CHAPTER 1: BACKGROUND

California has lost over 95 percent of its riparian habitat (Pollock 1991; RHJV). In urban areas, that loss is closer to 99 percent (Schemmerling 1997), and what little is left is usually not in good shape. As E.A. Keller and Hoffman (1977) observe, ". . . many urban streams represent a sad testimony to our civilization. They tend to be straightened, deepened, paved over, or lined with concrete and filled with every imaginable type of urban trash." As they also point out, many urban residents flee cities on weekends and holidays to seek areas where free-flowing streams and more natural landscapes can still be found. But not everyone is so mobile, and those who are not may "exist in a sensually substandard environment." The lack of natural areas in cities particularly impacts children, with the National Audubon Society identifying "making the environment accessible to urban children" as "one of the most daunting challenges in environmental education today" (Flicker 1998). But adults are affected too. Studies show that "nearby nature"—natural areas within a few minutes' walking distance—is critical to the psychological well-being of urban residents and their sense of satisfaction with their communities (Kaplan and Kaplan 1989). With 60 percent of the world's population predicted to be concentrated in urbanized settings by the year 2025 (Platt 1994), and 80 percent of California's population already living in urban locations,[1] the quality of life in these areas will be of increasing concern.

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[1]According to a 1995 Bank of America report on urban sprawl, California has become the most urbanized state in the nation, with 80 percent of all Californians living in metropolitan areas of one million people or more.

The loss of natural areas, and in California riparian areas in particular, has also harmed wildlife, since many California birds and mammals (including many endangered and threatened species) depend on riparian habitat during some portion of their life cycle (California Department of Fish and Game 1993). Although the value of riparian habitat has long been known to biologists and wildlife managers, recent studies at the Coyote Creek Riparian Station in San Jose have confirmed its importance, even in heavily urbanized areas, for migrating songbirds (Okamoto 1997). Otahal found that Coyote Creek—in the midst of San Jose—is a crucial stopover point for migrating warblers in the fall, where they are able to refuel and gain weight before continuing on to their wintering grounds in Central and South America (Okamato 1997).

Despite the ecological importance of riparian areas, little attention has been given to their preservation, particularly in urban settings. Once the large water-supply systems like Hetch Hetchy and others were built in the early part of this century, urban residents no longer depended upon their local watersheds for water supply, and no longer saw local creeks as important (Richard 1993). Indeed, as urban populations grew, residents began to see urban streams as nuisances and health hazards, particularly since raw sewage was often dumped into them (Dury 1995). To cover up these hazards and to try to drain urban areas more quickly and prevent flooding, many waterways were put in underground pipes, and buildings and parking lots were built on top of them. The creeks were "out of sight, out of mind," and urban residents felt less and less connection with the environment. The few urban streams left to flow freely were blamed for urban flooding, while, ironically, the true culprit—faster and larger volumes of runoff from the increase in paved surfaces that accompanies urbanization—was ignored. Many of the remaining open streams were eventually put into concrete channels, another engineering solution that was (erroneously) thought to prevent flooding.

In California, a new interest in urban streams and efforts to restore them emerged in the 1980s, in a "flurry of grassroots protests over creek channelization plans by local flood control districts" (Steere 1994). Since then, urban stream restoration in California has become a movement involving close to 100 "friends of creeks" groups that are working to preserve and protect urban streams (Urban Creeks Council 1999). These activists have helped change public agencies, influencing them to become more environmentally sensitive and aware of urban streams. Out of these efforts many cooperative interagency "watershed awareness" and planning efforts have arisen (Steere 1994), involving "friends of creeks" groups, municipal agencies, city planners, resource conservation districts, the conservation corps, environmental non-profits, and, lately, even the U.S. Army Corps of Engineers. As concerns about urban runoff and compliance with the Clean Water Act have increased, many cities have even begun looking to urban stream restoration as a means of improving water quality or as an alternative to traditional (and expensive) storm-drain replacement projects (Freitas 1998; Struve 1997; Riley 1998). Restoration projects can also decrease erosion and filter polluted runoff (Kondolf and Micheli 1995).

Urban streams offer corridors for wildlife, opportunities for urban children to experience a bit of the natural world, aesthetic areas where residents can escape the stresses of the urban environment, and a sense of regional and ecological identity that is often missing from urban environments. Restoration can increase these benefits, improve water quality, and even control flooding in a more attractive and effective way than traditional concrete channels or culverts. Urban streams and their associated riparian habitat are often the most ecologically valuable areas within cities (Haltiner 1997), and in California, restoration provides a way to increase the amount or improve the quality of some of the rarest habitat in the state. Restoration can provide economic and social benefits, by enhancing urban streams as amenities that draw visitors to a city or a downtown, and by employing people from local communities to work on and maintain restoration projects. Restoration projects also offer invaluable educational opportunities in communities where nature is becoming a scarce commodity, by putting the community back in touch with its forgotten waterways.

