FOUNDATIONS OF URBAN RIVER MANAGEMENT

A Master's project submitted by

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ABSTRACT

Urbanization causes a host of changes to natural riverine environments. Mitigation is required to forestall environmental, economic, and social costs. Existing strategies for river management include traditional "single use" schemes and newer "multipurpose" schemes that balance a host of uses. While the latter are more environmentally appropriate than the former, they are more susceptible to institutional barriers that prevent achievement of stated goals.

To understand the root causes of institutional barriers and to develop specific procedures for avoiding them I begin with fundamental political theories and then make approximations and simplifying assumptions to develop a useful form of each. One political economic theory that can be manipulated in this way is that of Tinbergen (1967). Based on Tinbergen's "one tool per goal" criteria for economic policy design I have developed a "Tools and Goals (TAG) analysis" procedure that identifies conflicting facets of a river project design and predicts the occurrence of institutional barriers. Two other theories that can be used to aid river management are those of Wilson (1984). According to the first, the outcome of a public policy is not only determined by the *magnitudes* of the costs and benefits, but also by their perceived *distribution*. According to the second, the responses of regulators to a public policy can be predicted depending on their personnel type.

I applied the TAG method to the Guadalupe River Master Plan (GRMP) for downtown San Jose. The evaluation procedure identified the basis for the success of some facets of the plan and indicated future problems that need to be addressed. The GRMP includes 13 design objectives and 35 unique tools. The evaluation procedure therefore required 1128 micro-analyses in order to identify the conflicts that will lead to institutional barriers. Thirty-three such conflicts do exist in this case. Also, Tinbergen's Rule is violated twice in this project, though only with low priority goals. As a result, the TAG analysis predicts that those goals will be dropped over the long term.

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INTRODUCTION

The morning of Thursday April 3, 1958 was a stressful one for San Fransisco Bay area residents.

> **Floods Hit Coast Areas. Palo Altans Flee Rising Waters. Creeks Top Banks, Pose San Jose Threat!**

read the headlines of the San Jose Mercury. In the following days, 53 of the region's instream water supply reservoirs reached capacity with some spillways overflowing (Fig. I.1). Rivers ripped through the South Bay suburbia. The Guadalupe River, "a wild brown torrent," looked like it might spread onto the streets of our nation's 11th largest city (Fig. I.2). October, 1994 began with a completely different outlook. A party was thrown- with golden shovels and all the rest- in honor of the groundbreaking for the construction of the Adobe Corporation's new headquarters immediately adjacent to the Guadalupe River in the downtown reach (Fig. I.3).

The events just described are not uncommon in our nation. Indeed, similar snapshots can be made for virtually all of our urbanizing river floodplains. But how can we account for the apparent senselessness in the proliferation of river corridor construction in light of the imminent hazard posed by aggrevated flood conditions? Obviously, no one intends to cause harm in promoting urban growth and development, but somewhere between human intentions and the course of natural events lies a field of endeavor where analysis and judgment must match the public and private growth objectives with *appropriate* means for achieving them. That field is natural resources management, or, in the case above, the specific realm of urban river management.

In the first two chapters of this paper I review the environmental, economic, and social impacts of urbanization on river corridors and assess the state-of-the-art of urban river management. Because existing river management practices fail to account for the complex political economic milieu in which they are implemented, they often fail to achieve their stated goals. In the third chapter I present new approaches for bypassing problematic institutional barriers, and in the final chapter I apply one of these approaches to evaluate the management plan for the aforementioned urban corridor of the Guadalupe River.

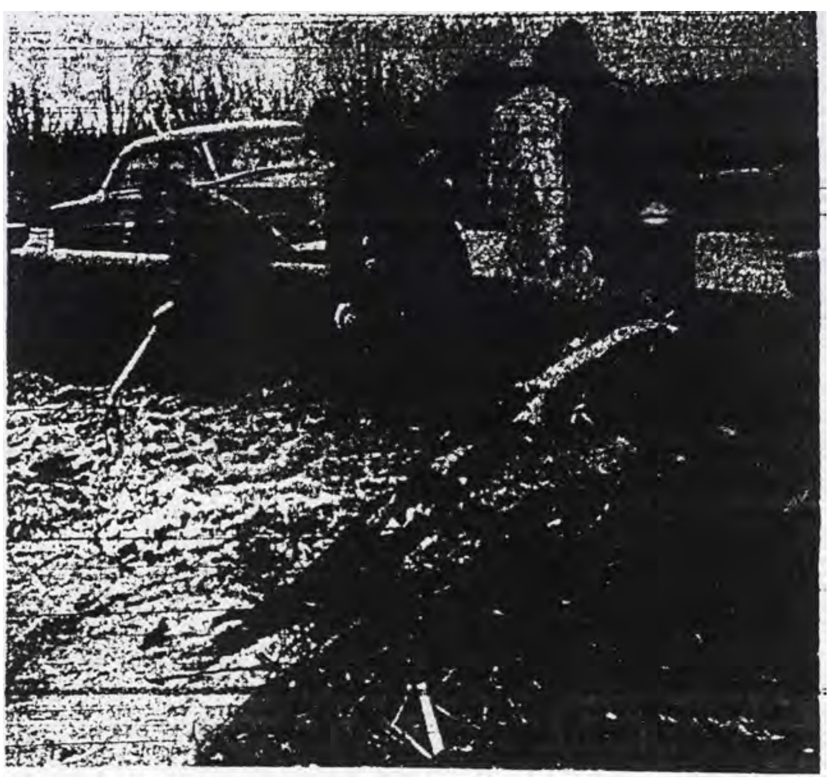
San Jose Mercury

SAN JOSE, CALIFORNIA, FRIDAY MORNING, APRIL 4, 1958 · ★★★★

Nature Leaves A Calling Card

TORRENT — Sending up clouds of spray, water pours over the spillway of Anderson Dam Thursday for the first time in the eight-year history of the reservoir. More than 10,000 acre feet of water cascaded into the reservoir in a 12-hour period ending at 6:48 a.m. Thursday. Water was running 4.7 feet deep over the spillway at 4 p.m. The reservoir, which holds 75,000 acre feet of water, is Santa Clara County's largest. It has been full only once before.

<u>Figure I.1: Overflowing South Bay water supply reservior.</u>



<u>Figure I.2: Guadalupe River 1958 flood in the downtown corridor.</u>

Figure I.3: Location of the Adobe Corporation's new headquarters.

URBAN RIVER CORRIDORS

According to the 1990 census there are 248,709,873 people living in the United States. Of these, 33,837,124 people, or 13.6%, live in the 31 largest cities (Table 1.1). Overall, 75.2% of the total population live in urbanized areas, as they are broadly defined by the U.S. Department of Commerce (1993). With hundreds of thousands of people coming to live in close proximity, it is easy to imagine that the landscape must be transformed in order to accommodate urban structure and infrastructure as well as all of the human detritus of living.

Urban River Corridors- The Environmental Problem

One facet of the landscape which is greatly influenced by human activity in and around it is the river corridor, which is defined to be the river channel, associated floodplains, and a narrow buffer of surrounding uplands. Because the river corridor can serve a number of human uses beyond its natural functions, it is subject to extensive alteration. Changes in the watershed upland from the corridor reverberate through the system and impact the river. The scope of urban impacts includes changes to the hydrologic, hydraulic, geomorphic, water quality, and ecologic systems that interface in the river corridor.

Before describing the various effects of urbanization, it is necessary to consider exactly what physical alterations urbanization involves. The most fundamental impact of urbanization is an increase in the amount and degree of impervious ground surfaces (Leopold, 1968; Lazaro, 1979). When homes, parking lots, buildings, and other civic structures are built, the soils are compacted by frequent use and the natural ground surface is covered with building materials like concrete, stone, and asphalt that block the flow of water.

Table 1.1: U.S. Urban Rivers

City	1990 Population*	River**	Drainage Area***	Base Discharge	Mean Annual Discharge	Station ID
New York, NY	7,332,564	Hudson				
Los Angeles, CA	3,485,398	Los Angeles	827		223	11103000
Chicago, IL	2,783,726	N. Br. Chicago	113	800		05536105
Houston, TX	1,630,553	Buffalo Bayou	358			08074000
Philadelphia, PA	1,585,577	Shuylkill	1893	18000		01474500
San Diego, CA	1,110,549	San Diego	429		39	11023000
Detroit, MI	1,027,974	Rouge	187	1200		04166500
Dallas, TX	1,007,618	Trinity	6106	11000		08057000
Phoenix, AZ	983,395	Salt	13391		349	09512190
San Antonia, TX	935,933	San Antonio	41.8			08178000
San Jose, CA	782,248	Guadalupe	146		40	11169000
Indianapolis, IN	741,952	White	1635			03353000
Baltimore, MD	736,014	Patapsco	285	2900		01589000
San Francisco, CA	723,959	N/A				
Jacksonville, FL	672,971	St. Johns				
Columbus, OH	632,945	Scioto	1629			03227500
Milwaukee, WI	628,088	Milwaukee	696	2000		04087000
Memphis, TN	610,337	Mississippi	932800			07032000
Washington, DC	606,900	Potomac	11560	44999		01646500
Boston, MA	574,283	Charles				
Seattle, WA	516,259	Green	440			12113350
El Paso, TX	515,342	Rio Grande	29267			08364000
Nashville-Davidson, TN	510,784	Cumberland	12856	85000		03431500
Cleveland, OH	505,616	Cuyahoga	404	1700		04206000
New Orleans, LA	496,938	Mississippi				07374510
Denver, CO	467,610	South Platte	3861		379	06714000
Austin, TX	465,622	Colorado	39009			08158000
Fort Worth, TX	447,619	Trinity	2615	4000		08048000
Oklahoma City, OK	444,719	North Canadian	13354	4400		07241500
Portland, OR	438,802	Willamette	11100		31900	14211720
Kansas City, MO	434,829	Missouri	485200			06893000

* Source: Farighetti, 1994
** Many cities have several rivers that flow through them.
*** Square miles

Equally important is the extensive removal of vegetation which plays a vital role in the hydrological cycle via transpiration (McCuen, 1989). Other engineered changes include the smoothing over of surface depressions, increased sloping of the land, and replacement of natural drainages with highly (hydraulically) efficient sewers and smooth open channels (US EPA, 1977). The actual process of urbanization is treated thoroughly by Lazaro, 1979, and summarized succinctly by Stankowski (1972):

> "...urbanization begins with the occupancy of rural lands by small, concentrated communities... Further growth is characterized by large residential subdivisions, ... , shopping centers, some industrial buildings, and an enlarged network of streets... Central business districts evolve... Industrial growth continues along waterways, ... , and major highways."

Urbanization has significant, measurable impacts on the hydrology of the river and associated watershed. In an undisturbed watershed with good soils, only 10-30% of the rainfall drains over the ground as runoff, with 50-70% returned to the atmosphere via evapotranspiration and the remainder taken up by soil infiltration and surface depression storage (Leopold, 1962; McCuen, 1989; Bedient and Huber, 1992). Even though city engineers and planners have long recognized that urbanization drastically alters a watershed, they did not have the technical data needed to account for and mitigate against the resultant hydrological impacts until the 1970s. One of the early scientific investigations of the effects of urbanization on hydrology was conducted by a U.S. Geological Survey (USGS) scientist, Lawrence Martens, in 1968. Martens studied the flood hydrology of seven streams in metropolitan Charlotte, NC. Through his study, Martens learned that urban development significantly increases the flood potential within the urbanized basin. Specifically, Martens found that the more impervious the ground surface was (i.e. more urbanized), the greater the peak and volume of the mean annual flood. Also, the lag time for fully urbanized basins- the amount of time between the time of the center of mass of the rainfall distribution of a storm and the time of the resultant peak discharge- was found to be one fourth that of the pre-development condition (Martens, 1968). Other researchers have subsequently observed that the durations of runoff events decrease with progressive urbanization (Brown, 1985). These concepts are illustrated in Figure 1.1, which plots flood unit hydrographs for an increasingly urbanized watershed.

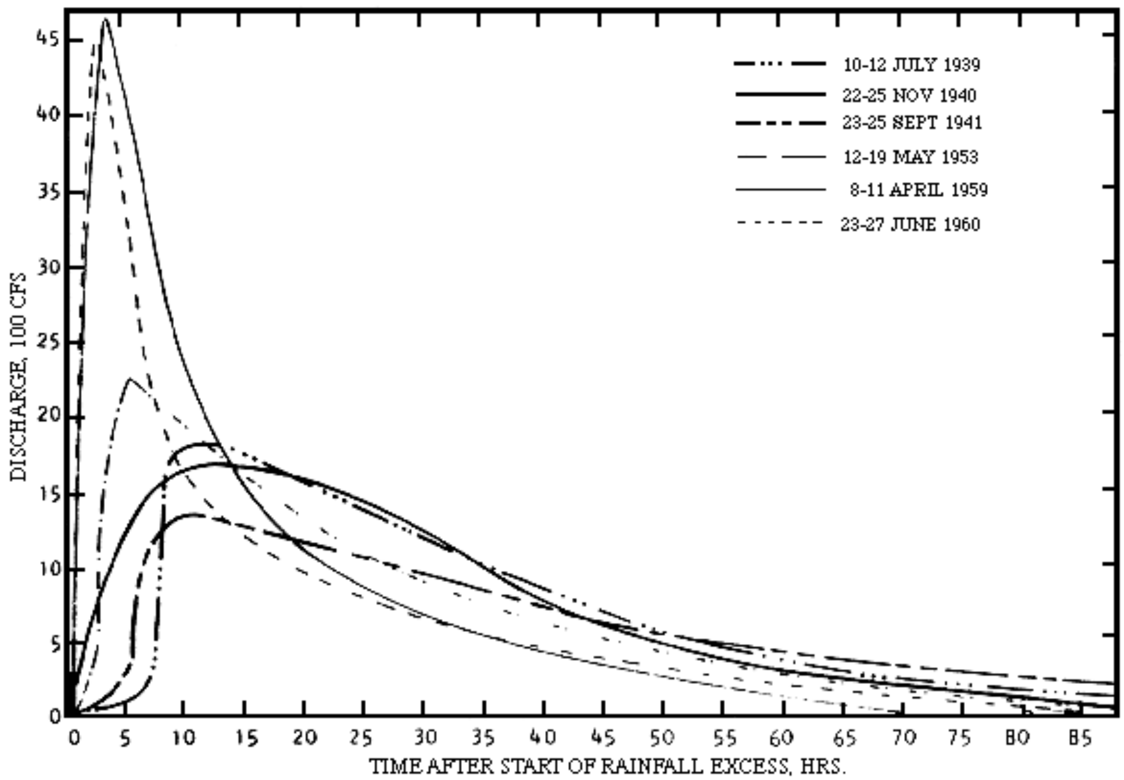


Figure 1.1: Brays Bayou unit hydrographs. (from Espey, 1969)

Because different magnitude storms occur with different frequencies, it is important to know the impact of urbanization relative to storms of different recurrence intervals. Martens found that the effect of impervious surfaces diminished as the size/infrequency of the flood event increased (Martens, 1968). This finding indicates that there are serious planning issues involving the small and medium-sized floods, as well as the large, infrequent ones.

Subsequent studies have refined and expanded the base of data supporting the conclusions of Martens, Leopold, and others. A frequently cited summary paper is that of Hollis, 1975. In his paper Hollis lists and reviews the results of fifteen urbanization studies. Based on the combined data set Hollis concluded that 1) small floods (recurrence interval less than or equal to one year) may be increased in magnitude by a factor of 10-20 depending on the amount of area paved, 2) 100-yr floods can double in size with a 30% paving of the watershed, 3) the relative impact of urbanization decreases with decreasing flood frequency, and 4) flood magnitudes for events with greater than one year recurrence intervals do not increase significantly until more than 5% of the basin is paved (Hollis, 1975). These conclusions are summarized graphically by Hollis so that urban planners and city engineers can predict and deal with the impact of urbanization in their watersheds (Fig. 1.2).

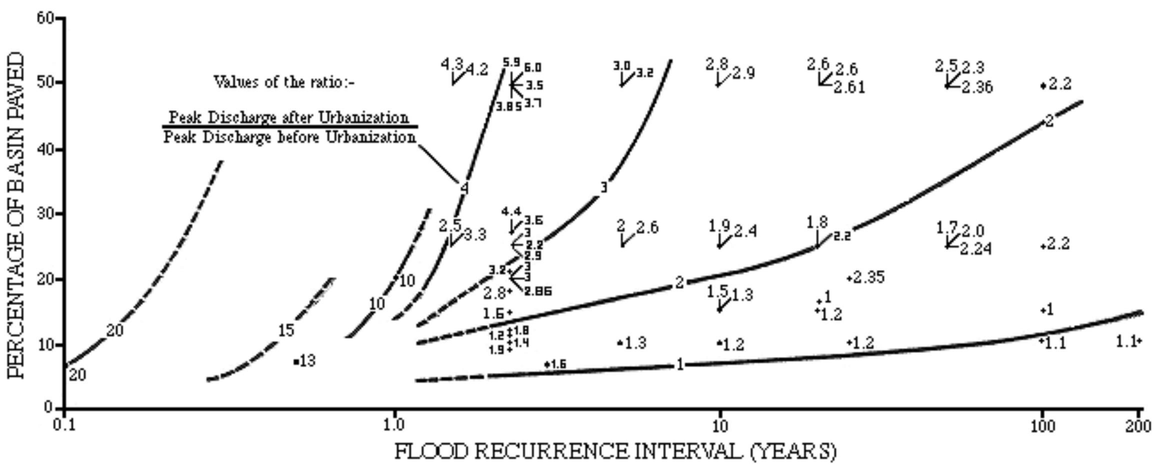


Figure 1.2: Effect of urbanization on flood peaks. (from Hollis, 1974)

Beside causing increased flood magnitudes and decreased lag times, urban development inhibits groundwater recharge and ultimately lowers a river's baseflow (Novotny and Olem, 1994). Baseflow is important for beneficial ecological values and water quality concerns (Lazaro, 1979; Novotny and Olem, 1994), especially during the summer months when water levels are already low due to a lack of rain and increased evaporation.

