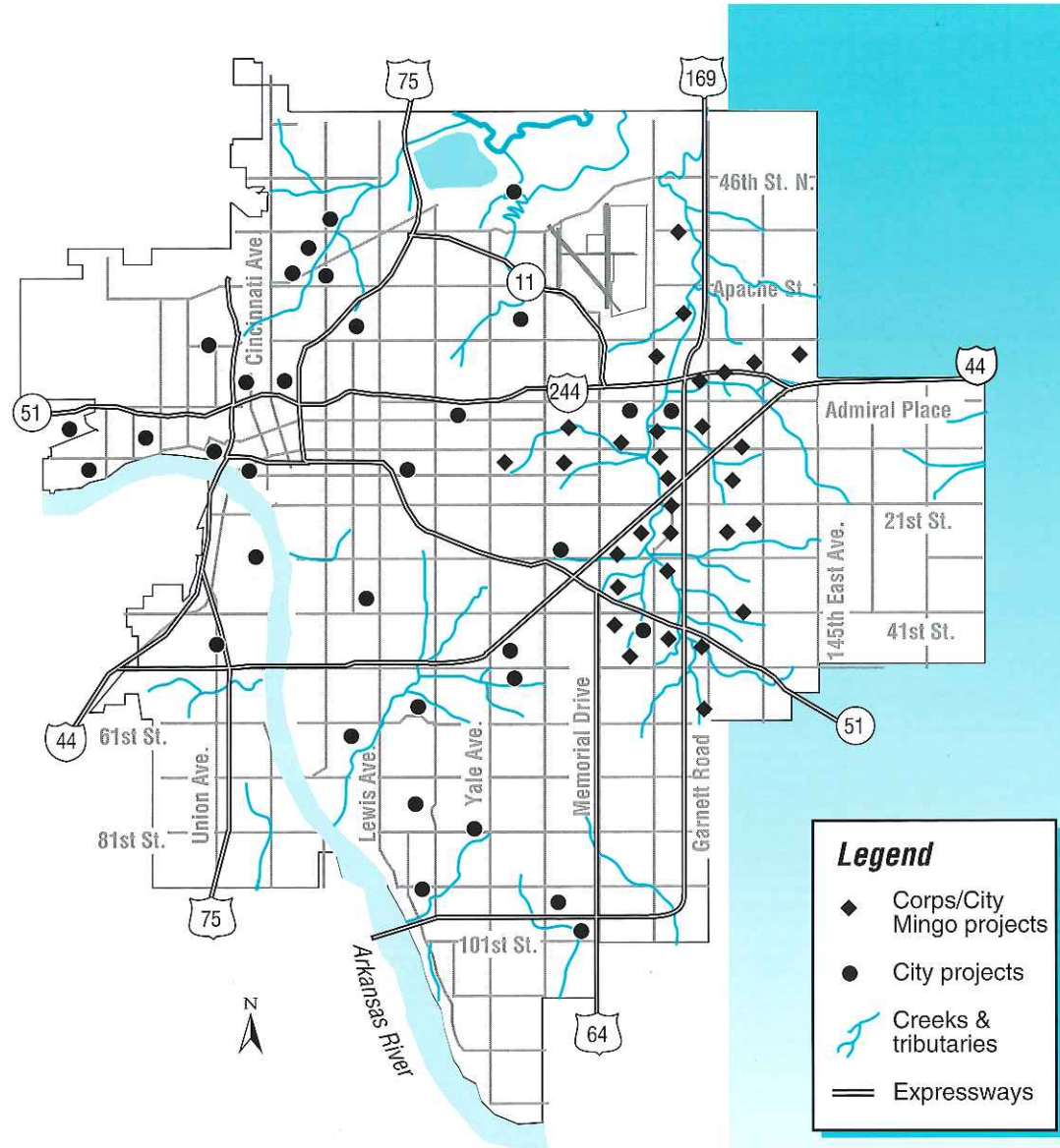
## PLANNING AND CAPITAL PROJECTS

A decade ago, Tulsa faced up to its need for half a billion dollars in corrective flood projects. The city had been built, over decades, without much of a drainage system, and the result was disastrous. The task appeared overwhelming.

Since then, Tulsa has completed or under construction more than \$200 million in capital plans and projects, including \$80 million in federal funds.

The capital program includes structural, nonstructural and multi-objective projects. By combining techniques, flood hazards have been reduced for thousands of Tulsans.