Restoring urban streams helps reinstate the "immediate, close-at-hand" kind of nature—the "small 'n' nature" Stuart Cowan and Sim Van der Ryn refer to in *Ecological Design*, when they write that "weaving nature back into everyday life breaks down destructive dichotomies between the built world and wild nature . . . remind[ing] us of the ecological processes and biological diversity present even in the city" (Cowan and Van der Ryn 1996). Urban stream restoration can also help restore a sense of ecological and regional identity to urban and suburban areas that have lost a sense of place. As Michael Houck writes in *Out of Place/Restoring Identity to the Regional Landscape,* "Giving meaning and significance to ordinary and largely unnoticed places, whether this happens to be a suburban street, a few square feet of prairie, or a representative forest landscape, is the basis of regional identity." This may be especially true for the urban flatlands of San Francisco's East Bay, where natural areas are more rare than in the wealthier communities in the hills, and the streams are more likely to have been put underground or be neglected (Schemmerling 1999). As Houck writes, where urbanization already exists, restoring the natural resources that remain to a state of health is critical to creating "sensory enrichment, delight, and sense of place" (Houck 1990). For all of these reasons, the Urban Creeks Council tries to sponsor projects in inner-city areas whenever possible.

What* is *urban stream restoration?

The term "urban stream restoration" means different things to different people, particularly since the terms "urban" and "restoration" can have different connotations. In this project, "urban" is used to encompass areas of different size that are "of, relating to, characteristic of, or constituting a city" (Webster's, 9th Edition). The term "restoration" encompasses a multitude of activities, from physical projects to watershed awareness programs and other educational efforts.

One form of restoration involves minimizing or avoiding the destruction of riparian habitat caused by traditional flood control and channelization projects, by using low-flow channels and widened floodplains, as was done on Wildcat Creek in North Richmond several years ago. Many restoration projects involve stabilizing eroding banks. In recent years, this has increasingly involved the use of more natural, environmentally beneficial methods, such as soil bioengineering techniques (Riley 1998), which use live and dead plant material to rebuild and revegetate eroding banks and trap sediment. Other types of restoration projects involve recreating meanders and/or pools and riffles for fish in stream channels. By replanting denuded stream banks with native riparian vegetation (and/or removing invasive, exotic species), habitat for birds and other wildlife that rely on riparian corridors is restored, while at the same time water quality is improved as the vegetation shades the creek, lowering temperatures and improving conditions for aquatic life. Often, biodiversity is increased after restoration, as recent studies have shown (Charbonneau and Resh 1992; Purcell, et al. in press).

Still other forms of restoration include removing trash from a creek's waters, monitoring water quality, or "daylighting" long-buried creeks, removing their culverts and allowing them to flow freely again above ground, where natural biological and geomorphological processes can resume. Many urban stream restoration projects involve a combination of these activities.

What are we restoring to?

In a 1995 paper in *Landscape Research*, geographer Susan Tapsell analyzed the benefits and constraints of a proposal to restore a 375-meter stretch of the Ravensbourne River (a tributary to the Thames) that flows through a large urban park in southeast London. The Ravensbourne flows above ground, but in a concrete channel, the result of a 1970s effort to control flooding. Tapsell argues that if restoration means returning a river or stream to a pristine, undisturbed state, full restoration of an urban river is probably impossible, both because of land-use constraints and conditions and our lack of knowledge of the "pristine" condition of any particular river. She suggests restoration may be better called "rehabilitation," which she defines as "*the partial structural and functional return to a pre-disturbance state,*" or river "enhancement," meaning "*any improvement of a structural or functional attribute*" *of a river*. Tapsell also argues that the words "enhancement" and "rehabilitation" imply smaller-scale projects. Her concern is that people will expect too much if the term "restoration" is used; however, it is questionable whether most urban residents would expect that an urban stream or river could be returned to a pristine condition. Still, it is probably not a bad idea to explain from the start the benefits and constraints of small scale restoration projects and the goals behind the restoration, whether to improve water quality, provide an amenity for people, restore fish and wildlife habitat, etc.