Whereas hydrology accounts for the inflow, storage, and outflow of water in a basin, the "budget" so to speak, hydraulics is concerned with the actual water flow processes involved as understood and quantified through the application of the laws of mass, momentum, and energy conservation. To influence the hydraulics of a river system, one must physically alter the drainage channels and/or change the fluid properties of water. Changes to fluid properties can occur via the water quality impacts of urbanization described later. However, these changes are usually not drastic enough to be hydraulically significant. Where they are, the impacts depend on the type of effluent involved, which is site specific and beyond the scope of this discussion. Meanwhile, physical changes to the watershed are the very backbone of urbanization and thus have widespread, generic impacts that concern all city engineers and urban planners.

One means by which urbanization changes the hydraulics in a watershed and its river corridor is through the switch from natural tributary channels to sewers, ditches, and paved open channels (Fig. 1.3).

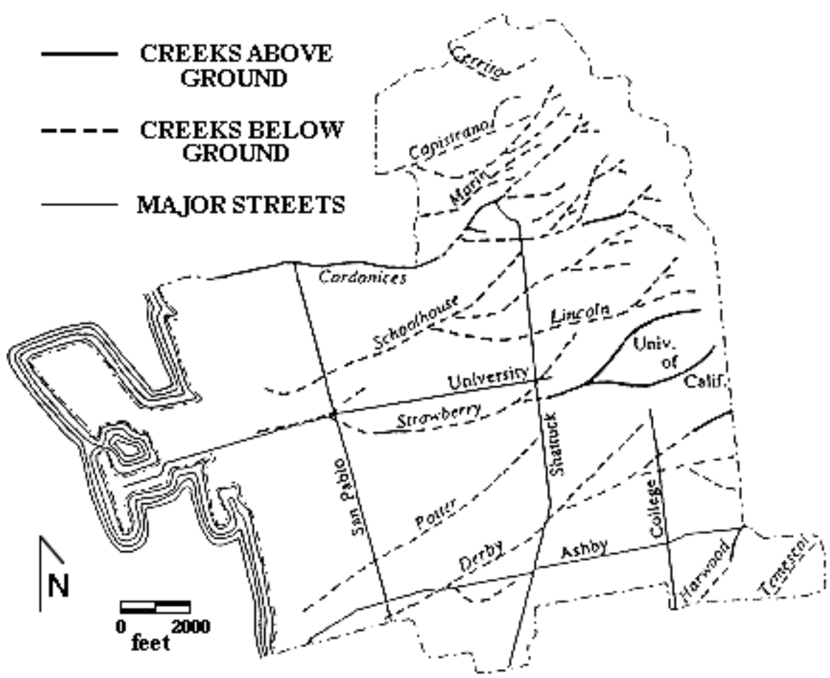


Figure 1.3: Loss of tributaries due to urbanization. (from Kondolf and Keller, 1991)

> "In many urban settings, rivers have been relegated to the level of utilities and buried underground... The River Fleet flows entirely in a pipe where it crosses the Sloane Square tube stop in London. In Berkeley [CA], most of the city's streams have been put in underground culverts." (Kondolf and Keller, 1991)

Whereas natural channels have complex cross-sectional geometries, meanders, various bedforms and debris, and extensive bank vegetation, engineered channels typically have simple rectangular or trapezoidal cross-sections, more gentle meanders (if any), no bedforms, little debris, and little to no bank vegetation (Linsey et al., 1992). As a result, the hydraulic roughness of engineered channels is much lower and the longitudinal slope is significantly greater than those of natural channels. Since velocity is directly proportional to slope and inversely proportional to hydraulic roughness, the manmade channels speed flows through them quicker and more efficiently (Robertson and Crowe, 1993). The results are disastrous. First, the water has little to no opportunity to infiltrate into the ground (Linsey et al., 1992). Second, water from distant points in the watershed may reach the main river channel fast enough to coincide with the local runoff thereby producing the more extreme flooding already described. Third, the speeding water has more energy (i.e. greater $v^2/2g$) and stream power (i.e. greater γQS) with which to alter the channel geometry in downstream natural reaches (Robertson and Crowe, 1993; Ritter, 1986).

Another way in which urbanization disturbs the hydraulics of a river corridor is through the placement of structures directly in the flow path.

Bridges are one class of structure that have very high densities in urban river corridors. For example, in the downtown river corridor in the city of Chicago, IL, there are 28 different bridge crossings (Zotti, 1990). As flood waters rise the constricted bridge cross-sectional area becomes incapable of passing the flow and water backs up until it pours over the upstream banks (Fig. 1.4). Poor bridge design has been responsible for extensive flood damage in many cities including that of Santa Cruz, CA. In Santa Cruz a proposed flood control project that features bridge modifications is expected to cost

$23 million to construct (Santa Cruz Department of Public Works, pers.comm.).

Since people have always tended to live near water, the development of floodplain lands is hardly surprising. However, the discharge of undisturbed rivers exceeds bankful every one to two years (Ritter, 1986), so the floodplain is an active part of the river system.

> "The river channel is large enough to accommodate all the water coming from the drainage area only in the relatively frequent event." (Leopold, 1962)

When water spills out of the river channel and onto the floodplain, buildings become barriers to flow (Fig. 1.5). This blockage causes water stages to rise thereby increasing flood damage.

Given that the manmade drainage infrastructure of urban areas leads to more hazardous hydraulic conditions, it is not surprising that the geomorphology of the river corridor is subject to change over the period of years to decades. According to the principle of dynamic equilibrium, process and form exhibit a cause-and-effect relationship (Ritter, 1986). With respect to a river, this means that there exists

> "... a delicate balance between the flow of water, the sediment transported, and the form of a river." (Florsheim, 1993)

In an undisturbed setting,

> "The first and most important aspect of the river channel is that it is self-formed and self-maintained." (Leopold, 1962)

In the urban setting, rivers are initially choked with sediment input during the construction phase (Ritter, 1986) and subsequently "starved" of sediment input because the impervious land cover resists erosion (Brown, 1985). Meanwhile, the river

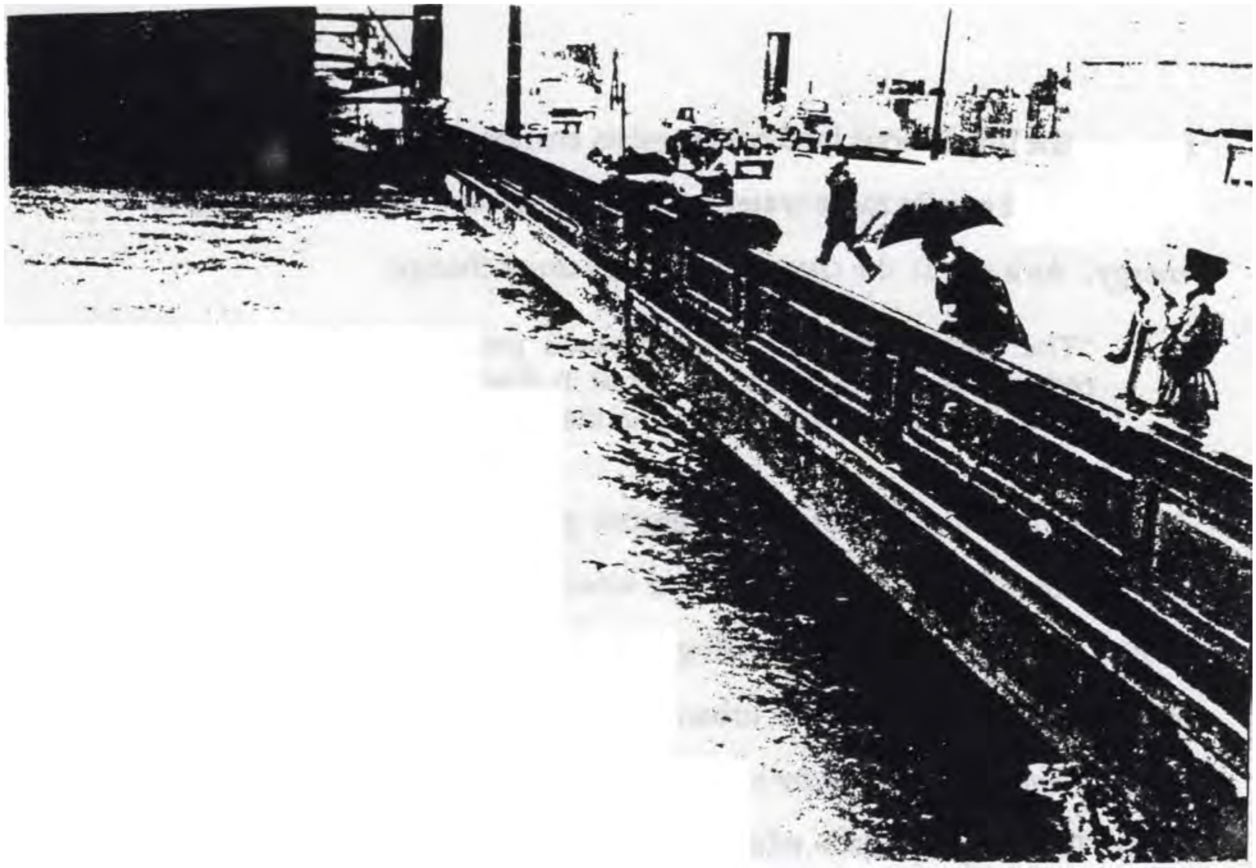


Figure 1.4: Water begins to pile up behind bridge; Guadalupe River, Dec. 1955.

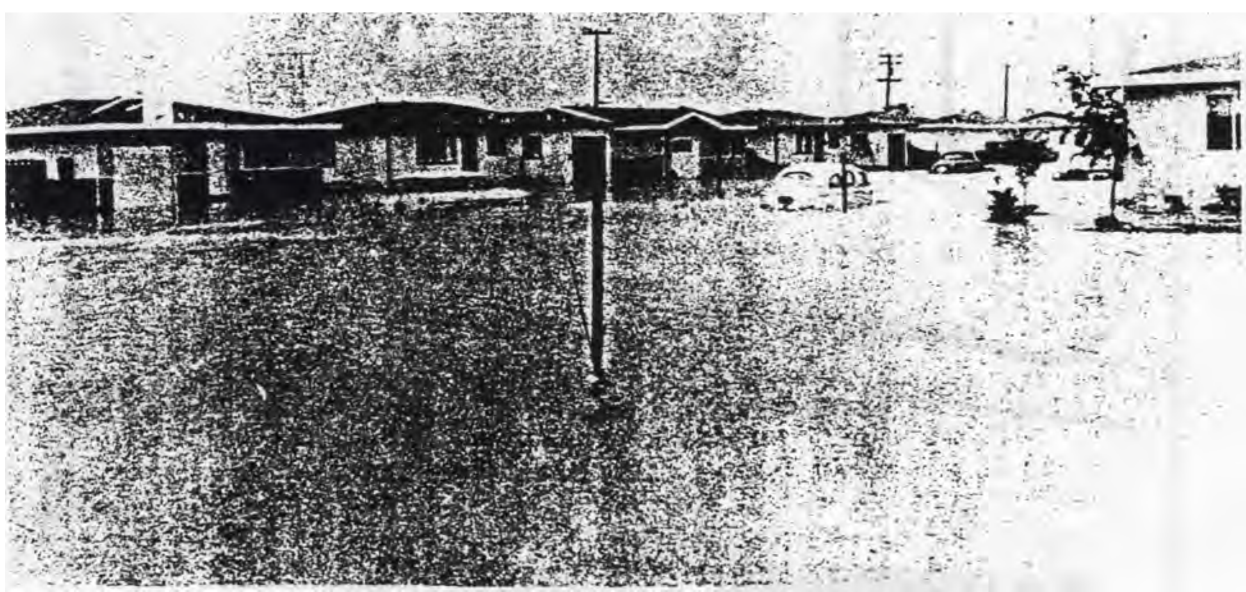


Figure 1.5: Homes that are barriers to flow; Guadalupe River, Dec. 1955.

channel carries more water moving at a faster speed and with greater energy. As a result, the channel geometry must change:

> "The combination of the increased peak runoff rates and the reduced sediment loads will result in channel degradation, channel widening, and a reduction in channel sinuosity." (Brown, 1985)

An example of a river that has undergone geomorphic change as a result of urbanization is the San Lorenzo River where it passes through Santa Cruz, CA. In 1959 the U.S. Army Corps of Engineers (USACE) excavated 770,000 yd^3 of material from the river in the urban reach, channelized the river, and paved it with concrete armor in order to provide flood control for the city (Copeland, 1986). The Corps. project- which cost $6,466,000- increased the river's longitudinal slope, but allowed the ocean base level to intrude much further inland than it did before the project was undertaken (Griggs and Paris, 1982).

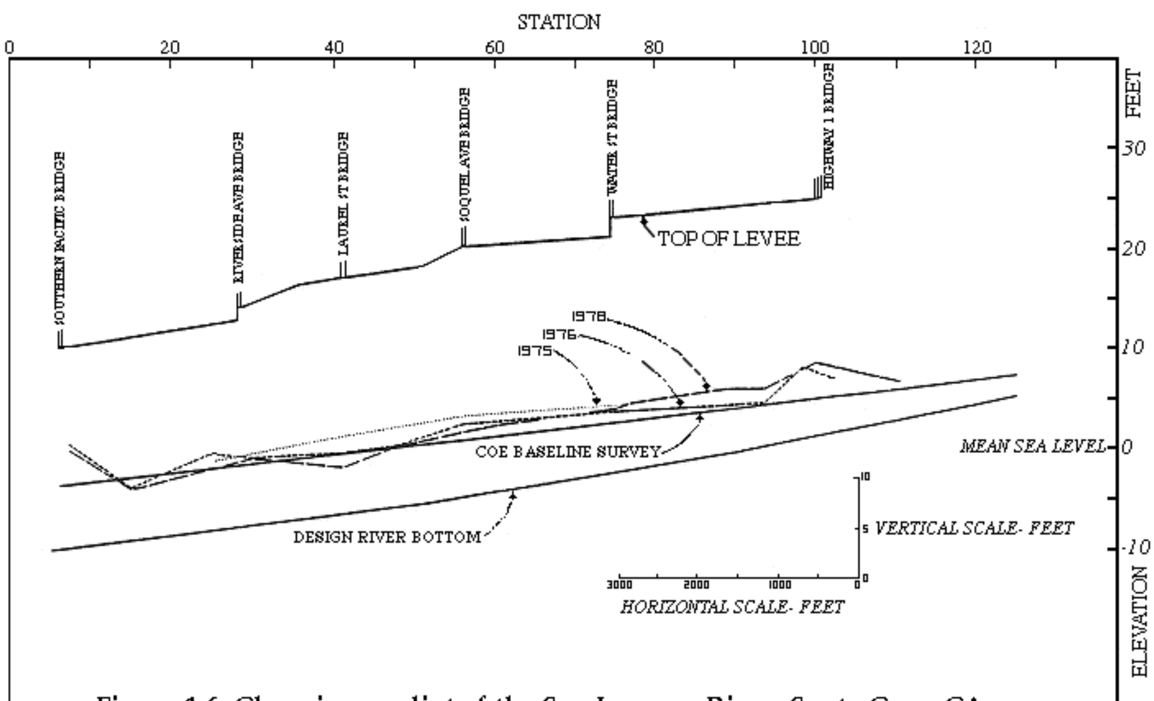


Figure 1.6: Changing gradiet of the San Lorenzo River, Santa Cruz, CA. (from Griggs and Paris, 1982)

Also, continued urbanization of the upstream watershed produced large quantities of sediment that were transported down to the project reach. Consequently the river's flow velocity in the urban section was significantly reduced by the standing ocean water, transported sediments were deposited, and the channel aggraded (Fig. 1.6). Without any project maintenance carried out by the local government or the Corps. 500,000 yd^3 of sediment had redepositied by 1980, thereby negating most of the flood control protection that the original project had created (Copeland, 1986). From 1978 to 1981 about 100,000 yd^3 of material was dredged, but that was quickly replaced from upstream sources (Copeland, 1986). In 1993 there was about 510,000 yd^3 of deposited material (Fig. 1.7), and it would cost $280,500 in 1957 dollars to remove (USACE, pers.comm.).

Water quality and water resources are intricately linked facets in the urban river setting. Ceteris paribus, when the quantity of water flow decreases in the face of a constant urban waste discharge, the quality of the receiving waters will decrease. One of the serious water quality problems facing many urban rivers is a result of the aerobic bacterial decomposition of raw sewage and the decomposition of the algae/plankton which opportunistically thrive on nutrients derived from the waste (Rao, 1991; Novotny and Olem, 1994).

> "Waste disposal has become one of the most important abiding functions of the Charles River [MA]... the basin is at present [1968] grossly polluted." (Stinson, 1972)

In order to break down the organic molecules making up the waste and algae, bacteria must use up tremendous amounts of oxygen. For example, to decompose one molecule of plankton, 138 molecules of oxygen must be consumed (Drever, 1988).