More than \$300 million in flood-reduction projects are still needed. Tulsa's program is still under way,



### Major Capital Projects

Tulsa has under way or completed more than \$200 million in flood projects, most since 1984. They include structural and nonstructural projects. This map generally shows only projects costing more than \$100,000.

**Piecemeal responses to flood events can make hazards worse. Half-measures don't work.**

and will be for years, to correct drainage problems that were created over many decades.

### Planning

The backbone of Tulsa's stormwater management system is its master drainage planning. The planning process involves extensive citizen participation, including hundreds of public meetings over the past decade.

**Master drainage plans.** Tulsa has completed master drainage plans for virtually all drainage basins. Each plan is a comprehensive, watershed-wide study of a drainage basin that documents existing floodplain information and recommends solutions for flooding and drainage problems.

A typical master drainage plan is developed within the context of the community, and so takes into account community values, existing conditions, goals and objectives, and future plans. The result is a plan for actions and projects, including costs and benefits.

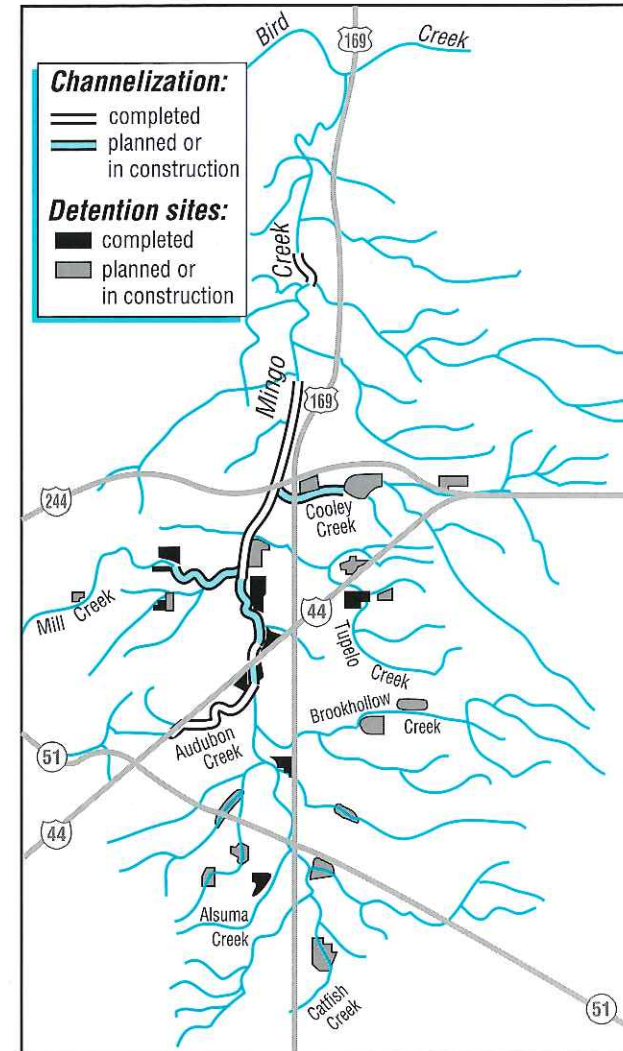
**City-wide master plan.** In 1989, the city synthesized its various master drainage plans into one city-wide document, *The City of Tulsa Flood and Stormwater Management Plan, 1990-2005*. This city-wide plan ranks and prioritizes hundreds of recommended projects, to guide capital scheduling.

### Capital projects

Priority-setting was challenging. Citizens in every watershed faced severe flooding problems. In general, priorities are based on hazard, cost, benefit, and feasibility.

**Mingo Creek project.** The 61-square-mile Mingo watershed drains the eastern one-third of the city but has accounted for two-thirds of Tulsa's flood damages in recent years. The U.S. Army Corps of Engineers and the city worked together in the late 1970s to develop a plan for Mingo flood control, which Congress authorized for construction in 1986.

The Corps estimates that the completed \$143 million project will prevent \$32 million in average



### Mingo Creek Flood Project

Most Tulsa damage has come along Mingo Creek in east Tulsa. To curb Mingo flooding, the city and the Corps of Engineers are building the \$143 million Mingo project. It includes 23 stormwater detention basins and about 10 miles of channels, all to be completed in 1996.



annual flood damages. With an average annual cost of about \$16 million, the Mingo project has a benefit-to-cost ratio of 2 to 1.