Tapsell also points out that for full restoration to take place, damage would need to be repaired at the watershed level—an undertaking that is not possible in most urban areas. Although a feasibility study concluded that rehabilitating the Ravensbourne in Queen's Mead park was technically possible, Tapsell raises other concerns about the project, such as the fact that the restored section would have to flow back into a culvert when it left the park, a large electricity cable near the river's banks would need to be moved, and a trash screen would need to be installed in front of the culvert. However, in restoring streams in urban settings, these types of constraints are almost always present, and they have been dealt with quite successfully in many projects, including several in San Francisco's East Bay, such as on Strawberry, Blackberry, and Codornices Creeks in Berkeley, and Baxter Creek in El Cerrito (in the upper watershed). Despite her reservations about small scale restoration, Tapsell concludes that the proposed project could act as a pilot project, and that perhaps restoration can be a "synthesis of past and present, a sort of best of the old with the best of the new, recreating old meanders and other features in a new urban setting" (Tapsell 1995).

Ann Riley (March 1999) points out that in urban areas, it may be advisable to seize opportunities for restoration when they are available, and then work on the rest of the watershed. Riley, a fluvial geomorphologist who studied with Luna Leopold, and the author of *Restoring Streams in Cities/A Guide for Planners, Policymakers, and Citizens* (Island Press 1998), suggests a theoretical restoration concept consisting of a "ladder" of different restoration levels, some of which overlap, ranging from enhancement of controlled channels (planting vegetation in riprap, for example, but not allowing the channel to move or erode), to "functional" restoration (enhancing the channel structurally as much as possible within a significantly modified landscape—i.e. reincorporating pools, riffles, meanders, and a floodplain), to "ecological" restoration (restoring a high degree of habitat values, functions, and diversity to a channel, including establishing a riparian corridor along the channel to provide canopy and habitat for insects, fish, amphibians, and other wildlife), to "historical" restoration, or restoring to as close to a pristine environment as possible (Riley 1999c). Riley suggests that in most urban settings historical restoration is probably impossible, both because the landscape has been so heavily modified and because in many cases, it is impossible to determine exactly what the historical landscape looked like (Riley 1999d).

CHAPTER 2: THE BAXTER CREEK WATERSHED

This research paper analyzes the possibilities and presents a plan for restoring a section of Baxter Creek in southwest Richmond. Like many urban streams, Baxter (or Stege as it is also known)[2] Creek has been much altered from its original conditions, so much so that it has become a forgotten, almost invisible stream. Baxter Creek is a small, multibranched perennial stream that originates in springs high in the Richmond and El Cerrito hills (Figure 1), and flows southwesterly across the flatlands to San Francisco Bay, from elevations of approximately 400 feet above sea level to sea level in just a little over two miles. Ohlone Indians of the Huchiun clan once drank from its spring-fed waters, and, in the bedrock outcroppings along the creek's banks in the upper watershed, ground acorns into mush and carved petroglyphs (CAC 1981). Grizzly bears, mountain lions, and elk roamed the hills of El Cerrito and Richmond and drank from the many freshwater streams in the area (Margolin 1978), while the native riparian vegetation along the streams provided food and shelter for many birds and small mammals. But today, the grizzlies and elk are gone, along with many of the native birds—and the creeks. With the exception of a few sections, Baxter Creek flows in culverts beneath the ground; most of the watershed has been paved. Not surprisingly, few residents make the connection that the remaining

[2]The origins of this creek's name are somewhat unclear. Although it is identified in the Richmond General Plan and the 1981 Investigation of Cultural Resources within the Richmond Harbor Redevelopment Project 11-A report prepared by the California Archaeological Consultants, as Stege Creek, in the early 1990s, an El Cerrito resident and graphic design artist labeled it Baxter Creek on a map he prepared of the Ohlone Greenway (a trail crossed by the creek) after having seen it so identified on an unknown map. Since that time, the local citizens' group (the Friends of Baxter Creek) working to preserve the creek and draw awareness to it has developed much public awareness of that name, so for that reason, it would be a shame to change it. (Riley also uses the name Baxter Creek in her book.)

open stretches are all part of the same stream, or that they live in its watershed. To add to this confusing geography, although this stream originally had one or possibly two branches (Figure 2), the storm drain system today takes three separate streams and joins them together in a culvert just where the hills meet the flatlands, to flow beneath Interstate 80 and through the city of Richmond (Figure 3). At Booker T. Anderson Park, at 47th and Cypress Streets in Richmond, the single stream finally reemerges from underground (Figure 4).