Another water quality problem in the urban setting is the discharge of toxic pollution. According to the Clean Water Act Amendments of 1977, the

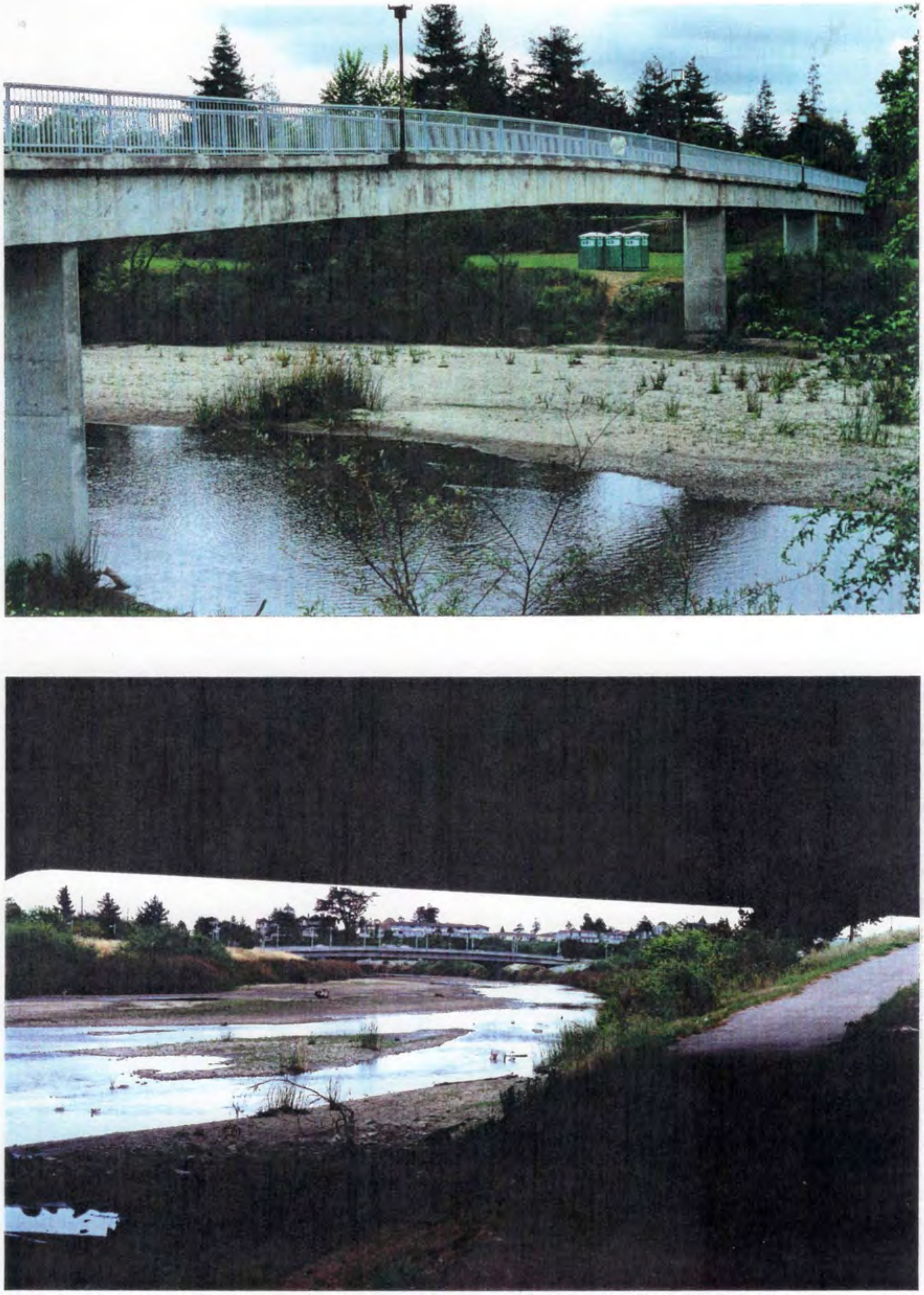


Figure 1.7: Sediment in the San Lorenzo River (Spring, 1994).

definition of toxicity covers almost all possible harmful impacts of pollutants on all types of organisms (Novotny and Olem, 1994). Examples of toxic pollutants common in the urban setting include heavy metals, detergents, polychlorinated biphenyls (PCBs), and a host of volatile organic compounds (e.g. gasoline, trichloroethylene, and perchloroethylene), which are used in fuel, electronics, and dry cleaning industries, to name just a few. A recent study of the Los Angeles (LA) River, CA found unsafe concentrations of oil/gasoline, bacteria, arsenic, and some volatile organic carbons (Danza, 1994).

Water quality problems in urban rivers are not restricted to the river channel alone.

> "Water is a potential carrier of pathogenic micro-organisms... Contact with the pathogens can be made by drinking the water or through other activities involving contact with water." (Rao, 1991)

Water-borne bacteria include those that cause cholera, typhoid, and dysentery. Water-borne viruses include strains of polio and infectious hepatitis (Rao, 1991).

> "The most commonly identified pathogen in outbreaks of water borne disease in the United States today is Giardia... While the outbreak of Giardia in Luzerne County [PA] was one of the largest ever observed [with 6,000 people afflicted], several large cities could be at risk..." (Harrington et al., 1991)

An example of an urban river that has been shown to have dangerous pathogen levels, as indicated by the presence of high concentrations of coliform bacteria, is the Charles River in Boston, MA.

> "...total coliform counts at the John Weeks Foot Bridge [Charles River, MA] went to 6,500,000 per 100 ml in August, 1967... Maximum coliform counts for swimming are 1,000 per 100 ml." (Stinson, 1972)

One unmonitored means by which water borne pathogens carried by urban rivers access human populations is through the unauthorized use of river banks for homeless refuge. According to the Los Angeles Times, an estimated 150 homeless immigrants bathe, cook, wash clothes, and defecate in the Los Angeles river's treated wastewater that is heavily polluted with illegally dumped wastes and chemicals.

> "... the number of river people is increasing. That has raised fears about health and safety of those who live in a place never intended for human habitation... 'They do not stay on the river; they go out to day jobs and come in contact with other people'..." (Los Angeles Times, August 13, 1990)

The ecological impact of urbanization is essentially a blitzkrieg in which all of the described facets of urbanization combine to drastically reduce and degrade natural fish and wildlife habitats. Since engineered channels have simplified cross-sections, no spawning gravels or desirable cobbles, and little to no bank vegetation to provide shading, the entire instream physical habitat for some fish species and other organisms is essentially eliminated. Also, as ambient water quality decreases, aquatic organisms are impacted via increased water temperature, increased turbidity, decreased dissolved oxygen concentrations, and chemical toxicity (Lazaro, 1979; Rao, 1991; Danza, 1994).

> "More than half of the U.S.'s rivers now have turbidity, temperature, or pollutant levels that adversely affect fish populations." (Williams, 1993)

> "The rivers and lakes near urban centres emit disgusting odours and fish are being killed in millions along [India's] sea coasts." (Rao, 1991)

Outside of the channel, river corridors only account for 7% of the land area in the U.S., but 70-80% of the vertibrate species may depend on the ecosystems located there (Searns, 1993). Roads, railways, and even "river walks" dissect and isolate the riparian vegetation buffer producing unsustainable "islands" of plants and wildlife.

> "Many species of amphibians, reptiles, and mammals which commonly occur in riparian habitats in undeveloped areas are often missing in urban riparian settings, as these animals are least able to coexist with humans, urban impacts, **and the lack of adjacent natural land habitat**." [emphasis mine] (Stanley, 1993)

The final consequence of lost instream and riparian habitat along with degraded water quality is a decrease in fish and wildlife numbers and biomass, loss of species diversity, retarded growth, and bioaccumulation and biomagnification of toxic heavy metals, organic compounds, and organometallic compounds (Novotny and Olem, 1994).

Increased flood potential, strengthened stream power, reduced channel stability, growing pathogen concentrations, and decimated fish populations are all specific problems that are made worse by urban growth and development. Figure 1.8 presents a useful schematic of the causal process by which urbanization adversely affects the river corridor and associated watershed. In the next section, the ways in which these degradations of the natural environment threaten public safety, social welfare, and national economic interests will be addressed. Once the interconnections between environmental, social, and economic costs are understood, it will be possible to assess the different means by which society confronts the urban river problem.

Urban River Corridors- The Social and Economic Problem

The urban transformation of river corridors and associated watersheds induces widespread, chronic change in the river system. What may be a less obvious but very important observation for urban river management is the fact that in an urban setting this change, the response of the river system to

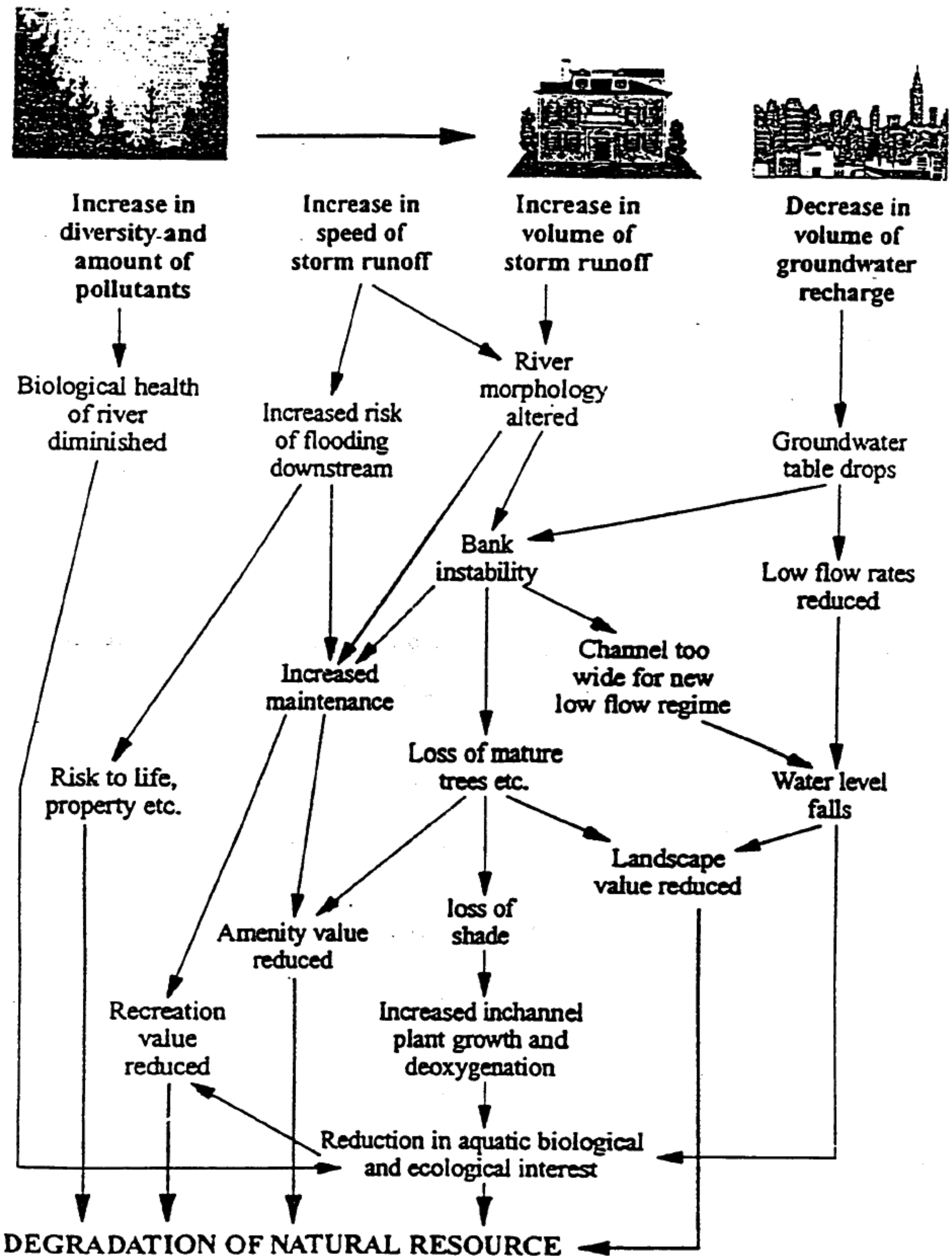


Figure 1.8: Complex response of the river corridor and watershed to urbanization (from Gardiner, 1993).

engineered impacts, has costly social and economic consequences. Likewise, urban impacts on water quality, riparian ecology, and instream ecology exact direct (and external) social and economic costs.

First, increased flood hazard leads to increased risk of flood damage. According to the U.S. Federal Emergency Management Agency (FEMA),

> "Ninety percent of the natural disasters in this country are flood related... In 1975 the Water Resources Council estimated total average annual flood damages in 1975 at $3.6 billion, $1.2 billion of which were urban flood losses." (FEMA, 1981)

In 1993 the "Great Flood" in the Mississippi River watershed washed away whole towns and caused damage in major cities to the tune of several billions of dollars (Philip Williams, pers. comm.). After 15 floods in 25 years, the residents of one town, Chelsea, decided to pick up their 330 homes and move completely out of the floodplain (American Rivers, pers. comm.)! That strategy may help relieve social and economic tension for small communities, but what of our densely populated urban centers? Along the Guadalupe River in San Jose, which serves as a case study for this project, the USACE estimates that a 100-yr flood would cause $75 million worth of damage (USACE, 1985). That estimate is from 1985. Since then, the price of space along the river has tripled (San Jose Redevelopment Agency, pers.comm.), so flood damages would be much costlier today. In the recent (October 1994) flooding of southeast Texas rivers, significant damage has been caused by the rupture of a gasoline pipeline:

> "A pipeline big enough to carry one-sixth of the nation's gasoline supply suddenly ruptured under the flooded San Jacinto River east of Houston yesterday, sending flames 100 feet into the sky and igniting boats, a railroad trestle, and homes on the river bank... At least 69 people were treated for burns and smoke inhalation." (New York Times, 10/21/94)

Because of the high economic and social costs illustrated in the above examples, flood damage has been the primary concern of urban river managers, and this concern is reflected in the orientation of existing urban river management strategies.

Second, geomorphic changes to an urban river corridor often result in the loss of valuable land. Urban land is expensive land (Whitman et al., 1971). In the city of San Jose space in the corridor adjacent to the river presently costs about $100 per square foot (San Jose Redevelopment Agency, pers. comm.), which equals a whopping $4,356,000 per acre! This value is similar to that for many of our largest cities, including Los Angeles, New York, Boston, and Washington, D.C. Consequently, city engineers must work to stabilize the river channel; but alas, further modification and urbanization will only intensify the river's tendency toward instability (e.g. the San Lorenzo River, Santa Cruz, CA)! Clearly, the topic of urban river management is ripe for continued discussion.

Third, the degradation of water quality poses economic and social costs via its threat to public health. When people in a community get sick there are socio-economic losses sustained by individuals, businesses, government agencies, and water supply utilities (Harrington et al., 1991). A few examples of such costs include time to obtain medical treatment, lost consumer purchasing, time to purchase or boil water for household or restaurant use, and work time to determine cause of the public health crisis. In Milwaukee, WI an April 1993 outbreak of the water borne parasite cryptosporidium in the municipal water supply inflicted over 400,000 people bringing the city to a halt (Milwaukee Journal, 3/27/94). 104 people died in that incident (Milwaukee Journal, 3/27/94). The social cost of public fear and skepticism of the water supply is impossible to put a dollar value on, but as a result of the Milwaukee outbreak the city is facing 1419 lawsuits totaling $25 million (Milwaukee Journal, 3/20/94). Also, that event and others like it may force our nation’s cities to expend millions on expensive new water filtration systems that can cope with the hazards of degraded river waters. At a time when national health care costs are the fastest growing governmental burden, anything urban planners can due to maintain good water quality is important.

Fourth, the disappearance and poisoning of fish in urban rivers poses a threat to the people who use them as a supply of food. In some urban areas, river fish represent an important historical symbol and attract tourist business. For example, seasonal fish from the densely populated Connecticut River corridor are featured on the menu throughout historic New England. In other urban areas, fish are the primary source of food for the poor. In Washington, D.C., people fish along the shoreline from the base of Chain Bridge, which marks the beginning of the urban river reach, all the way down to historic Mount Vernon below the city, where George Washington himself probably cast out a line or two in his day! The Anacostia River in Washington, D.C. has been designated as the second most endangered river in the country by the non-profit group, American Rivers, because of its degraded condition, yet people still fish along its banks.

Finally, the degradation of riverine ecosystems constitutes an economic and social cost because some people value those resources in and of themselves. In a welfare state like the United States, the social welfare is defined as the sum of individual welfares (Eisner, prof. of public policy, pers. comm.). Since there exist individuals who pay money to protect those resources, it becomes the interest of society-at-large to protect them. The aforementioned non-profit organization, American Rivers, is an example of a group of citizens promoting their individual welfares by acting to protect urban river corridors. Other organizations that promote the protection and restoration of ecological "values" in urban river corridors include Friends of Trashed Rivers, Friends of the Los

Angeles River, Friends of the Chicago River, the American Canoe Association, and the Canoe Cruiser's Association of Washington, D.C.

Risk of flood damage, lost land, parasitic outbreaks, and food poisoning are specific social and economic problems that are caused by urbanization. The existence and interconnectedness of environmental costs, social costs, and economic costs make urban river management a multifaceted problem. Today, engineers and planners have wide access to the findings of the studies cited in this chapter and numerous other studies that have been published. In the next chapter, the different urban river management strategies for dealing with these important problems will be addressed. Ultimately, their success must be measured in terms of quantitative improvements in the state of the river system, whose engineered transformation has been wrought at a high total cost.

NORMATIVE FOUNDATIONS OF URBAN RIVER MANAGEMENT

Existing strategies for urban river management include traditional "single use" projects that promote flood control only and "multipurpose" schemes that balance a host of uses. Sound environmental and engineering urban river management in fact requires that multiple human and ecological uses are accounted for in the planning process. While the later strategy is an "enlightened" one, expert opinion and analyses suggest that projects founded on either methodology often fail to achieve their stated goals.

Traditional Urban River Management

The traditional practice for managing urban rivers involves "single use" projects that promote flood control as the sole goal. The reason for this focus is that river management agencies have no control over the bulk of the watershed, and thus are limited to projects in the channel itself (Haltiner, 1993b). Floods represent a clear threat to public safety and economic welfare. When the problem of urban rivers is approached with blinders on, urban watershed processes are taken as independent variables to be accommodated for in a structural design.

> "The primary inclusion of watershed processes in the traditional approach to river management has been to use the 'ultimate buildout' version... to predict peak flows during a 100-year storm event, then design the river channel downstream to convey this flow." (Haltiner, 1993b)

Given an estimated peak flow to pass through a channel reach, a river engineer must ensure that his project will indeed convey it. This need leads to two problems with the "single use" project. First, there is uncertainty in the estimate of the peak discharge. Because engineers are responsible for public safety and are susceptible to lawsuits, they always overbuild projects by adding "freeboard" that is intended to insure that the channel will carry the design flow. Presently, the USACE is working to eliminate this practice by implementing a new methodology called "risk-based analysis." This new approach will apply additional statistical methods to determine actual project parameters for a given peak flow, so that freeboard is no longer needed (USACE, pers.comm.). As the new risk-based methodology percolates down to river engineers around the nation, the traditional method will become somewhat improved.