The local cooperation agreement signed by the city helped forge new legislation, written into the Water Resources Development Act of 1986, which also gives communities credit for past construction projects. The federal government recognized that before 1986 Tulsa had constructed some Mingo channels and detention basins that were compatible with the Corps project. The federal government agreed to give the city credit toward its local share plus reimbursement for the federal share of prior expenditures that pertain to the project. Tulsa has received \$10 million in reimbursements and expects to receive about \$10 million more.

**Acquisition and relocation.** Over the past 15 years, Tulsa has cleared more than 900 buildings from its floodplains. The largest clearance came after the 1984 flood, when more than 300 single-family homes and 228 mobile homes pads were acquired and cleared.

The city's floodplain program is gradually reducing its inventory of thousands of floodprone buildings. The city is also updating its post-flood mitigation plan to include acquisition and relocation recommendations for before, during, and after a flood.

**Small capital projects.** Many flooding and drainage projects throughout the city are localized but troublesome. They are addressed through small capital projects, generally less than \$100,000 each. Every year, \$700,000 is allocated from the utility fee for small projects. Some are also funded through long-range capital sources.

**Floodproofing.** In some instances flood damages to existing structures can be averted by spot floodproofing, such as elevation of the existing structure on site, shields for windows and doors, and ring levees. Oklahoma law does not allow the city to spend public funds to floodproof individual structures, so currently the city's role is limited to technical assistance to private property owners.



**Tulsa has cleared more than 900 buildings from its floodplains.**

◀ Lands cleared after Mingo Creek floods (left) now serve as picnic grounds (below). ▼



**Maintenance is one of the most popular and visible activities of a stormwater management program.**

## STORMWATER QUALITY

Stormwater quality is of growing concern in municipal drainage management. Tulsa has geared up to meet new federal requirements for stormwater discharge NPDES permits (National Pollutant Discharge Elimination System permits). Tulsa's most serious problem with runoff quality was found to be sediment, which is being addressed through vigorous regulation of erosion from construction projects.

The city is also emphasizing street sweeping, environmental monitoring, and stormwater laboratory services as part of its stormwater quality program.

## MAINTENANCE AND OPERATIONS

City leaders clearly saw the need for better maintenance when the 1984 flood swamped debris-choked creeks and channels, clogged and collapsed sewers, and neglected pump stations. The resulting public and private costs were enormous.

The flood triggered a search for stable, continual maintenance funding. The answer came in 1986, when city fathers approved a drainage utility fee. Now maintenance is an essential element of Tulsa's program.

The contrast is telling:

■ In 1980, the city spent about \$400,000 on stormwater maintenance.

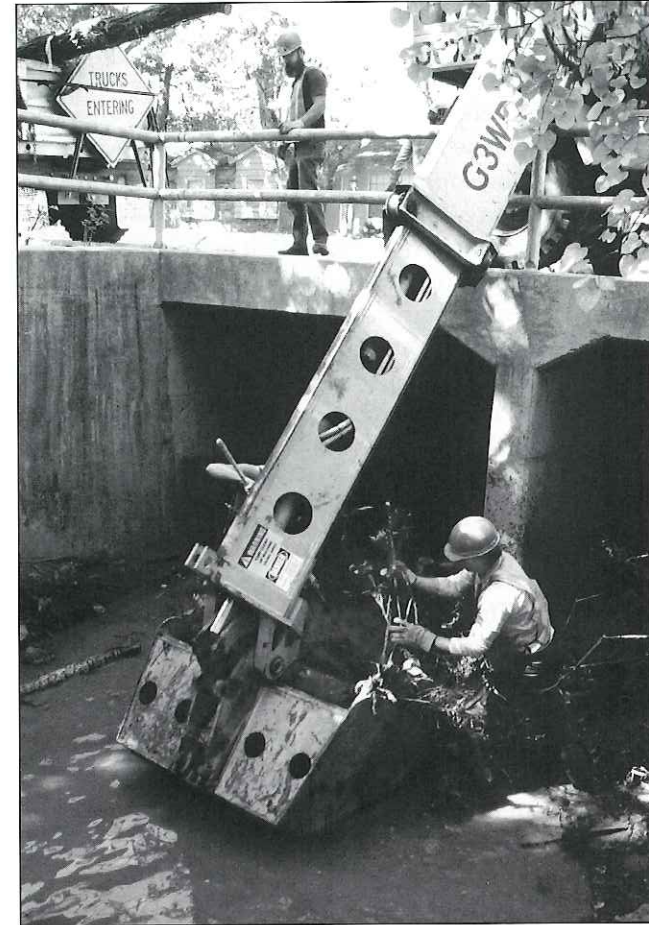
■ By comparison, in 1993, the city was able to spend about \$6 million on stormwater maintenance.