Second, there is uncertainty in how a natural channel will actually convey the peak flow. Since current technology cannot predict the full three-dimensional hydraulics of unsteady, nonuniform flow, the engineer chooses to re-design the natural channel into a prismatic geometry that conveys flow in a way that is much easier to model. In essence, this second problem demonstrates the real world applicability of the Heisenberg Uncertainty Principle, as it is liberally interpreted: the more you do to identify and constrain one characteristic of a particle, the more you change the other characteristics. In this case, change means degraded environmental, economic, and social conditions as discussed in the previous chapter. When the traditional approach is taken to its logical conclusion, the urban river channel is turned into a sterile, straight, enlarged prismatic ditch with levees or floodwalls on either side (Fig. 2.1a,b).

The drawbacks of "single use" projects that result in channelized urban rivers have already been accounted for to an extent in the previous chapter because the history of "single use" projects is the history of unchecked urban development. Beyond the previously discussed drawbacks, "single use" projects are problematic because they fail to recognize any beneficial use of the urban river other than flood control; hence the phrase "single use." Beneficial uses will

Figure 2.1a Sterile, straight, enlarged trapezoidal morphology of the Los Angeles River in the downtown corridor.

Figure 2.1b: Ad hoc berms added to the LA River flood control system.

be enumerated later, but a few examples include municipal water supply, contact recreation, and waterfront development. Jim Danza has developed a simple "graphical representation of the degradation of beneficial uses caused by the transformation of the [urban] river into a single-purpose flood control channel." (Fig. 2.2) He applied his "transformation model" to the case of the LA River:

> "Over time... the river was increasingly channelized and concreted, causing beneficial uses... to decrease. Note that beneficial uses are not eliminated, but are reduced in value (degraded) or in number (lost). Also note that channelization does not reach the maximum on the graph, taking into account the portions of the river that are not entirely concreted." (Danza, 1994)

Another drawback to the "single use" project is that it is a static structural solution that can not accommodate future changes, be they geomorphic or economic.

> "The inadequacies or failures [of river basin projects] are the result of imposing a **static plan** on **dynamic natural and economic conditions. Flexibility for change** is, then, the central theme of our observations." [emphasis mine] (Kasser, 1973)

In the last chapter the geomorphic problems with the "single use" project on the urban stretch of the San Lorenzo River were described. In return for protecting their lives and property, the people of Santa Cruz sacrificed other beneficial uses, which are numerous because Santa Cruz is a year-round coastal tourist attraction (Santa Cruz Department of Public Works, pers.comm.). As a result of the river's response to the channelization (and the lack of local attention to the problem), the city does not even have the flood control benefit it desired. In southern California, the economic growth and development in the LA River watershed occurred at such an unprecedented rate that in 1969 the U.S. Senate authorized a review of the LA River flood control system. The review ultimately determined that the "single use" project was no longer adequate to offer the level of

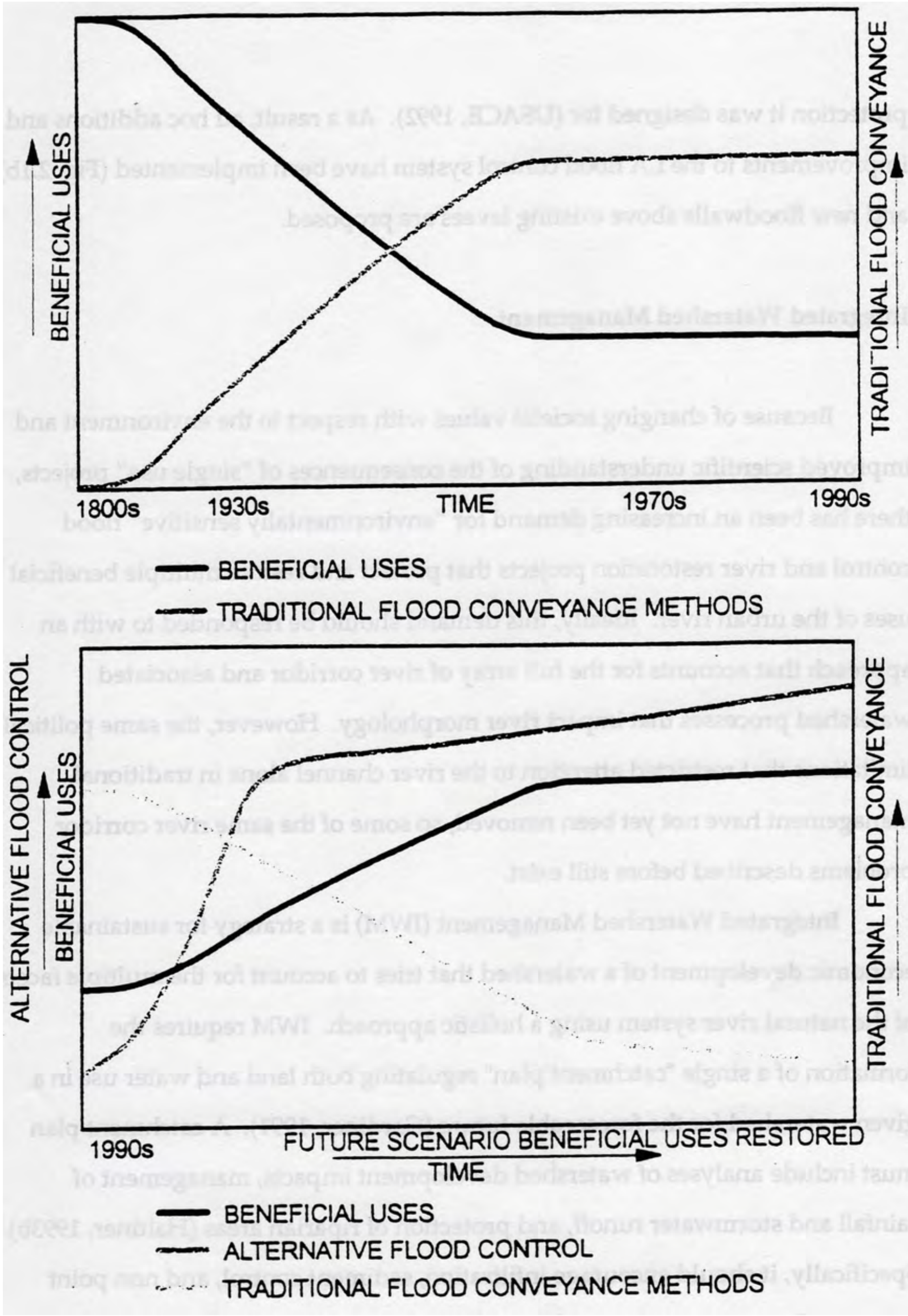


Figure 2.2: Danza's urban river transformation model: a) As flood conveyance is promoted, beneficial uses of rivers decrease; b) If conveyance is phased out and alternative methods are phased in, beneficial uses increase.

protection it was designed for (USACE, 1992). As a result, ad hoc additions and improvements to the LA flood control system have been implemented (Fig. 2.1b) and new floodwalls above existing levees are proposed.

Integrated Watershed Management

Because of changing societal values with respect to the environment and improved scientific understanding of the consequences of “single use” projects, there has been an increasing demand for “environmentally sensitive” flood control and river restoration projects that protect and restore multiple beneficial uses of the urban river. Ideally, this demand should be responded to with an approach that accounts for the full array of river corridor and associated watershed processes that impact river morphology. However, the same political limitations that restricted attention to the river channel alone in traditional management have not yet been removed, so some of the same river corridor problems described before still exist.

Integrated Watershed Management (IWM) is a strategy for sustainable economic development of a watershed that tries to account for the multiple facets of the natural river system using a holistic approach. IWM requires the formation of a single "catchment plan" regulating both land and water use in a given watershed for the foreseeable future (Gardiner, 1991). A catchment plan must include analyses of watershed development impacts, management of rainfall and stormwater runoff, and protection of riparian areas (Haltiner, 1993b). Specifically, it should encourage infiltration, sediment control, and non point source pollution prevention and abatement wherever possible. It must also provide for a stable channel that can pass design floods without sacrificing bank vegetation and instream habitat. In some instances this objective could require structural additions to a river channel such as flood bypasses that function when episodic channel-changing floods or debris flows occur (Haltiner, 1993b). Obviously, IWM presents a terrific challenge for river planners, but it provides a rational framework for curing the "disease" as opposed to traditional urban river management which only treats the symptoms.

Although Integrated Watershed Management is the best strategy that scientific and engineering theories can provide, it is difficult to actually use because it requires a long term window of opportunity in the political climate and presupposes that planners have the authority to legislate regulations that span multifarious jurisdictions. A typical catchment plan takes years to design and may be implemented over decades. Meanwhile, a region will feel the effects of swings in the business cycle on a relatively frequent basis. Unavoidable changes in the economic climate may induce changes in government spending and regulation practice that run counter to and take short term precedence over the catchment plan. As discussed before, agencies responsible for river management do not in fact have unilateral governance over land use and processes in the upland watershed. Competition between agencies effectively obstructs such transgression (Wilson, 1984). Also, for reasons that will be explained later, the nature of the distribution of costs and benefits in river management as well as its long time frame discourages elected officials- who see only as far as the next election- from effectively engaging in the river management process.

"Multipurpose" Urban River Management

While IWM has been beyond the reach of urban river planners, scaled back versions have recently been developed for many urban river corridors.

“Multipurpose” river management involves approaching the river with blinders on with respect to the upland areas and promoting multiple beneficial use of the corridor itself. “Multipurpose” management typically involves designing a "riverwalk" (for dense urban areas) or "greenway" (where more space is available) for human recreational uses with limited structural components.

Perhaps the landmark case for nonstructural, multiple objective alternatives to single use flood control projects was the “Littleton Plan.” When the USACE presented the suburban community of Littleton, CO (upstream of Denver) with a structural flood control project involving a dam and an “improved” structural channel, the people of Littleton fought against it and came up with an alternative, nonstructural plan.

> “The plan was simple but revolutionary. The COE was asked to abandon the notion of construction and commit the funds budgeted for structural work to the acquisition of the undeveloped portions of the floodplain. Littleton even sweetened its proposal with a $400,000 bond issue to help with the land acquisition.” (Searns, 1991)

Because the USACE interpreted its mission narrowly and would not proceed with the alternative plan without legislative approval from the Federal government, the people of Littleton went to Washington, D.C. and pushed the passage of The Water Resources Development Act (Public Law 93-251).

> “Section 88 of the Act authorized federal participation with local interests for acquisition of land for flood control purposes in lieu of structural improvements... Today, a 625-acre high plains riparian preserve, known as South Platte Park fronts the South Platte River in Littleton.” (Searns, 1991)

Once Littleton had successfully implemented its nonstructural “greenway” solution for managing floods rather than controlling them structurally, other urbanizing communities along the South Platte desired similar amenities. Today, Denver's Greenway system has a full trail and boating infrastructure in place with preserved acres of existing riparian forest and 10,000 newly planted trees (Searns, 1991). Other major cities that have promoted greenway alternatives to flood control include Sacramento, Ca (American River Greenbelt Project), Pueblo, CO (Arkansas River Greenbelt Project), and San Antonio, TX (San Antonio Riverwalk project). Even Boston, MA has cleaned up its act along the Charles River to the point that beneficial uses like contact recreation have been restored. Now, when communities consider their options for their urban river corridors, it is not unusual for them to model their projects on the aforementioned ones.

> "To the extent feasible, it is the City's desire to model the riverwalk project after the 'San Antonio Riverwalk' project" (Santa Cruz Department of Public Works pamphlet, 1994)

While the Denver Greenway has successfully balanced a number of uses and values, "multipurpose" projects on the whole have been found to fail to achieve their stated goals when evaluated by experts. One reason for this is that the agencies that are active with urban streams view their missions- be they flood control, endangered species protection, recreation, etc- narrowly and are thus incapable of carrying out multiple purpose plans (Harder, 1974).

> "It is not realistic to expect a flood control agency beleaguered by budget cuts and lawsuits to be eager to take on new responsibilities such as ecosystem management or public access." (Williams, 1993)

From a political science point of view, this outcome is neither new nor surprising:

> "Few organizations, and especially few successful ones, can tolerate having more than a single governing ethos: the need for morale, for a sense of mission and of distinctive competence, and for standard operating procedures means that competing norms will be suppressed, ignored, or isolated." (Wilson, 1984)

A second reason for limited success with "multipurpose" projects is the increased tendency in the U.S. towards filing lawsuits after accidents coupled with the larger sums awarded. This development has deterred the people with the technical know-how in their implementation of multiple objective design plans.

> “The dramatic increase in lawsuits and liability have only increased a reliance on traditional practice... The concept of ‘attractive nuisance’ has saddled cities and counties with liability for irresponsible individual behavior.” (Haltiner, 1993b)

One “multipurpose” management plan that failed to achieve its stated goal involved a collection of environmentally sensitive flood control projects on streams in the San Francisco Bay Region.

> “The purpose of the project was to demonstrate through a set of designs and analyses that the flood control objectives of urban stream management can be combined with open space and recreational benefits to the end that a sharing of project costs could be achieved... During the course of the project **several obstacles to a fuller multipurpose use of urban stream areas became apparent**.” [emphasis mine] (Harder, 1974)

Clearly, IWM and its watered down “multipurpose” counterpart are the urban river management strategies of the future. Greenways and other multiple use river corridor systems are scientifically, environmentally, and economically sound solutions to a complex societal problem. However, such projects are susceptible to failure when they ignore upland watershed processes or face political obstacles. In most case of declared failure, the primary reason given is the catch-all, “institutional barriers” (Harder, 1974; Haltiner, 1993b; Whipple et al., 1976; Whipple, 1977; Williams, 1993). In the next chapter a political framework will be developed for understanding the ways in which IWM and “multipurpose” management are undermined politically, and how those political obstacle can be overcome.

POLITICAL ANALYSIS OF URBAN RIVER MANAGEMENT

"Multipurpose" river management projects that have been undertaken since 1970 have been designed to incorporate multiple societal uses and ecological functions, but have been found to achieve only a modicum of success. The primary complication, or drawback, to the multiple objective approach is that it involves a significantly complex political process- one that can only be understood from a political analysis point of view, which engineers and river planners typically lack. Political complications that obstruct a more holistic management strategy include neglect of "one tool per goal" concepts, strategic conflicts between project facets, failure to account for the distribution of political costs and benefits of river regulations, and neglect of regulator behavior issues.

Most analyses of river management divorce the scientific and engineering foundations of river management from the political milieu in which it occurs. By doing so it may be possible to analyze the outcome of each strategy under relatively ideal, non-obstructive political conditions. However, in reality, river management is fundamentally a political process.

By definition a public policy- be it law or executive decree- is nothing more than a purposive pattern of coercive action (M. Eisner, Wesleyan University, pers. comm., 1994). It is a purposive pattern in that people spend time debating and selecting its various components. It must be coercive because if people were voluntarily doing what the policy calls for, then it would not be needed in the first place!

Understanding this, urban river management is fundamentally an application of public policy. People *do* carefully select the components of a river management plan; and they do so using rational, technical methods whenever possible. Also, river management must be coercive- without government involvement no coherent management projects would be undertaken. This fact is illustrated by the crucial role of the federal government in developing the water resources of the western United States.

> "Thanks to irrigation, thanks to the Bureau [of Reclamation]- an agency few people know... millions settled in regions where nature, left alone, would have countenanced thousands at best..." (Reisner, 1993)

The sum of federal spending on river management has not been tallied to a single number, but the order of the figure is 10s to 100s of *billions* of dollars. That scale of spending could not have occurred if water resources development was left to private market forces alone. A simple illustration is the case of small scale channel stability problems:

> "It is not uncommon along an incising urban creek in California for each property owner to install a different type of channel protection scheme, without coordination, knowledge of potential success, impacts on others, etc." (Haltiner, 1993)

Because urban river management is fundamentally an application of public policy, the root problems inhibiting successful "multipurpose" management can be determined using well established theories of policy analysis. One such theory is known as Tinbergen's Rule, after the man who derived it in 1967 in order to promote rational economic policy design. The "Tools and Goals" method that is proposed here is an application of Tinbergen's Rule and can be used in the design phase of a river management plan to overcome technical shortcomings and forestall institutional barriers.

"One Tool per Goal" Criteria

J. Tinbergen (1967) demonstrated that the number of quantitative goals of an economic plan must be matched by an equal or greater number of financial instruments in the relevant mathematical model for a unique solution to be found. Where river management goals and instruments can be expressed mathematically, the river analogy of Tinbergen's conclusion can be tested given specific models that govern river processes. Unfortunately, there are no existing mathematical models that account for the range of human uses and natural functions of a river system. At best hydraulic models can provide flow kinematics coupled with crude sediment transport estimates (HEC-6) or physical habitat suitability indices for a single species at a single stage of life (PHABSIM). Since the limits of human understanding of rivers preclude systematic, *quantitative* testing of Tinbergen's conclusion, *qualitative* analysis and *empirical* studies must be used to do so. The relevance of a "one tool per goal" principle has been empirically demonstrated for a range of public policies (M. Eisner, pers. comm., 1994). When a number of river projects have been evaluated for "one tool per goal" adherence and degree of success, empirical testing of the applicability of the theory to this field will be possible.

A "one tool per goal" rule for project design can be qualitatively assessed. If a river project attempts multiple goals with only one tool (i.e. via a "trickle down" mechanism) then only the most immediate result can be predicted with the associated goal achieved. "Trickle down" targets are precluded by the increasing effects of perturbations in the nonlinear system that go unchecked. If a unique tool promotes each goal, then independent equations can be used to predict independent outcomes. Because each goal is being directly forced by a unique tool, small perturbations from other tools may not have a relative influence. If the perturbations are significant, then tools are inherently conflicting and cannot be used in combination.

Tools and Goals (TAG) Method for Project Evaluation

Assuming that a "one tool per goal" principle is valid it is possible to develop a "Tools and Goals" (TAG) method for assessing a multiple objective project to insure that the river management plan violates it as few times as practically feasible. The TAG method can also highlight the strategic conflicts between planned project facets based on scientific theory, again paralleling work done by Tinbergen (1967). Left alone, such conflicts ultimately result in large perturbations, unpredictable results, and missed targets. TAG involves listing all project goals and design objectives, designing tools for achieving each goal, assessing which tools conflict with other project tools and goals, and finally, deciding on the array of tools to implement (Fig. 3.1).

Goal Identification, Prioritization, and Evaluation

There is a range of generic river management goals, some or all of which are proposed for enhancement via a “multipurpose” plan (Table 3.1). Underlying each generic goal must be a set of specific objectives that, when met, will indicate fulfillment of that goal. The TAG method does not dictate which goals are appropriate for a given project. Multi-objective designs are sometimes based entirely on the expressed interests of local groups and offer no accountability for the river corridor or watershed processes that cause river management problems, or what is feasible from an engineering standpoint (Whipple, 1977; M. Kondolf, University of California at Berkeley, pers.comm., 1994).

Explicit prioritization of river management goals facilitates proper implementation of those goals or at least increases accountability for project operation evaluation and litigation. An example of a river management project that failed to sufficiently prioritize and enforce its goals is the Folsom Dam

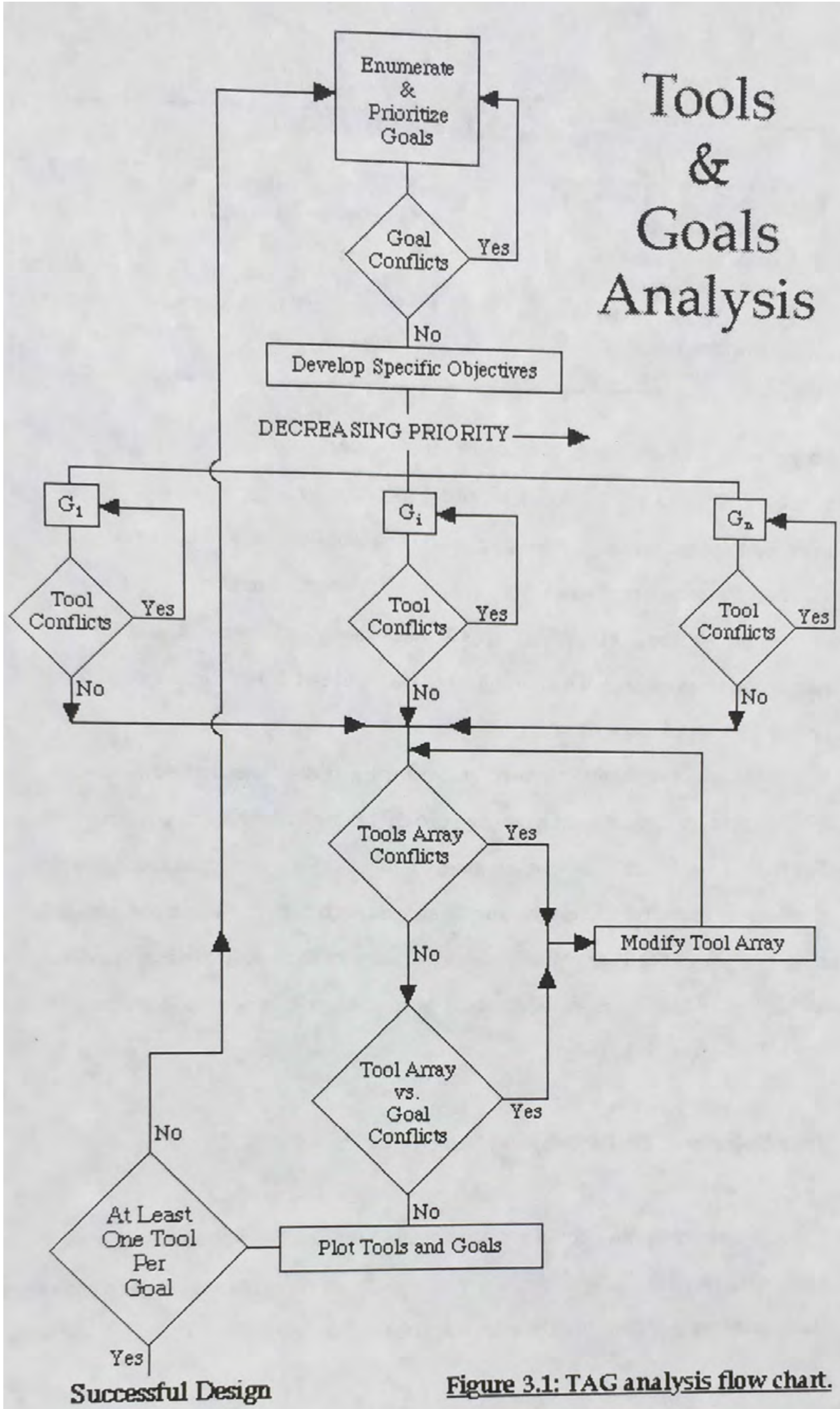


Figure 3.1: TAG Analysis flow chart (scan from original).

Table 3.1: Urban River Goals	
1. Aesthetics & historic values	8. Non-contact recreation
2. Channel stability	9. Stormwater management
3. Contact recreation	10. Unauthorized uses
4. Flood drainage	11. Waste/Heat disposal/remediation
5. Groundwater management	12. Waterfront development
6. Municipal water supply	13. Wildlife values & fisheries
7. Navigation	

project on the American River upstream of Sacramento, CA. During the February 1986 flood Folsom Dam operators chose to store water behind the dam in order to promote the goal of increasing the water supply. This decision violated operating procedure specifications that served to provide for flood control (P. Williams, Philip Williams & Associates, Ltd., pers.comm., 1994). As a result, the state capital of California was jeopardized when the flood waters nearly overtopped the dam!

Once goals are enumerated and prioritized they should be re-evaluated from a technical standpoint to make sure that none are inherently contradictory. For the case of “multipurpose” management it is likely that plans will promote conflicting goals that cannot be jointly accommodated. For example, an urban river plan might call for waterfront industrialization on a site that has existing archeological significance. Also, short term goals may interfere with long term ones (Tinbergen, 1967).

Tool Definition, Evaluation, and Selection

Economic policy tools are quantitative financial instruments that are applied to meet specific numerical goals. Because river management tools range from quantitative to qualitative, an appropriate definition for a tool is needed so that the number of tools impacting a goal can be counted. A river management tool (if it is not explicitly quantitative) is defined as a means to achieving a goal that is of *equivalent scale* to that of the goal. Table 3.2 lists fifteen categories of generic tools and several specific means by which specific objectives can be attained. These tools span the full range of structural to nonstructural options and scale from small to large. For some goals there is little elasticity in the choice of tools (e.g. navigation), while other goals are highly elastic (e.g. non-contact recreation). As with goals, the TAG method does not dictate which tools should be used, but proposed tools should be clearly enumerated and explicitly prioritized to the full extent possible.

The selection of specific tools should be made using rational analyses. A tool used to facilitate one goal may inhibit the promotion of other goals. Land buyouts in the floodplain directly obstruct private waterfront development. Further, tools may be inherently contradictory. Increased baseflow providing fish habitat may caused undermining of some bank protection devices. Because the sciences incorporated into river management provide mediocre predictions there may be disagreement as to whether a conflict really exists, or to what degree. Consequently, the basis for deciding that a conflict exists must be stated to allow for challenges and scientific consensus.

Conflict considerations point out an unpleasant feature of the TAG method schematized in Fig. 3.1: given m tools that meet n design objectives, there are “m choose 2” micro-analyses that need to be performed to check tool to tool conflicts. Similarly, there are m·n micro-analyses needed to assess conflicts between tools and design objectives, and “n choose 2” more for goal to goal conflicts. This rational management approach suggests why a “single use” project might be preferred over a “multipurpose” project- the former only requires one micro-analysis, while the latter would require 435 in order to meet

Table 3.2: Generic urban river management tools.

A. Channel Modifications
1. Pavement
2. Stabilization measures
   a. Revetments
   b. Spurs
   c. Retardance structures
   d. Bulkheads
   e. Dikes
3. Deepening
4. Widening
5. Levees & floodwalls
6. Meander modification
7. Overbank flow channel (i.e. spillway)
8. Stream cross-section complexation
9. Open channel bypass

B. Culverts
1. Flood water bypass conduits
2. Separate stormwater & sewage drainage
3. Urban runoff interceptors

C. Dams
1. Permanent storage reservoir
2. Bubble / flexible dam
3. Check dam

D. On-site Detention
1. Detention/retention ponds
2. Roof storage/infiltration systems
3. Parking lot storage
4. Holding tanks
5. Porous pavement
6. Aeration of vegetative strips

E. Soil conservation practices

F. Sedimentation Reservoirs/Basins

G. Aquifer Recharge ("Spreading") Basins

H. Vegetation
1. Biotechnics for bank stabilization
2. Riparian plantings (native or nonnative)
3. Wetlands

I. Flood Warning System
1. Real-time flow elevation monitoring
2. Hazard alert system
3. Flood forecasting
4. Evaculation stategy

J.Water Quality Measures
1. Effluent outfall design
2. 2nd/3rd wastewater treatment
3. Street cleaning

K. Landscape Measures
1. Trails / riverwalk
2. Public access points
3. Picnic facilities
4. Sculptures
5. Exercise stations / frizbee golf
6. Greenway
7. Historical/information kiosks
8. Open spaces
9. Handicapped accessibility

L. Policy Measures
1. Drainage ordinances
2. Floodplain land use zoning
3. Flood insurance
4. Land buyouts

M. Floodproofing
1. Raising structures and bridges
2. Small walls/levees around structures
3. Rearranging property inside structures

N. Upstream Water Diversion
1. To other watersheds
2. From other watersheds

P. Maintenance Measures
1. Maintenance roads
2. Equipment access points
3. Trash cleanup
4. Vegetation maintenance

10 design objectives with 20 tools! When one considers that urban river projects cost between 50 to 1500 million dollars it is not unreasonable to ask for such scrutiny. In fact, the checks are relatively easy to perform.

Returning to the problem of what qualifies as a tool, judgment must be used when evaluating a project design. The case of the Guadalupe River will illustrate what qualifies as a distinct tool and what does not. As a generic example, if a design objective is to provide play space for 50 children, then a single carousel or playground would be an appropriate tool. If the objective is to provide space for 5000 children, then 50 carousels and 50 playgrounds do not count as 100 different tools because each is not of *equivalent scale* to the problem at hand. Instead, the sum of carousels and the sum of playgrounds each count as one tool. By induction, any tool that can be subdivided into n smaller parcels should only count as one tool, not n tools. For tools that cannot be subdivided in this way, the threshold that should be used in determining whether that tool is of equivalent scale will depend on the nature of the tool and that of the goal. A conservative assessment helps to insure that all goals are adequately promoted.

Once all of the tools and specific objectives are accounted for in the analysis they should be matched up in a table to check the "one tool per goal" criteria and facilitate the conflict assessments. The plot for all of the generic tools and goals is provided in Table 3.3. For a real case the table should include a tools-to-goal match for each specific objective. Higher priority or more complex objectives should be checked for an array of tools each. Likewise, goals for the long term should have more tools than short term objectives.

If a single tool is ultimately selected to attempt multiple goals/uses, then specific criteria for *balancing* the goals/uses should be established. When independent means are used, no such compromise is necessary. Examples of balanced uses are easily found, but properly specified and enforced ones are not.

Table 3.3: Matching of generic tools and goals.*

Urban River Goals	Tools that Facilitate Goal	Tools that conflict with goal
1. Aesthetics & historic values	A8 : B2, 3 : D1 : H : J : K4, 6	A1,5 : N
2. Channel stability	A1, 2, 5, 8 : C3 : E : F : H1, 2	A3, 4, 6
3. Contact recreation	A8 : C1, 2 : D1 : K2 : N2	A1, 3, 4, 6 : J1 : N1
4. Flood drainage	A1, 3, 4, 5, 6, 7, 8, 9 : B : C1 : D E : F : H : I : K6,8 : L : M : N1 : P	H : K3, 4, 7 : N2
5. Groundwater management	A4 : C2, 3 : G : H : N2	A1, 6 : N1
6. Municipal water supply	B2 : H3 : J : L2 : N2	J1 : N1
7. Navigation	A3, 4, 6	N1
8. Non-contact recreation	D1 : K : L2	J2
9. Stormwater management	B2, 3 : C1 : D : E : H : J : L	N1
10. Unauthorized uses	A8 : B2, 3 : J : K	A1,5 : J1 : N1
11. Waste/Heat disposal/remediation	C2 : H2 : J : L2	N1
12. Waterfront development	A2, 3, 4 : H1, 2 : K : L2, 4 : N2	A1
13. Wildlife values & fisheries	A8 : B2, 3 : D1 : H : J : K6 : N2	A : B1 : C1 : J1 : N : P2, 4

* Judgement has been used in developing this table. Other interpretations exist.

In the city of Berkeley, CA there is a man-made lake (Aquatic Park) that balances multiple uses. Two conflicting contact recreation uses are waterskiing and flatwater kayaking. These are conflicting because motorboats produce sizable wakes whereas flatwater kayaks require relatively still water since they are designed for maximal speed at the price of stability. Thanks to properly specified and unequivocal legislation, motorboats have been restricted to one end of the lake where a ski jump has been installed and are limited in numbers during particular times of the day. Unfortunately, the waterskiers have not stuck to the rules, so paddlers are presently seeking to permanently ban motorboats from the facility. As predicted by Tinbergen's Rule, balanced use of the lake is jeopardized and a one goal per tool outcome is pending. When the economic and social costs that result from improper goal balancing are accounted for (e.g. the $2.5 billion dollars that it may cost to build adequate protection for the city of Sacramento in light of the bungled balanced use of Folsom Dam), the theoretical efficiency of using one tool to achieve many goals is demonstrated to be a myth in the realm of river management. Pareto optimality (i.e. net economic gain) is most likely to result when Tinbergen's Rule is obeyed.

The Tools and Goals method described in this section provides a useful means for determining which facets of a particular urban river policy will end in success or failure. If goals inherently conflict with goals, tools conflict with goals, or tools conflict with other tools, there is increased likelihood that aspects of the project will fail. Furthermore, if there is not at least one tool per goal then the risk of institutional barriers leading to failed achievement of goals increases dramatically. Tinbergen's Rule is one useful insight that can be obtained from political theory and applied normatively as a check on project design.

The Politics of Regulation

> "... there *is* a politics of regulation. To citizens, such a statement will appear self-evident, even trivial; to scholars studying the subject, it is controversial." (Wilson, 1980)

Earlier it was stated that in many cases of declared "multipurpose" management failure the primary reason given is the catch-all, "institutional barriers." In essence, institutional barriers to "multipurpose" urban river management are the obstacles to policy implementation that are caused by the actions of the regulated or the regulators. Theories that can predict the behavior of these people can be used to help facilitate the river management process.

Marxist theory and Stigler's economic theory have been applied to describe and predict regulatory behavior, but do not account for many of the observed activities that regulators and the regulated perform. These two theories state that

> "regulation is acquired by the industry and designed and operated primarily for its benefit." (Wilson, 1980)

And,

> "... government officials... will seek to maximize their votes (if they are elected officials) or their wealth (if they are appointed officials) or both." (Wilson, 1980)

Both theories provide useful insights to political functioning, but ultimately fail as general principles because there are in fact many regulatory agencies that were founded on anti-industry sentiments and do not exhibit class consciousness. Specifically, neither theory could have predicted the founding of agencies like the Environmental Protection Agency, Occupational Safety and Health Administration, or even the Antitrust Division of the Department of Justice because these regulators restrict free market capitalistic behavior. Also, the actions of some agencies that may have been formed to protect industry have been increasingly anti-industry (Wilson, 1980).

One theory of regulation which *is* useful for understanding the politics of urban river management is James Wilson's political economic theory of regulation. According to Wilson, the outcome of a public policy is not only determined by the **magnitudes** of the costs and benefits of the policy, but also by the their perceived **distribution**. In river management planners rely solely on the monetary costs:benefit ratio- a measure of relative magnitudes- to determine the value and potential outcome of a project. If Wilson is right, then there is a fundamental flaw in the design process that can lead to project failure.

The distribution of costs and benefits do in fact have a role in determining the outcome of a policy proposal. Depending on who bears what costs and reaps what benefits there will be different incentives for political organization and collective action. Also, if a policy is not perceived as fairly distributing the costs and benefits, then it may run into legitimacy problems. In general, the costs and benefits of a project may each be widely distributed or narrowly concentrated.

> "Though there are many intermediate cases, four political situations can be distinguished by considering all combinations of the dichotomous cases." (Wilson, 1980)

When costs and benefits are both widely distributed everyone expects to pay for and gain from the proposed policy ("majoritarian politics"). Wilson points out the examples of social security and a standing military force as policies of this type. An urban river example would be a greenway proposal since it stands to benefit all of the uses in Table 3.1. Specifically, a greenway provides flood storage, provides aesthetics and recreation, increases the value of adjacent developments, preserves riparian habitats, etc. For a "majoritarian" proposal to succeed 1) it must get onto the political agenda, 2) people must perceive it as a legitimate governmental concern, and 3) technical feasibility must be established

(Wilson, 1980). For the case of urban river management, a "majoritarian" project proposal meets the first and second requirements without difficulty. Therefore, such a proposal should focus most effort on the technical aspects of the project.