The difference was the stormwater utility fee.

The maintenance program's first goal is to keep systems operating at full capacity.

The system includes hundreds of miles of surface channels and floodplains, thousands of miles of underground sewers, public detention basins, pump stations, roadside ditches, bridges, and the curbs and inlets along the street system.

The list of duties continues to expand, extending through turf control and tree planting, debris removal, emergency response during storms, and management of maintenance trails along drainageways.



▲ Maintenance is a cornerstone of Tulsa's program, based on stable and on-going funding by the stormwater utility fee.

## EMERGENCY MANAGEMENT

Capricious climate makes Tulsa vulnerable to weather emergencies, particularly tornadoes, violent thunderstorms, and floods.

Overall responsibility during emergencies lies with the city-county Tulsa Area Emergency Management Agency; but in flood management, TAEMA shares its lead with Tulsa's Public Works Department.

Tulsa's emergency management goal is to reduce hazard and damage before, during and after storms.

### Forecasting and warning

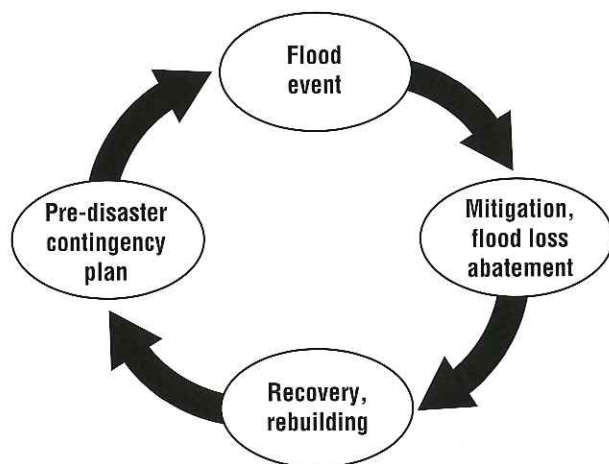
Flash floods require the earliest possible warnings. Tulsa's system works in cooperation with the National Weather Service, news media, TAEMA, and the City of Tulsa. A computerized ALERT system includes 39 rain, 19 stream, and seven detention gauges that report changes as they happen. The system is based on detailed basin inventories and includes a hydrologic program that develops stream and flood forecasts, to be released for appropriate action before flooding occurs.

### Response

Emergency response is triggered by the possibility of severe weather anywhere in the community. Response teams are guided by detailed plans and protocols – and their extensive field experience during emergencies. The plans also identify critical facilities with hazardous materials, vulnerable occupants, and essential community functions.

### Recovery and mitigation

Traditionally, recovery meant rebuilding as fast as



▲ A prototype ALERT System helps manage emergencies.

possible. But recurring disasters have taught Tulsans that rebuilding in kind can mean reinvesting in disaster. Tulsa today emphasizes mitigation projects, which seek to make the response to each disaster reduce future losses. For example, hundreds of flooded homes have been relocated to dry sites. In addition, the city is updating its flood-hazard mitigation plans, to include actions to be taken before, during, and after a flood.