When the costs of a proposal are narrowly concentrated and the benefits widely distributed, there is little motive for benefactors to work in favor of it, but there is strong incentive for those who face the costs to organize against it. Examples of "entrepreneurial politics" include auto-safety bills and anti-pollution bills. For urban river management an example would be a proposed regulation to preserve a historic site and in doing so prevent private development there. From a river management point of view, the planner must work aggressively to change the perceptions of the community at large so that people come to believe that the benefits are in fact concentrated. Public perception of a river project is strongly influenced by third parties like the media, celebrities, influential writers, or even paid advertising companies. Also, change in public sentiment toward an increased sense of concentrated cost usually occurs following a crisis like a water shortage, flood, or large fish kill.

> "...it may seem astonishing that regulatory legislation of this sort is ever passed. It is, and with growing frequency in recent years- but it requires the efforts of a skilled entrepreneur who can mobilize latent public sentiment..." (Wilson, 1980)

When the benefits of a proposal are narrowly concentrated and the costs widely distributed, there is little motive to work against it, but there is strong incentive for those who will gain to encourage its adoption. Examples of "client politics" include the policies of the Civil Aeronautics Board and those of some Public Utility Commissions. Almost all water resource development projects fall into this category because they are funded by the taxpayers at-large who may never even see the project, while local benefactors will reap substantial gains.

For example, the Auburn Dam project on the American River in California is proposed to provide flood control for the city of Sacramento, but the cost estimate for the project is 1.5 to 3 billion dollars, depending on whose numbers you believe. Even with cost sharing the federal government stands to spend a whopping final sum for benefits that will only accrue to the residents of one small city. More examples are readily available in Reisner, 1993.

If a river management proposal aims to benefit an industry or other "client" interest then the proposal should include appropriate incentives to foster a positive regulator-client relationship. However, the pace of "client" politics in water resources management has been curtailed dramatically in the last two decades, in part due to a growing public sentiment that federal funding of water projects is not accomplishing national objectives. As a result,

> "... an important organizational change has occurred that has altered the normal advantage enjoyed by the client group in these circumstances- the emergence of 'watchdog' or 'public interest' associations that have devised ways of maintaining themselves without having to recruit and organize the people who will be affected by a policy." (Wilson, 1980)

If a river planner fails to account for the change in public sentiment or the interest of a watchdog association, then his or her project will run into institutional barriers. The aforementioned Auburn Dam has been held up for more than 20 years while public interest groups battle with regulators over the siting and operation of the dam (Reisner, 1993; USACE, pers.comm.). When a watchdog association does get involved and the planner recognizes this, he or she may be able to get a jump on the problem by initiating action to maintain the general public's sense of widely distributed costs. Alternately, the planner may need to consider the consequences of the fourth and final distribution scenario, "special interest politics."

When both the costs and benefits of a proposal are perceived as narrowly concentrated, the planner is faced with “special interest politics.”

> “A subsidy or regulation will often benefit a relatively small group at the expense of another comparable small group.” (Wilson, 1980)

When airlines are given subsidies, railroads become less competitive. Likewise, in the case of Aquatic Park in Berkeley, when flatwater kayaking is given regulatory protection, waterskiing is restricted. “Special interest politics” are very common with “multipurpose” urban river management plans. To manage this distribution scenario the project planner should apply the previously discussed Tools and Goals analysis in order to include something for everyone in the final design.

> “Neither adversary party gets all it wants; each is optimally disgruntled.” (Wilson, 1980)

TAG may even be used as a pseudo-free market mechanism so opposing interests can trade tools and balance goals in a democratic, free market process.

For the urban river planner, Wilson’s distribution theory provides a useful tool to predict how the relevant interests in a given community will respond to a project design, how a design may be altered to enhance political coalition building, and how people must be influenced in order to bring them in line with the project. The different distributions of costs and benefits of a regulatory policy are summarized in Table 3.4 with specific action recommendations for urban river management.

> “In sum, the politics of regulation follows different patterns, mobilizes different actors, and has different consequences depending... on the perceived distribution of costs and benefits of the proposed policy.” (Wilson, 1980)

The politics of the regulated is not the only institutional barrier to a river project. In fact, potential political institutional barriers arise from regulators themselves. These barriers stem from the established political and technical

Table 3.4: The perceived distribution of the costs and benefits of regulation and specific foci for urban river management.

Costs \ Benefits	Widely Distributed	Narrowly Concentrated
Widely Distributed	"Majoritarian" Technical Feasibility	"Client" Provide Incentives
Narrowly Concentrated	"Entrepreneurial" Mobilize Public Sentiment	"Special Interest" Tools and Goals Analysis

practices that different personnel-types employed by regulatory agencies exhibit. In order to understand, predict, and avoid these obstacles the urban river planner must employ a political economic theory of regulatory behavior that explains who regulators are and what actions they are likely to take.

> "In short, the behavior to be explained is complex and changing... To account for this, I suggest we view these agencies as coalitions of diverse participants who have somewhat different motives." (Wilson, 1980)

According to James Wilson, there are three kinds of employees that influence an agency's attitude toward a policy proposal- careerists, professionals, and politicians. Careerists are the employees who identify their careers and reward structure with the agency itself. These people have relatively stable jobs with strictly regulated salaries and come to a decision as to the agency's purpose based on their own experiences and judgment (Wilson, 1980). The primary threat to a careerist's job and comfort is crisis and scandal. As a result,

> "Government agencies are more risk adverse... they prefer security to rapid growth, autonomy to competition, stability to change." (Wilson, 1980)

In order to bypass careerist institutional barriers it follows that an urban river management plan should try to accommodate the defensive, threat-avoiding instincts that careerists bring to an agency. This can be accomplished by clearly stating and explicitly prioritizing the tasks that a regulatory agency must conduct as well as legislating an incentive or penalty system with appropriate measures of agency performance. When the role of a regulatory agency is explicit, threats are reduced, and the incentives are clear, careerists are most able to chart a safe path into the future for their agency and thus themselves.

The second regulatory agency personnel-type is the person who is hired to perform tasks that require professional training and/or certification.

> "The extent to which someone acts as a professional as opposed to a careerist depends on the extent to which he or she receives important rewards, intangible as well as tangible, from professional colleagues outside the government agency." (Wilson, 1980)

Because engineers and scientists are beholden to their professions, they must display appropriate behavior if they wish to accumulate credibility, seek better jobs, and be regarded with respect. Whereas careerists obstruct proposals that might cause scandal, it follows that professionals must oppose proposals whose technical details are contrary to established professional norms. As a result, urban river plans should be in line with established thinking if they seek agency cooperation.

Because agency careerists and politicians recognize this outcome they will try to staff themselves with professionals who will inherently agree with the goals of the agency (Eisner, pers.comm.). This practice of professionalization forces planners to capitulate or face institutional barriers to their projects. Clearly, this poses a problem for planners: if the goal is to try an alternative means for urban river management, then what is to be done? The situation with urban rivers is usually even worse: what if one profession dictates one approach while another dictates an exactly contrary approach? A common example of this is bank vegetation since it would be removed by hydraulic engineers but increased by landscape architects! The solution proposed here is two-dimensional: 1) use TAG analysis to provide for multiple tools so if one needs to be trimmed there are still others available to achieve the stated goal; and 2) use cost/benefit distribution theory to determine the potential for overcoming the objections of one or the other agency and then include explicit measures for forced compliance of that agency in the legislation.

When a "multipurpose" river management plan is forwarded without accounting for professional obstinance and without legislating compliance, the professional can easily derail the project's unpalatable goal by acting away from the limelight in the implementation phase to promote his own implicitly prioritized and curtailed set of objectives. This is the single most prevalent cause of "multipurpose" project failure and should be treated with utmost care and diligence.

> "Regulations that stipulate a clear and timely standard for compliance such that all improper behavior can be specified or reasonably inferred in advance will be more effective than those that do not." (Wilson, 1984)

Finally, politicians are the elected or appointed officials who attempt to use their regulatory agency positions to promote their own careers. As mentioned earlier, ambitious politicians are not in regulatory office long enough to see a river management plan go through both design and implementation. Also, river management usually involves concentrated costs or benefits, so it follows that politicians will shy away from proposals that may come back to haunt them in the future unless they have personal motives for pursuing those projects. The key aspect of politicians for river management is that they tend to not get involved unless involvement is unavoidable.

> "There are scarcely any votes to be had from... intervening in specific regulatory issues." (Wilson, 1980)

Regulatory agencies are complex institutions that participate in urban river management. A wide range of behaviors may be exhibited by a regulatory agency depending on its mix of careerists, professionals, and politicians. For urban river management the most difficult problem stems from conflict between planners and professionals and/or professionals and professionals. When the designers of a "multipurpose" management plan account for the politics of regulation they can effective steer their project away from institutional barriers.

TAG analysis, cost-benefit distribution theory, and regulator behavior theory are three specific tools that urban river planners can use to design solid multiple objective projects that avoid or overcome political barriers. In this chapter the complexities of the politics of urban river management have been described in great detail. Without an understanding of the complex political nature of urban river management engineers and planners are likely to continue designing and advocating projects that are infeasible. In the final chapter the normative foundations of urban river management and those of political analysis will be used to assess the potential success of an ongoing urban river "multipurpose" project.

TAG EVALUATION OF THE GUADALUPE RIVER MASTER PLAN

The Guadalupe River drains a 640 mi^2 basin in Santa Clara County, CA (Johnson, 1988) flowing through San Jose (the eleventh largest U.S. city) to its mouth at the south end of the San Francisco Bay (Figs 4.1, 4.2, 4.3). The Guadalupe River is subject to large seasonal fluctuations in discharge resulting from the dry summers and wet winters. Since 1945 there have been 13 times when the river stage exceeded the ~20' high channel banks so that "a wild brown torrent" of water spread over parts of downtown San Jose (San Jose Mercury, 4/3/58). Damages from the 1958 flood, the most destructive flood event on record, were estimated to be $3,200,000 (1974 dollars) during the flood, a figure challenged by Johnson (1988) who found no evidence to substantiate it, suggesting it may have been exaggerated to encourage emergency assistance. In any case, extensive urbanization of the Guadalupe River watershed and floodplain since 1958 has substantially increased the risk of flood damage.

The Guadalupe River Master Plan (GRMP) is a "multipurpose" management strategy that recognizes beneficial uses of the Guadalupe River while promoting flood control. Authorized to protect San Jose from flood hazards, the U.S. Army Corps of Engineers (USACE) periodically studied the river from 1940-1985 until they produced a final feasibility study for a "single use" flood control project (SCVWD, 1992). As the Corp worked on their feasibility study the San Jose Redevelopment Agency (SJRA) headed up an effort to design a plan for improvements to the dilapidated condition of the river channel and adjacent properties to attract development. Local sentiments against the Corps' NED "single use" project for the downtown corridor lead to a 1992 Local Cooperation Agreement for cost-sharing of the city's $134 million alternative plan (GRMP) which included an underground flood bypass culvert

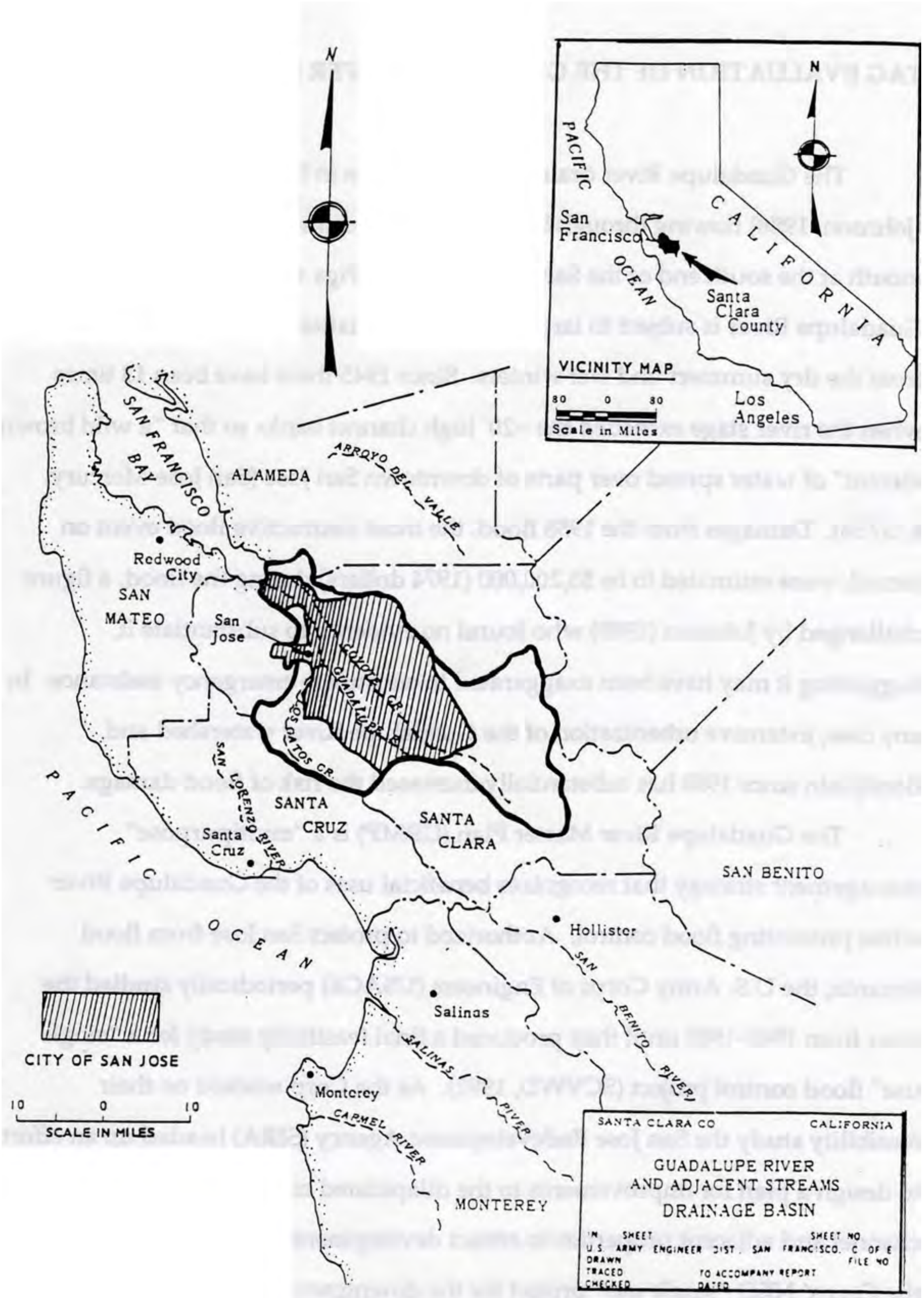


Figure 4.1: Guadalupe River drainage basin location relative to San Jose, CA (from USACE, 1985)

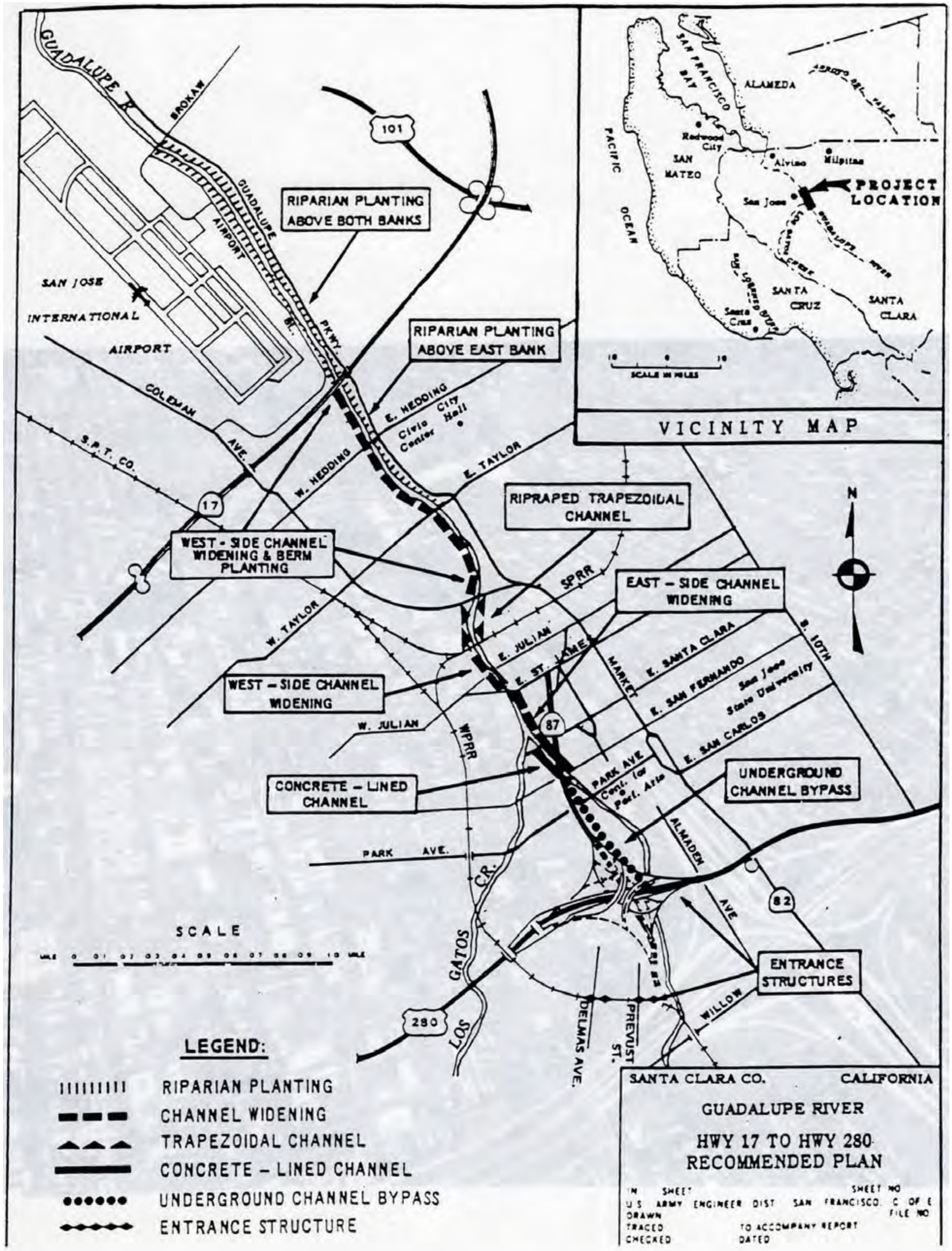


Figure 4.2: Downtown San Jose section of the Guadalupe River (from USACE, 1985)

Figure 4.3: Aerial photograph of the Guadalupe River and San Jose (from USACE, 1985)

and means for restoring some beneficial uses (SCVWD, 1992).

Using the TAG method I have evaluated the GRMP to predict where it may encounter technical shortcomings that will lead to failed goals. I analyzed the GRMP to find explicit statements of the goals and tools for the plan, used scientific theory to identify conflicts among goals, among tools, and between tools and goals, and assessed "one tool per goal" adherence. My analysis is based on thorough readings of two versions (1985, 1994) of the GRMP, an environmental impact statement (1990), and the 1985 USACE feasibility study; two day long field excursions to the river (Appendix A); and a two hour interview with Ken Talbot, the GRMP coordinator since 1986 (Appendix B). The results of the TAG analysis represent testable hypotheses that future researchers may assess to validate or belie TAG analysis for river management.

Data

Seven primary goals are expressed in the GRMP (Table 4.1). The two most

Table 4.1: GRMP primary goals.*

A. Waterfront Development	E. Channel Stability
B. Flood Control	F. Restored River Habitat
C. Non-contact Recreation	G. Stormwater Management
D. Aesthetics	

*Based on the available information the goals have been listed in the priority in which they are presented.

important goals are explicitly stated to be waterfront development and flood control. Development derives from the urban revitalization mission of the SJRA who has the leading role for the GRMP. Flood control stems from major funding sources for the plan that serve to provide flood protection- the USACE (44% funding source) and the Santa Clara Valley Water District (40% funding source).

Recreation and aesthetics goals are stated as beneficial uses of the river that promote the leading goal of waterfront development, and are moderate priorities. Channel stability is also stated to be a moderate priority because river corridor land sells for $1 million per acre. The last two primary goals, restored river habitat and stormwater management, are not as prominent in the GRMP as the other goals.

Thirteen design objectives were mentioned (Table 4.2), but these have not been explicitly prioritized. Lacking explicit data I rank them in the same order as

Table 4.2: GRMP design objectives.
A. To have the Guadalupe River serve as a major organizational element of the evolving land use and redevelopment pattern of San Jose. B. Pass the 100-year R.I. peak discharge of 14,600 cfs. C1 "Fun in the sun" activities like festivals, sporting events, and picnics. C2 Gathering space for up to 50,000 people. C3 Cultural functions. C4 Relaxation space and strolling areas. D1 "Quiet serenity"; feel escape from the city on one side of the river. D2 Urbanite setting and aesthetics on the other side of the river. E1 Protect new office buildings. E2 Protect bridge piers. E3 Maintain existing channel using as little structural engineering as needed, but used where v exceed ~10 ft/s. F. Natural river habitat "with wooded trails, rolling meadows, and gardens."
G. Maintain good water quality in downtown reach.

Table 4.3: GRMP tools.*

A
1. Tax breaks
2. Surrounding area revitalization
3. Guadalupe River Park

B
1. Underground floodwater bypass culvert for 1 mi. central downtown section
2. Channel widening in the lower section
3. 10 foot berms along some sections and smaller berms along other sections
4. "Flood meadow" and other land set-asides (open spaces)
5. Maintenance to remove trash, debris, and unplanned/invasive vegetation
6. Flood warning system
7. Flood insurance
8. Raise the ground floor of all buildings in FEMA designated floodplain to 3 feet above design flood stage (i.e. flood proofing)
9. Parallel / separate stormwater runoff sewer system to discharge into river below the constricted central downtown river reach.

C1
1. McEnery Park (Tennis courts, volleyball courts)
2. "Monopoly in the Park"
3. Children's play area
4. Carousel
5. 7 picnic areas

C2
1. Open spaces and "flood meadow" used as 3 public assemblies

C3
1. Children's Discovery Museum
2. Technology Museum
3. Center for Performing Arts
4. Visitor's center
5. "Parade of Animals"
6. Veteran's Memorial

C4
1. Multiple public access points and a pedestrian bridge
2. Riverwalk
3. Ridder Plaza

D1
1. 5 "Sister City" gardens
2. Tree groves

D2
1. Gooseberry and blackberry bushes
2. Stepped terraces abutting bridges
3. Public art

Table 4.3: GRMP tools, continued.
E1 1. Underground floodwater bypass culvert for 1 mi. central downtown section **2.** Concrete sandbags with interstitial vegetation 3. Vegetated gabions **E2** 1. Underground floodwater bypass culvert for 1 mi. central downtown section 2. Bank paving, riprap, and/or gravel under bridges 3. Stepped terraces abutting bridges **E3** 1. One bank uses vegetation for stability (i.e. natural river edges) 2. Underground floodwater bypass culvert for 1 mi. central downtown section 3. Vegetated gabions 4. Riprap **F** 1. One bank uses vegetation for stability (i.e. natural river edges) 2. Tree groves **G** 3. Parallel / separate stormwater runoff sewer system to discharge into river
below the constricted central downtown river reach.
*Tool numbers do not indicate explicit prioritization. **Boldface** is used to designate each unique, unshared tool. Underlines identify the priority goal that a unique, shared tool will implicitly promote.

the primary goals, with multiple objectives for a single goal left unprioritized. Thirty-five unique tools have been identified in the GRMP (Table 4.3). None of the tools are quantitatively expressed in the perused documents, so the equivalent scale criteria has been applied to sort and group the design elements.

Results

Through 78 micro-analyses (13 choose 2) 14 inherent goal to goal conflicts

Table 4.4: Goal to goal conflicts.

Design Objective	Objectives that conflict with it	Shortened scientific bases for conclusion*
B	F	Adopted conveyance strategy requires "clean" channel of simple geometry. 1
D1	C1, C2, C3	Loud uses interfere with "quiet serenity." 2
E1	E3	Existing vegetated channel cannot provide adequate bank protection. 3
E2	E3	Existing vegetated channel cannot provide adequate bank protection. 3
E3	E1, E2	Protection of structures will require further channel modifications over the long term to prevent erosion. 3
F	B, C1, C2, C3, E1, E2	Channel modifications for flood control and channel stability destroy existing habitats. 4
		Underground bypass eliminates ecological functioning of floods.
		50,000 people recreating in the habitat areas (<50 acres) will degrade natural functioning. 5

* See Discussion section for thorough assessment.
1. (USEPA, 1977; Haltiner, 1993b; USACE, pers. comm.)
2. By observation.
3. By observation and as discussed with Ken Talbot.
4. (Stanley, 1993)
5. Observation; (Searns, 1993)

have been identified (Table 4.4). These conflicts involve human use versus natural habitat, structure protection versus natural channel stability, and noise level problems. Conflicts between human uses and natural ecosystem functioning led to the abandonment of the Corp NED plan, and scientific questions over the destruction of endangered species' habitat remain. To a degree these conflicts have been overcome by agreement that natural ecosystem functioning (as opposed to managed habitat for a few species) is a low priority given the constraint of the urban setting.

Conflicts between structure protection and maintenance of natural banks exist because even if some natural banks are preserved, the unerodible protected banks will force the water to erode the natural banks over the long term. Catastrophic erosion could result during a flood event.

Conflicts between loud uses and quiet uses were apparent on both field excursions. Riverwalk use for quiet reflection and "escape" is degraded by the sound of nearby construction and automobile traffic that drowns out all other sounds along the river. Festivals, "fun in the sun" activities, and other human gatherings for *50,000* people will generate sufficient noise and confusion to inhibit achievement of the proposed "quiet serenity" in the downtown river corridor.

Of the 35 identified tools, seven have shared usage to achieve two design objectives, and one other is used for four (Table 5). The two highest priority goals have three and seven unshared tools, respectively. Two objectives, C2 and E3, have no unshared tools. Consequently the "one tool per goal" principle is violated twice, though only with low priority goals.

Through 595 micro-analyses (35 choose 2) seven potential tool to tool conflicts were found (Table 4.5). These conflicts all pertain to channel stability and natural river edges. The basis for the conflicts is the observation that

Table 4.5: Tool to tool conflicts.

Design Tool	Tools that conflict with it	Shortened scientific bases for conclusion*
E3.1	E1.2, E2.2, E2.3	Paved banks force erosion of soil and vegetation in gabions. 1
F.1	E1.2, E1.3, E2.2, E2.3	Structural methods are not in fact limited to one bank only. 1
		Protection of structures will require further channel modifications over the long term to prevent erosion. 1

** See Discussion section for thorough assessment.

1. By observation and as discussed with Ken Talbot.

engineered structural banks force erosion of adjacent natural and engineered non-structural banks. These conflicts will result in long term damage that will run up maintenance costs, degrade natural habitats, and lead to regulatory conflicts over protection of waterfront developments.

455 micro-analyses (35·13) uncovered twelve potential tool to goal conflicts (Table 4.6). These conflicts involve tools that obstruct the goals of maintaining the natural channel banks and restoring the natural river habitat, and are scientifically founded on the aforementioned concerns.

Discussion and TAG Predictions

The TAG method shows that much of the GRMP is well founded and adequately provided for (1095 non-conflicting results), but that two major groups of conflicts are present that will lead to obstacles to achieving full human and ecological multipurpose use of the river. Both groups include conflicts of all three types that can be assessed using this approach. One other minor source of conflict has also been identified.

Many of the unique tools called for in the plan do help achieve multipurpose beneficial human uses for the river corridor without compromising other river functions. Together, B.3 through B.8, C1., C3., C4., D1., and G. tools contribute to flood management, recreation, aesthetics, and stormwater management. Other tools (e.g. floodwater bypass and vegetated gabions) attempt to meet human needs without completely destroying existing natural habitats. These approaches are appropriate and satisfy TAG criteria as long as they are understood as mitigation tools.

The conflicts between structural river engineering and natural channel stability is the most important problem facing the GRMP. Channel stability is

Table 4.6: Tool to goal conflicts.

Design Goal	Tools that conflict with it	Shortened scientific bases for conclusion*
E3	C4.3, E1.2, E1.3, E2.2, E2.3	Ridder Plaza replaced existing natural bank with riprap and stone, and thus may induce erosion of the existing channel. 1 Hardened banks will force erosion of natural banks. Protection of structures will require further channel modifications over the long term to prevent erosion. 1
F	A.2, B.2, B.5, E1.2, E1.3, E2.2, E2.3	Channel widening and banks protection eliminated existing natural habitat. 1 Maintenance has removed natural vegetation and eliminated habitat. 1 Revitalization eliminated some habitat directly and has encouraged frequent, dense, and high impact human use of habitat. 1

** See Discussion section for thorough assessment.
1. By observation and as discussed with Ken Talbot.

not only a goal in and of itself, but also a constraint on other goals including high priority waterfront development. Because the river's natural tendency is to meander across the valley alluvium, or downcut in lieu of meandering, no *natural* condition consistent with GRMP goals and existing urbanization is possible. Regulatory constraints that prohibit the use of non-native biotechnical means for stabilizing the bank further limit the range of possibilities for non-structural engineering approaches. As it stands, no unique, unshared tool is being applied to the problem of maintaining natural channel banks, though the vegetated gabions do provide some mitigation.

Given that the "one tool per goal" principle is not adhered to for the E3 goal, that there are multiple conflicts with it and its tools, and that the engineering of channel stability fundamentally lacks adequate tools to meet the relevant GRMP multiple goals, technical shortcomings will force abandonment of E3. Over time the channel will continue to downcut, vegetation will be washed away, and banks will fail. These environmental problems will lead to concerns over the protection of the "Fortune 500" companies' headquarters that are being built next to the channel as well as concerns over the integrity of the public lands within the Guadalupe River Park. Barring future technical innovation, the long term TAG prediction is that the lower priority conflicting goal (E3) will be implicitly dropped thereby preserving the higher priorities of the plan. What TAG requires for the success of the E3 goal is a unique tool operating under low to moderate flow conditions and reduced dependence on the tools that conflict with E3.

The second group of conflicts identified by the TAG analysis relate to the problem of restoring natural habitat. Although this goal is a low priority one given the urban setting, it is called for by 25 relevant mandates (Fig. 4.4). Environmental protection represents a volatile political issue that can make or

Fig. 4.4: Relevant environmental mandates (from USACE, 1985).

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Fig. 4.4: Relevant environmental mandates (from USACE, 1985).

break a project of this scope. According to geomorphologist Luna Leopold, a river is self-formed, self-maintained, and only capable of passing small flows within its channel (Leopold, 1962). The natural instream and riparian habitats in a river system survive because they form a coherent ecosystem that responds to the environmental conditions that the river provides. Engineered changes to the river channel that reduce overbank flooding and promote bank stability interfere with the river's natural functioning by definition. This interference degrades the natural ecosystem. To attempt to dampen natural flood processes, harden the channel banks, and also truly restore the natural river habitat that has been lost to urbanization is fundamentally impossible. Certainly parcels of managed habitat for specific species can be provided for as *mitigation*, but calling such parcels " restored natural river habitat" is inappropriate. In the case of the Guadalupe River, the goal of river restoration is in fact a low priority one, and the goal is truly mitigation, not restoration. A recent fact sheet obtained from the San Jose Redevelopment Agency confirms this: the cost of "mitigation" for the project is $1 million, which only accounts for 0.75% of the project price. However, the GRMP materials include a picture of an egret standing on a concrete sandbag dotted with invasive weeds with the caption, "wildlife and vegetation thrive in the Guadalupe River Park, which includes a **natural river habitat**..." [emphasis mine] Such propaganda distorts the truth and is suggestive of a more pristine setting than is present. In fact, concrete sandbags do not constitute natural wildlife habitat!

River restoration versus flood control and river restoration versus channel stability conflicts have and will continue to present technical barriers to the successful implementation of the GRMP multipurpose plan. Specifically, operation and maintenance parties who serve to promote the two highest priority goals will be forced to implicitly promote flood control and channel stability goals at the increasing cost of river restoration / mitigation.

Conclusions

"Multipurpose" river management plans that attempt to balance an array of human uses and natural river functions are subject to strategic conflicts that cause suppression of uses when they fail to apply systematic TAG analyses, and perhaps when they ignore the "one tool per goal" criteria. I have used a TAG method to evaluate the multi-objective Guadalupe River Master Plan for San Jose, CA. Much of the Master Plan has been found to be well provided for and is expected to be successfully achieved. Maintenance of the natural channel and restoration of "natural river habitat" are two design objectives that are predicted to be neglected in favor of higher priority goals. The case study of the Guadalupe River demonstrates the usefulness of the TAG method, and contributes to the effort of establishing the relevance of a "one tool per goal" principle by presenting testable predictions.

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APPENDIX A

Guadalupe River Excursions Field Notes

Thursday, August 18, 1994:

I drove down to San Jose by I-880 and then followed the map in Margaret Johnson's 1988 Landscape Architecture thesis to get to the downtown corridor. Her map got me to the river, but I found that many of the details have changed since 1988, which gave me my first indication that the Guadalupe River (G.R.) Master Plan had been implemented in at least some aspects. The downtown corridor is bounded by two major highways- I-280 on the upstream end and I-17 on the downstream end. The I-280 boundary is immense- big enough that there is a public parking lot under part of it. Public parking only cost $2 for the day, an that lot feeds into the new Children's Museum, so vehicular access to riverside recreation appears to be good. Many other parking lots were found later, but these were not public, so they cost more.

To get to the river I walked around the Children's Museum and up to the I-280 boundary. A multi-use path that end at I-280 provides access to the river downstream from the highway. Looking upstream toward the highway the river appears to have very little water, but the channel itself is surprisingly natural in its appearance. I attempted to cross the highway to find the floodwater bypass inlet, but I could not get by it at all on the river left side and could only make a little progress on the river right side before the riparian vegetation became too thick.

Back on the river left side I strolled down the multi-use path and it opened up into a large field. Far to the left of the field sat the Children's Museum. The field is well maintained and there are a few trees in it. Looking at the river from the field is impossible because a line of dense trees block the view. Also, a small berm (~3ft) is present to provide additional flood control. Partway down the path there is a stone and concrete overlook to the river and staircase down to the low flow channel's edge. The toe of the structure is protected by riprap with a diameter of something like 2 ft. Looking downstream the river right bank is planted with some young trees and the wetted bed is choked with algae. It appears that they are not accounting for much stream power given the expensive plantings.

Moving on, the channel is deeply incised throughout this whole section and I wonder what would count as "bankful" discharge for this case. Based on my readings and this field excursion I would guessed that a true bankful discharge would have to be ~70-80 year event, not a 1.5-2 year event! Clearly there is a strong instability here and no attempt to deal with that problem.

Further down the multi-use trail ducks back down into the channel and the natural banks are replaced with artificial banks with three levels of tiered, planted gabions followed by the trail and then three sets of concrete stairs leading up to the roads that parallel the river. A bridge is built into this concrete structure and it appears that flood waters would back up behind it because the cross-section goes from very narrow in the natural section to very wide behind the bridge. The bridge pier in the channel is thin but the total cross-section is much less than that of the channel immediately upstream. I imagine that backed up waters would flood onto the field and some useful storage would occur. Flooding on the other side would not impact the buildings there much at all because they are build with their main floors higher than street level. Perhaps some parking lots would be flooded..

Immediately downstream from the bridge on the river left side is the huge River Towers office building. This building abuts the river channel and is grossly oversized relative to the river at its base. Between the building and the river there is an artificial water cascade, then a stairway to the multi-use trail, then three tiers of vegetated gabions, and finally the channel. Two pipes lead from the building to the channel but are not discharging presently. Perhaps these periodically flush the water used in the artificial water cascade. A handicapped person drives his wheelchair along the path, demonstrating that the path is indeed multi-use. Bikers, walkers, joggers, etc. were all seen along the trail. Inside the channel itself, the gabions appear to have very young vegetation that does not look very stable at all. The river right side appears completely natural, though this strip of vegetation is very thin before it opens onto the Center for the Arts and other human facilities. I climbed down into the channel itself for a hydraulic viewpoint and saw that the channel itself appears to be quite rough and densely vegetated, though it did not appear that way from above!