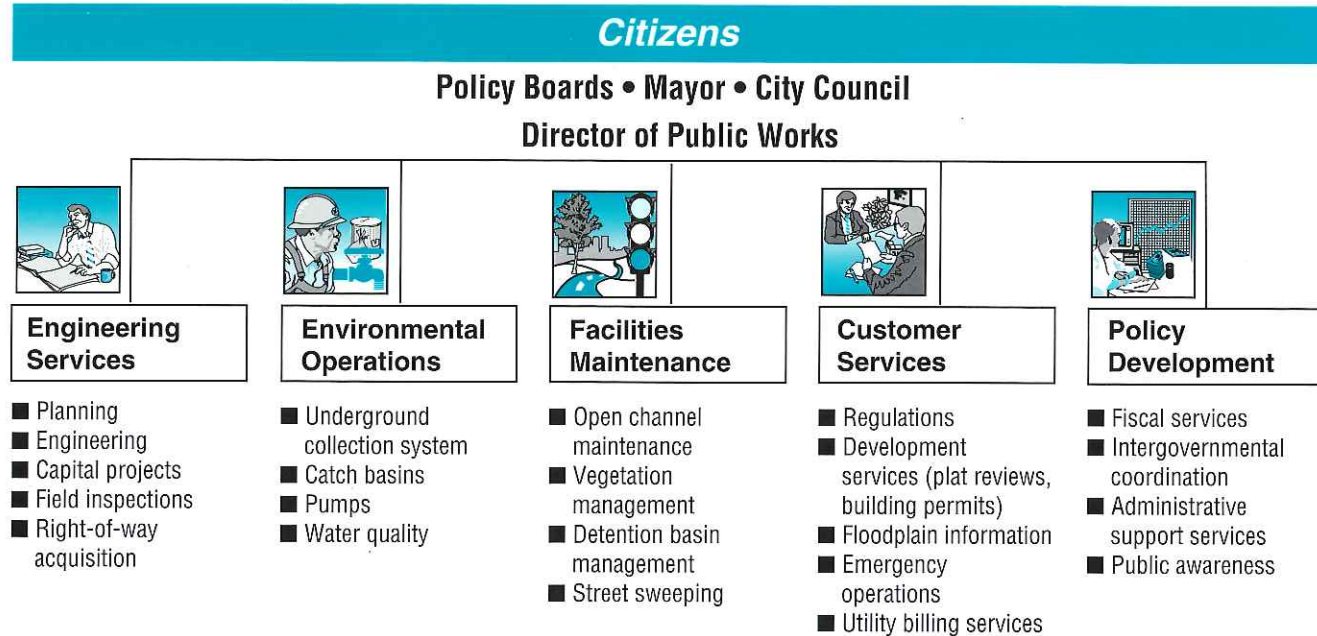
### PUBLIC AWARENESS

The city pushes public information and involvement to keep citizens aware that floods frequent Tulsa, requiring prudent preparation.

Diverse information pieces include flood maps,

*Public awareness and backing can become, over time, the best insurance against a repetition of a kind of history that wrecks physical damage and, worse, leaves emotional scars.*

## Stormwater Management Structure



brochures, news releases, fact sheets, reports, slide shows, videos, direct mailings, displays, speeches and presentations, roadway signs, and individual contacts – anything and everything possible to get out the word.

For example, the city mails periodic notices to floodplain occupants, warning them of hazards, offering them flood preparedness tips, and urging them to buy flood insurance.

Tulsa's stormwater ordinances include requirements that full information about flood hazards must be provided by property sellers to prospective buyers, and by landlords to tenants.

### PUTTING IT ALL TOGETHER: ORGANIZATION AND FINANCE

After the 1984 flood, Tulsa leaders determined that the city's drainage program was scantily funded, poorly coordinated, and largely neglected. They termed stormwater the "forgotten utility."

Creating a comprehensive program was a daunting challenge, beginning with the staff estimate that some \$500 million was needed for high-priority flood control. As for the full range of maintenance and other needs, no one could hazard a guess.

By 1985, Tulsa had pulled all related functions together into a new Department of Stormwater Management. By 1986, the city had levied a new stormwater utility fee to finance it.

In three successful votes in 1985, 1987, and 1990, voters handily approved more than \$135 million in capital sales tax and bond funds – including local match for the \$143 million Corps of Engineers project to tame Mingo Creek.

With a change in the form of city government in 1990, the stormwater program was merged into a new Public Works Department.

Today, the program continues to progress, institutionalized in Public Works, under the executive wing of Mayor M. Susan Savage. Citizen advice is

City of Tulsa

**Official  
Notice**



**Flood Hazard  
Information**

provided by the Stormwater Drainage Advisory Board, which was created after the 1984 flood. Tulsa's City Council is responsible for legislation, policy, and budgets.

The fiscal foundation of Tulsa's program is the stormwater utility fee.

The fee was calculated by determining essential program requirements, then allocating the needed charges equitably to all homes and businesses. Residents of single-family homes pay \$2.58 per month. Business owners pay the same amount for every 2,650 square feet of impervious surface on their properties.