Beyond the River Towers building the water ponds behind some instream vegetation that blocks the low flow. Some birds are paddling around in the pond. Beyond the blockage there is another bridge and the water is flowing again. At this point both sides of the river are paved with a multi-use trail. I climbed down into the channel and looked at the water itself. It appeared to be clear. Gravels in this section are placed to protect the bridge from scour.

Downstream of the bridge there is a mattress of concrete sandbags that has been invaded by opportunistic vegetation. A few trees do appear to be planned, but the bulk of the vegetation appears to be invasive. This is the first section of the river (other than beneath bridges) that has a completely structural bank. it turns out that the sandbags were opted for because they do not accumulate trash and broken glass in the way that riprap does. Also, it is not quite as unappealing as smooth pavement.

The multiuse trails go back up out of the channel before the route 17 crossing. Some recreation space is present on the river right side and I followed that down past the highway. Then I went back down into the channel and walked as far up as I could. I was able to get under the highway and I saw that there is a ~3 ft check dam ponding water behind it. Under the bridge there is a lot of gravel. Two more small dams are also present, but they have water trickling over then so they appear to be riffles to the untrained eye.

Below this point Los Gatos Creek enters the river, but it has virtually no flowing water right now. The G.R. channel now appears to have natural banks on both sides and is no longer accessible. From a bridge further down a small structural dam can be seen blocking the flow. According to the plans, this whole reach is to be ripped out to provide a “flood meadow.”

Out of the channel that is a fenced-off paved lot that says it is the site of part of the G.R. park. This section will be part of the flood meadow. below this point the channel appears to be natural.

I went and looked at the G.R. Master Plan at the San Jose Library in the California Room and I skimmed over its EIS. I also found the 1985 USACE feasibility study there.

As I drove away I followed the parkway along the lower section of the river. I didn’t have time to stop and look in the channel, but there were sizable levees in this lower section and I believe that the river has been channelized in this downstream reach.

Thursday, October 20, 1994:

This trip occurred a day after the first rain event of the season. Most of the time I spent in interview with Ken Talbot (see Appendix C). When I went down to the river I found that the water was much higher than before and it was very turbid.

At the upstream end there were trees that had fallen across the river! Looking downstream there were some riffles and much of the bed/low bank vegetation was lying flat.

From the stone stairwell I saw an egret perched on a rock in the channel. The vegetation on the lowest gabion tier was covered with muck and didn’t look like it would survive. In the reach adjacent to the River Towers building the vegetation was much thinner than before and some of it looked like it had a tenuous hold on the bank. I suspect that the width of the vegetated buffer has been reduced.

The biggest surprise came when I saw that the concrete sandbag mattress had been completely cleared of invasive vegetation! A few tall trees were still present because they had ~4-6 foot stems that would not offer too much resistance to flow. Apparently that maintenance was done because the Adobe Corp. is breaking ground on its headquarters right next to the channel there. That explains the presence of the structural protection as well.

APPENDIX B

Guadalupe River Park Questionaire

Interviewee- Ken Talbot, Project Coordinator

Description of interviewee- Mr. Talbot is a Landscape Architect that has been the G.R.P. coordinator for eight years, which is basically for the entire life of the project.

Interview lasted for about 2 hours and was held in the office of the S.J. Redevelopment Agency.

What agencies are involved in the Guadalupe River Park project?

Leading Agency- S.J. Redevelopment Agency
    Jurisdiction over "needy areas"
    Infrastructural improvements -> "better", wealthier people move in
    ->tax revenues for city increase
    Second largest redevelopment agency

Operator- Santa Clara Valley Water District

Others- S.J. Dept. of Public Works
    S.J. Parks and Recreation
    USACE
    Design consultants
    Construction contractors
    Two congresspeople from this area

What is the federal responsibility in the project?

Congressional authorization- 2 California reps. in Congress played a big role in promoting the G.R.P.

Flood Control- USACE physical model at Vicksburg to study floodwater bypass hydraulics andchannelization needs.
    USACE Dec. 1991 (Revised June 1993) General Design Memorandum, Guadalupe River, CA.
    USACE doesn't understand land costs in California
        Washington bureaucrats underestimated land costs by a factor of 3!
        Space is ~$100 per square foot.

Endangered Species- recent concern over the Western Pond Turtle

Not too much concern about fishes until recently- lawsuit appears imminent over salmon.

Is there any State level involvement?

Water District is responsible for flood control and they bring in USACE

Redevelopment agency has "superagency" authority and they are regulated by state laws.

Mr. Young told me that the flood bypass was completed, can you show me its path?

Inlet under I-280 bridge, goes behind River Tower office buildings, outlet after Route 87 bridge.

When and how is it to be operated? Are there still plans to divert all natural flows? Since there is a lot of woody debris upstream, are you worried about the bypass getting clogged?

First 1500 cfs will stay in natural channel. Above that the inlet weir is opened and additional water goes through bypass culvert.

100-yr flow at inlet is 14,600 cfs: 55% of design flow goes to bypass, 45% to natural channel.

PROBLEM: in the physical model they can only get 88% of the designed diversion! They do not understand why the hydraulics isn't working. Mr. Talbot has a video but he couldn't find it to give to me. May want to contact him about it in the future. He showed me pictures of their set-up under low flow and design flow. They have also modeled larger flow events.

No concern about debris expressed. Maintenance can be done after a flood.

How much did the bypass finally cost to build? What are the projected maintenance costs?

Total flood control costs for the project are $62 million.

Every bridge in the downtown corridor has been replaced in the last 5 years!!!

Along the Chicago river in the downtown river corridor developments are required to be a minimum of 30′ back from the active channel and are asked to be 50′ back. How wide of a corridor do you think the Guadalupe river should have, and how wide should the vegetation buffer be?

No time to ask this question.

Looking at the Plan and the river, it appears that the vegetation buffer is quite thin, in some places only a few trees thick or relegated to the steep bank slope only. IS the vegetation intended to be anything more other than a landscaping measure for aesthetics?

Aesthetics are the #1 interest. Native vegetation is primary tool.

Wildlife are not a real goal

In the plan, slope stabilization is expected to be achieved through riprap. Was there any consideration of using willow layering instead of or in conjunction with the riprap, as they have along the Carmel river?

Velocity about 10 ft/s needs armoring, in general.

Opposing forces: some people want a San Antonio type Riverwalk. They opted for concrete-sculpted terraces with an urban aesthetic over a natural aesthetic.

Fish and Game REQUIRES native plantings ONLY. But the Park and Recreation people do not have much use or value for native species because they aren't establishing themselves in the channel and on gabions. Ecological consultants have been brought in.

City refused riprap solution because riprap collects trash, harbors rodents, and collects glass. Instead they used gabions with decorative vegetation coverings and concrete sandbags.

The concrete sandbags filled with invasive vegetation. because the sandbags were used adjacent to the Adobe Corp.'s site for their new headquarters, the Redevelopment Agency went in there and ripped all the vegetation out before the ground-breaking ceremonies. No concern over hydraulics, just want the Fortune 500 company's photo shoot to look good.

Waterfront Development is KEY to this project, but despise stated interests, they are not really mimicking San Antonio model because they are letting Adobe, IBM, and others build huge office buildings abutting the channel itself. There is one outdoor cafe, and art centers, museums, fields, etc are in place.

Zones B,C,D have rapidly varying widths (from narrow to wide to narrow again). Are you concerned about the impact of this irregular geometry on the flood flow hydraulics?

The hydraulic model has been used, but that is not answering many of the pertinent questions, like this one. No one has any idea, but there really isn't anything they can do about it anyway because of the political and economic situations.

Have the buildings next to the channel been designed with floodproofing aspects?

Buildings are operating under FEMA guidelines. The main floors of the buildings are required to be at least 3 feet above the 100-yr flood level. As a result, 1st floors are raised and disabled persons ramps had to be installed.

Are there still plans for a permanent water element?

No -- Therefore, I have moved all of my questions about that to the end of this questionnaire.

The G.R. plan was developed using $5 mln dollars of local money. two alternatives were developed. The first, which is what was passed out and what I have was reviewed in a 1990 EIS and found to be too environmentally damaging to be used. It intended to turn off the river and pump water up from the aquifer to create an artificial, clean flow! A recreational lake was a also planned.

The 2nd alternative was accepted by locals and USACE, and was allowed in place of the USACE best alternative that was spelled out in the 1985 feasibility study.

Is there a flood monitoring/warning system in place?

Physical model at Vicksburg helps them plan for different scenarios.
modeled one mile stretch from Highway 280 bridge to Highway 87 bridge.

How much time and money was spent scientifically evaluating the state of the river before the project? Are any of these results published?

Basic answer was, “are you joking!”

How does this project fit in with the overall management of the river system?

the organization that promoted prop. 13 in order to block public spending has been trying to block the G.R.P. This has made management difficult.

IBM and Fairchild has had a groundwater pollution problem. As a result they have been pumping water through the system for several years. This has allowed some fish species to move further up into the G.R. system and establish themselves. This has raised new F&G issues. However, IBM and Fairchild are finishing up their projects and that water will be turned off. Fish requirements and blind to integrated watershed management, so they will try to force perennial flows from upstream water supply dams.

There is a tertiary wastewater treatment plant that is presently putting water into the G.R. near the mouth. This is hurting salt water habitats because it is fresh, so they will be forced to pump the treated water uphill for use along freeways, at the airport, and for river corridor vegetation irrigation. Also for groundwater recharge, perhaps.

Rolland Kasser, V.P. of Harza Eng Co. wrote that "the inadequacies or failures [of river basin projects] are the result of imposing a static plan on dynamic natural and economic conditions. Flexibility for change is, then, the central theme of our observations." How do you build engineering and regulatory flexibility into your urban river project?

Not much growth left in this area. There are no long term plans for the river corridor.

Cannot be done. No real flexibility has been attempted. Will deal with the channel responsively, not proactively.

"I have not heard the word geomorphology since I left U. Penn!"

James Wilson, a policy analyst, has written that "few organizations, and especially few successful ones, can tolerate having more than a single governing ethos: the need for morale, for a sense of mission... and for standard operating procedures means that competing norms will be suppressed, ignored, or isolated." Do you think this postulate is valid for multipurpose river management? or, in other words, do you think that multipurpose planning is viable?

People don't understand plans and don't take them seriously until the bulldozers come.

I explained my tools and goals method to provide a pseudo free-market system and he said that that is the direction they have been going in without explicitly meaning too... compromise has been the key to this multipurpose project, and it has occurred in a tools and goals fashion!

No clear delegation of responsibility is indeed a big problem. Original survey of land had bridge elevations off by two feet! That's a lot for flood considerations. The problem here was that each agency felt that another one would do it, but then no one did it. This is a classic Free Rider situation. Ultimately, each agency in fact needs a different level of precision, so the work of one agency may not be useful for another one. Cost-sharing was unrealistic.

Do you think that a "superagency" with jurisdiction over the whole watershed would be a more effective and appropriate means by which society can manage river corridors / watersheds?

No. Adversarial role sharpens thinking and results in a better plan. The problem comes when you are told what to assume before the project begins. Not enough latitude.

People can work together to build plans and the voted politicians are the final decisionmakers anyway.

this contradicts Jeff Haltiner's and P.William's attitudes that integrated watershed management should be under the authory of one superagency.

Questions about the canceled plan: (didn't need to ask these since the plan is not going through!)

I am surprised that this concept did not upset local environmentalists and watchdog groups. How did they respond to these ideas?

Has the groundwater been tested yet? What is the proposed pumping rate?

Have you considered the impact of the three proposed dams on altering the river channel? Especially given the river's present tendency toward downcutting?

What is the nature of the flexible dam to be used (show picture)?

In LA a bubble dam used for groundwater recharge was shot and destroyed. Are you concerned about crime and vandalism in the river corridor?

The dam is said to be designed to automatically lower under pressure. What pressure is being used in design? Will you Clean out the reservoir periodically? What about the downstream impact of the sudden release of the dam water? People in Alviso might not appreciate that.

In Zone E a meandering low flow channel was proposed. Since the Guadalupe is fundamentally a meandering river, are you concerned about the long term impact of inhibiting its natural tendency toward meandering?

Zone E is intended to focus on natural vegetation restoration, but again, the buffer is quite thin. Is the goal here primarily aesthetic or habitat?

APPENDIX C

Los Angeles River Excursions Field Notes

Friday, July 8, 1994:

This morning I drove to Long Beach from where I was staying in LA and followed the Los Angeles (LA) river from its mouth ~35 miles to the Tujunga Wash. This trip occurred during the dry regime. Whenever I asked passersby about the river they commented that it was not a river, but merely a "wash" or sometimes just a "sewer." Some commented about the proposal to allow cars drive along the bottom during the dry regime and I told them that that proposal had been shot down. They were disappointed! I did not run into any of the homeless people that the LA Times said live along the river.

The lowest section parallels the Long Beach Freeway and has 5 bridge crossings in 15 miles (bridge density = 3 br./mi.). From the mouth of the river there is no indication of the transformation of the upstream section. On the river right side there is a large marina for cruise ships, while the river left side is where the city of Long Beach sprawls. A park of some sort is visible across the river on the Long beach side, but I don't have time to check it out. A restaurant on the river right side is right against the channel with no flood proofing evident. The bank beside it is protected with large riprap.

Upstream of the mouth the river flows in a virtual straight line. From the Willow St. bridge I can look surprisingly far up the river. I an surprised by the quantity of water flowing in this section, but it is clearly tidal. I wonder how far upstream the water goes.

Stopping at Del Amo bridge I climb down into the channel to look at the water up close. The water is moving at a good clip and clumps of moss or algae are floating by. As I climb up out of the channel I am greeted by some bikers and joggers. This section has a multi-use trail that parallels the channel. A Dept. of Public Works sign on the fence indicates that no dumping is allowed. Over the levee on the river left side there is an urban runoff channel of some kind. It might be an off-stream storage site, but I don't know. In any case, it is choked with algae indicating that it is loaded with nutrients. Paralleling the river on the river left side for some stretches in this reach is a wide power line right-of-way.

My next stop is Interstate 105 which has a huge river crossing. The crossing completely isolates the river from its surroundings and prohibits useful access to the river. The big surprise here is the presence of a water conservation/re-use project. Some industrial/ commercial plots of land next to the river have been left undeveloped and these have been turned into farming lots that are irrigated with "brown" water. About 10 Hispanic people were working the land that I was able to access. Further down I saw other farm lots and some rickety shacks where I presume the people live. I crossed the farm lots to get to the river and found the spot where the river changes from fully covered with water to just having water in its low flow channel. To the best of my facilities I cannot see why the river flow spreads out at this point unless the geometry of the low flow channel changes or there are effluent inputs below the surface.

At the next bridge crossing, Imperial Highway, I am able to walk out onto the bridge and get right over the low flow channel. Looking carefully I can see innumerable effluent pipe ends below the surface in the low flow channel. I don't know if these are present to discharge wastes or merely to reduce hydrostatic pressure that may build up behind the levees, though the latter possibility seems less likely. The water in the low flow channel is moving swiftly.

At the next stop I manage to get a shot of the confluence of Rio Hondo and the LA River. Rio Hondo is a diversion channel from the San Gabriel watershed. Rio Hondo does not have a central low flow channel. Instead, water flows down the sides of the channels and pools before dumping into the LA River. On this day the Rio Hondo is virtually dry.

Upstream of the junction with the Rio Hondo the LA river enters an industrial corridor. At one point the channel morphs into a rectangular channel. Bridges in this section have streamlined piers and begin to look like bridges, not just roads over a sewer.

The next shot I take is in the central industrial corridor as I approach the city. It is the classic shot of a sterile trapezoidal channel surrounded by power line r-o-w's, warehouses, and railroad tracks. I actually caught a train going by and got a picture of it.

The downtown reach of the LA river flows through a dilapidated, rotten urban core. The best thing here is that the bridges are terrific in the way they highlight the fact that they are river crossings. I suspect that they predate the paved channel because the newer bridges tend to obfuscate the river's presence rather than highlight it. Anyway, it is clear that there is no room for additional flood protection features other than flood walls because industry is built right up against the river channel.

Above the urban core section the river enters the Griffith Park section. This section is the only one that is not paved because there are naturally flowing springs in the channel there that defy cement. At the downstream end of this section is where Interstate 5 crosses the river. The piers for I-5 have a lot of debris plastered to their upstream faces indicating the force of the river and the river stage under flood conditions. I am surprised that this hasn't been removed since the lower sections are all very well maintained, but then it is the summer time so they may not do maintenance until just before the wet regime begins in October.

Upstream of Griffith Park the river takes a sharp turn to the west and passes Glendale. At this point it becomes much more difficult to follow the river because there are no more highway to follow. Using the Thomas Guide I follow the backroads and track the river through Hollywood. Across from a Jewish cemetery I come across a very nice off-stream storage basin. Some point in this reach the river morphs from trapezoidal to rectangular in cross-section. Along the bed of the now-rectangular channel there are tire tracks indicating that people do go down in there.

Behind Robert Redford Ave I find a place where the water changes from flowing in the full cross-section to just the low flow channel. This time the effect is visibly forced by the channel geometry of the bed.

In the final section that I follow I am surprised to find that the rectangular channel has been added to ad hoc. This has been done by setting aside ~15 feet of land on either side of the river and then excavating down about 5 or six feet in the space right next to the concrete channel. They have not paved this ad hoc addition, and I wonder if they will. One interesting thing is that they have planted a dense swath of flowering vines and trees to block the view of the river so people cannot see what is going on. Also, all roads cross the river without any indication that the river is there. From outside the channel the flower barrier looks nice, but I wonder how safe the people live next to it really feel... well, out of sight, out of mind, I guess!

It is now 5:00 pm and the light is starting to a go just a little bit. My path paralleling the river is now blocked by a large members-only golf course. I think about going around it and continuing on, but I decide not to because it is more of the same and then the river leaves the urban area and becomes difficult to follow through the canyons.