The charge is based on the theory that stormwater runs off every property in the city; dwellers on both hillside and lowland contribute runoff. Since everybody helps create the need for a floodplain and stormwater program, everybody helps pay for it.

The utility fee yields about \$9 million annually. The largest share goes to maintenance. The balance goes toward management, planning, public education, small capital projects, and other uses.

The utility fee is not used directly for major capital projects. Major projects are financed, instead, by general obligation bonds, sales tax revenues, and –

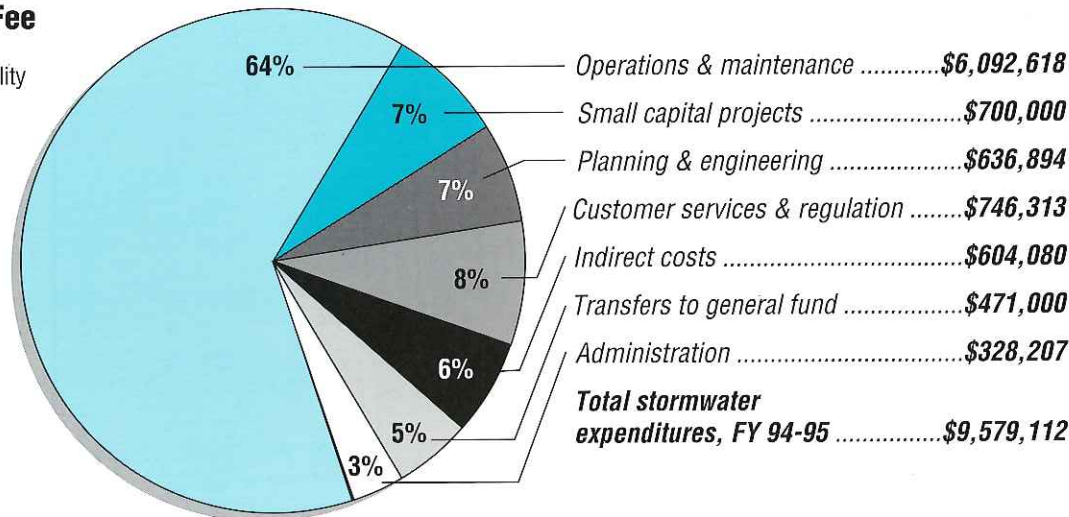


when available – federal funds. Similar sources are used for master drainage planning. Other funds include fees in lieu of detention and permit fees.

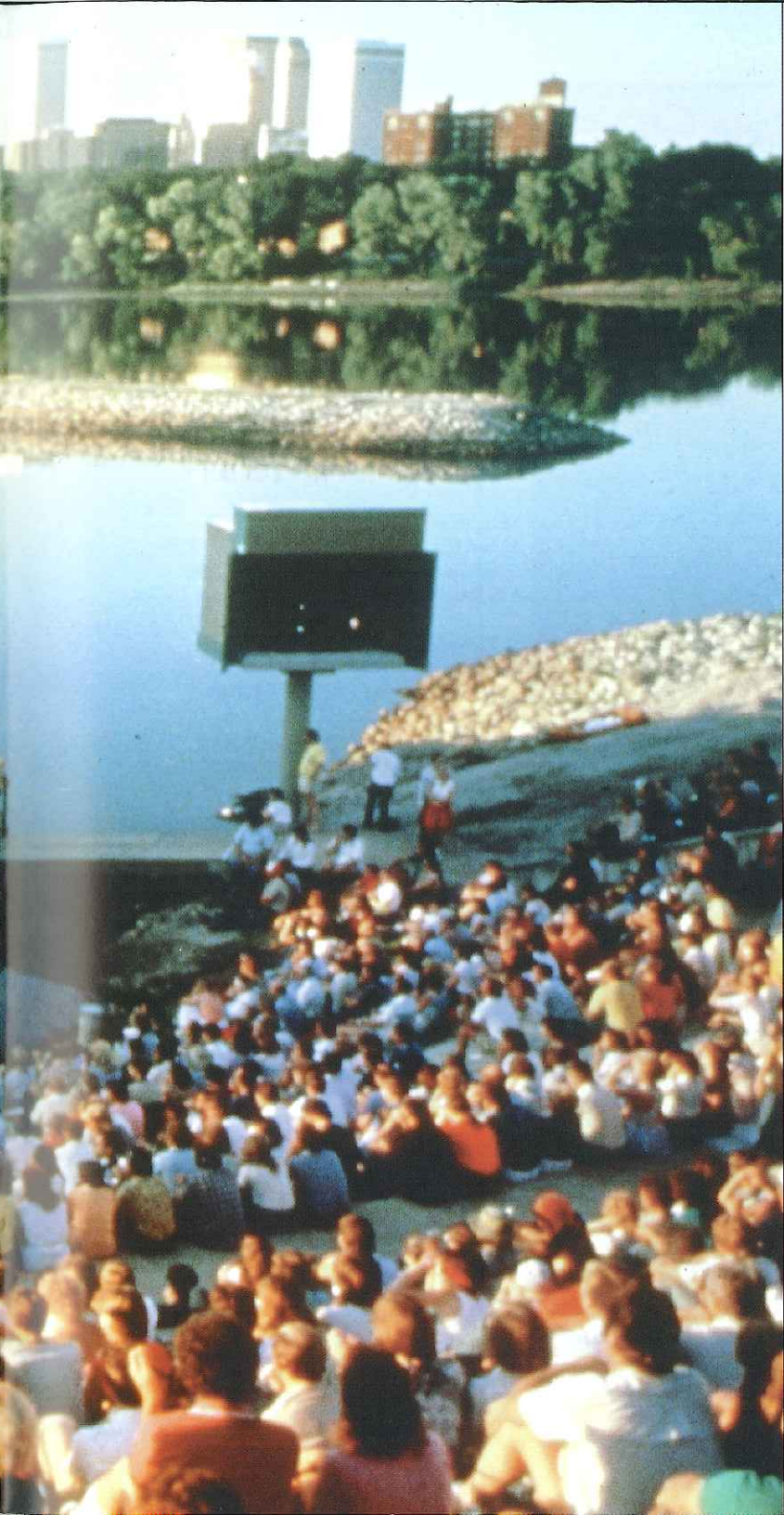
▲ The Stormwater Drainage Advisory Board provides policy guidance.

### Stormwater Utility Fee

Most of the Stormwater Utility Fee is budgeted for maintenance and operations. In addition, Tulsa spends about \$10 million per year in local capital funds for flood projects.







◀ Once a shunned dump, Tulsa's Arkansas River floodplain is now the city's prized River Parks.

# The View Ahead

## *Beyond the Ark*

When a town like Tulsa is battered by unrelenting disasters, the number one priority has to be public safety and loss reduction.

But in time, after enough progress and a spell of gentle weather, town leaders may be able to look beyond just "building an ark" for protection.

They are beginning to see that stormwater and floodplains can be among their most important community resources. They can become assets, not enemies.

Tulsans are slowly rediscovering the graceful floodplain treatments that marked the city's fine early development.

Now, whenever possible, flood projects include active and passive recreation and environmental elements. In some cases, projects are incorporated into existing parks. Elsewhere, acquisition areas, detention basins, and floodplains include recreation.

Some projects have become small nature oases in the urban area, used by migrating birds such as Canada geese and other wildlife.

The city is converting some drainageways into greenways.

On a backbone of maintenance roads along creeks, the Tulsa Trails program is building paths for jogging, hiking, and bicycling.

Tulsa's future may well go beyond the ark, to become more than merely floodsafe.

Where once loomed death and destruction, Tulsa's future floodplains can hold strip parks, landscaped creek banks, sporting fields, and reflecting pools, all in the name of floodplain and stormwater management, for the benefit of Tulsans for generations to come.

***It is a long stretch to consider flood waters that can take human life as community assets and an even longer reach to suggest that a potential killing ground can become a place of recreation and renewal.***

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Tulsa Park and Recreation Department photo

► Tulsa's Woodward Park:  
Water is an invaluable  
community resource.

***After all, man can lend  
but paltry assistance to  
nature in the beautifica-  
tion of her open spaces.***

– 1924 Tulsa Plan

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▲ Tulsans cherish their River Parks along the Arkansas River floodplains.



*“Your city, its growth, enterprise, cleanliness, beauty, and prosperity is your responsibility. Are you working at it? A City, like a tree, grows as it is trained, straight or crooked. If selfishness dominates it, it will not thrive, and no one will love it. If generous men and women with vision are its cultivators, it will grow and flourish, and the stranger at its gates will enter and ask for a chance to work for it.”*

– 1924 Tulsa Plan