Figure 1. Baxter Creek originates in springs high in the Richmond and El Cerrito hills, including beneath the Mira Vista Golf Course.

Photo by author. 1997.

Figure 2. Rancho San Pablo in 1894. (Possible original watershed boundary indicated with dashed line.)
Source: San Pablo Historical Society: "Map Showing Portions of Alameda and Contra Costa Counties." George Sandow, C.E. 1899.

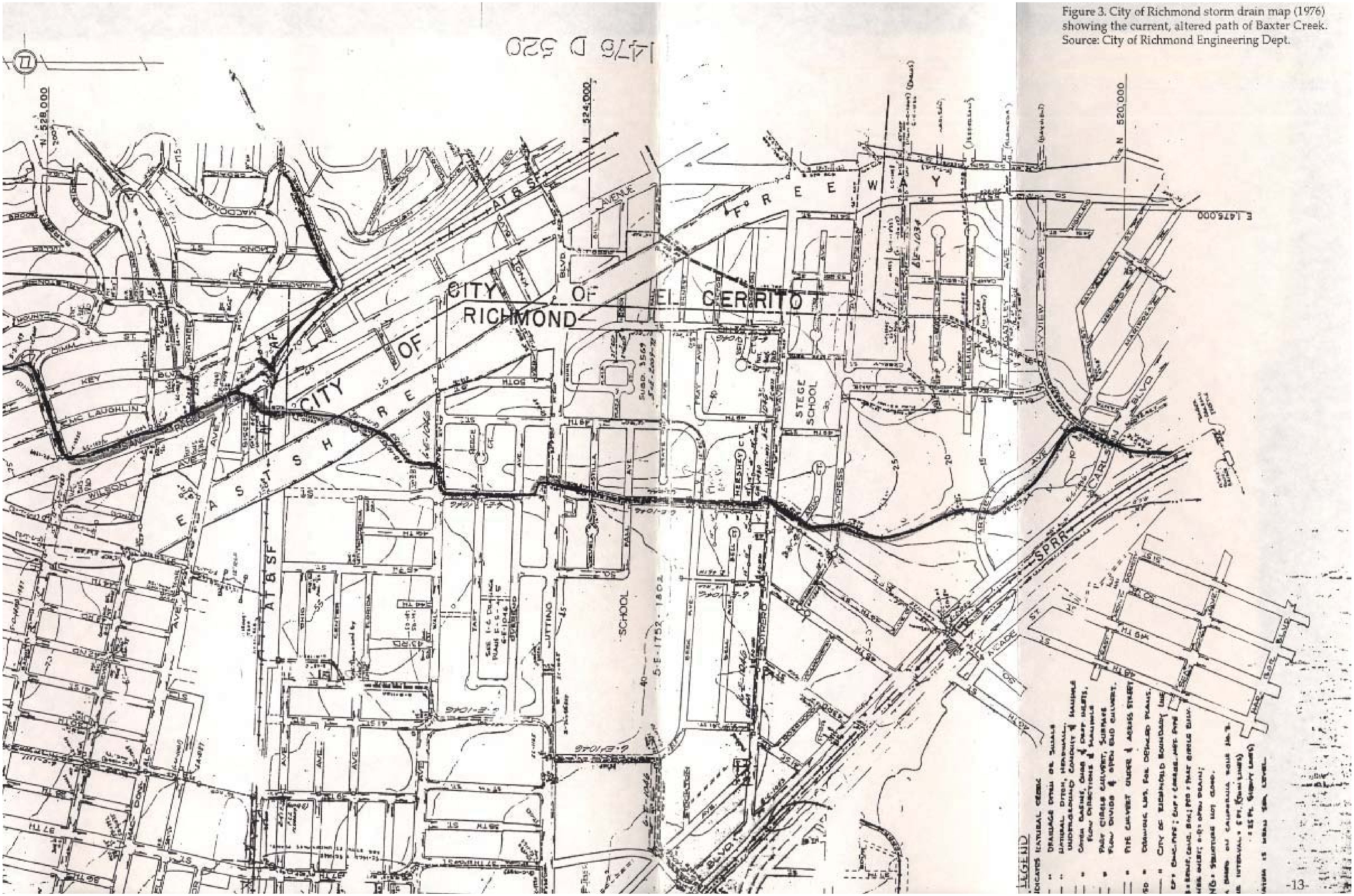
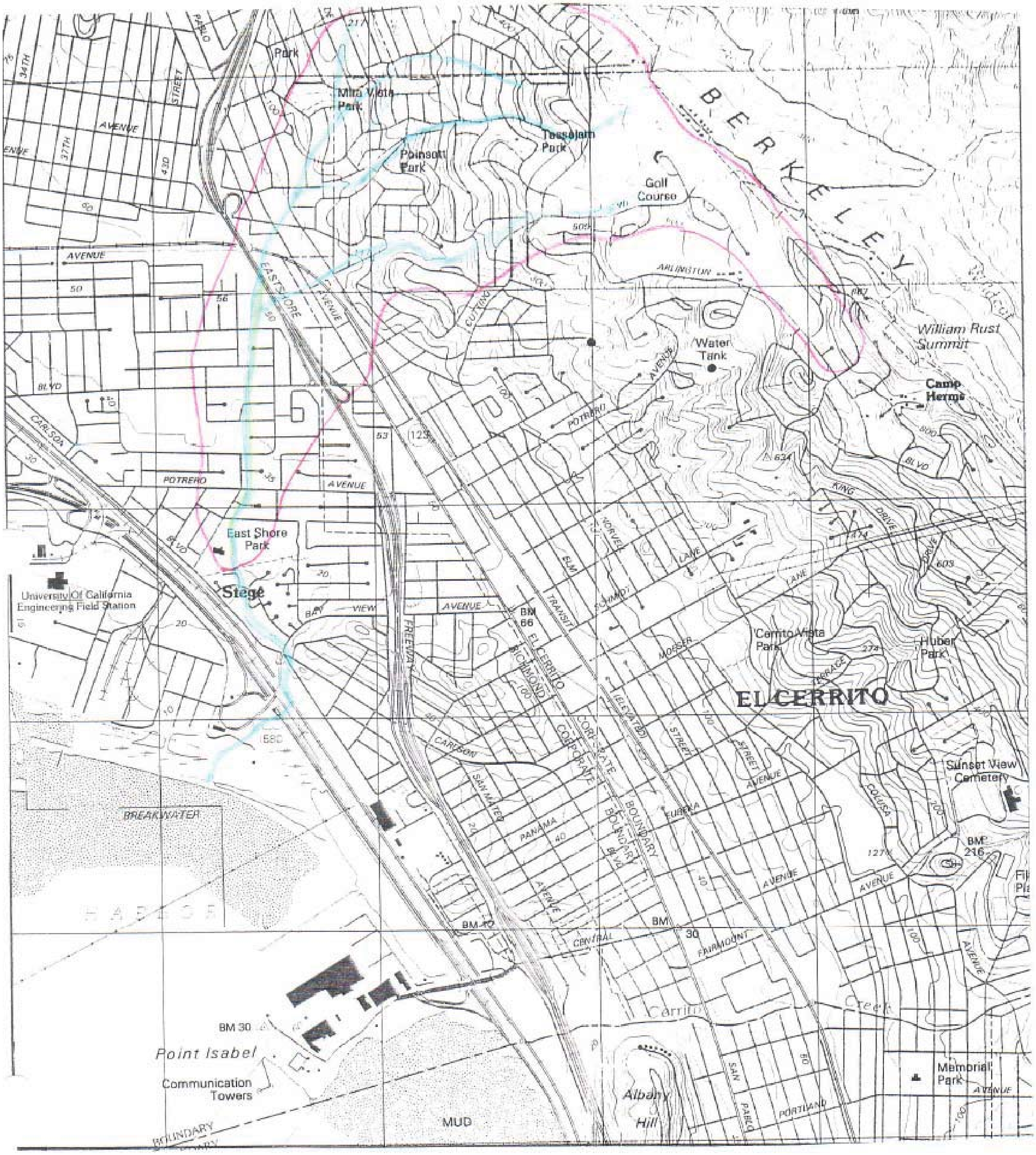


Figure 3. City of Richmond storm drain map (1976) showing the current, altered path of Baxter Creek.
Source: City of Richmond Engineering Dept.

Figure 4. Section of USGS topographic map, Richmond Quandrangle. 1993.
Scale=1:24,000 = Watershed Boundary = Stream branches



After flowing through the park, the stream returns to a culvert to flow southwesterly again beneath a low-income housing development known as Crescent Park. It next emerges in a straightenened channel beside the railroad tracks that parallel the Interstate 580 freeway, just southwest of Bayview Avenue and Carlson Boulevard. The creek then makes a sharp right turn and flows beneath I-580 and into Stege Marsh and San Francisco Bay (Figure 5).

Figure 5: Aerial Photo

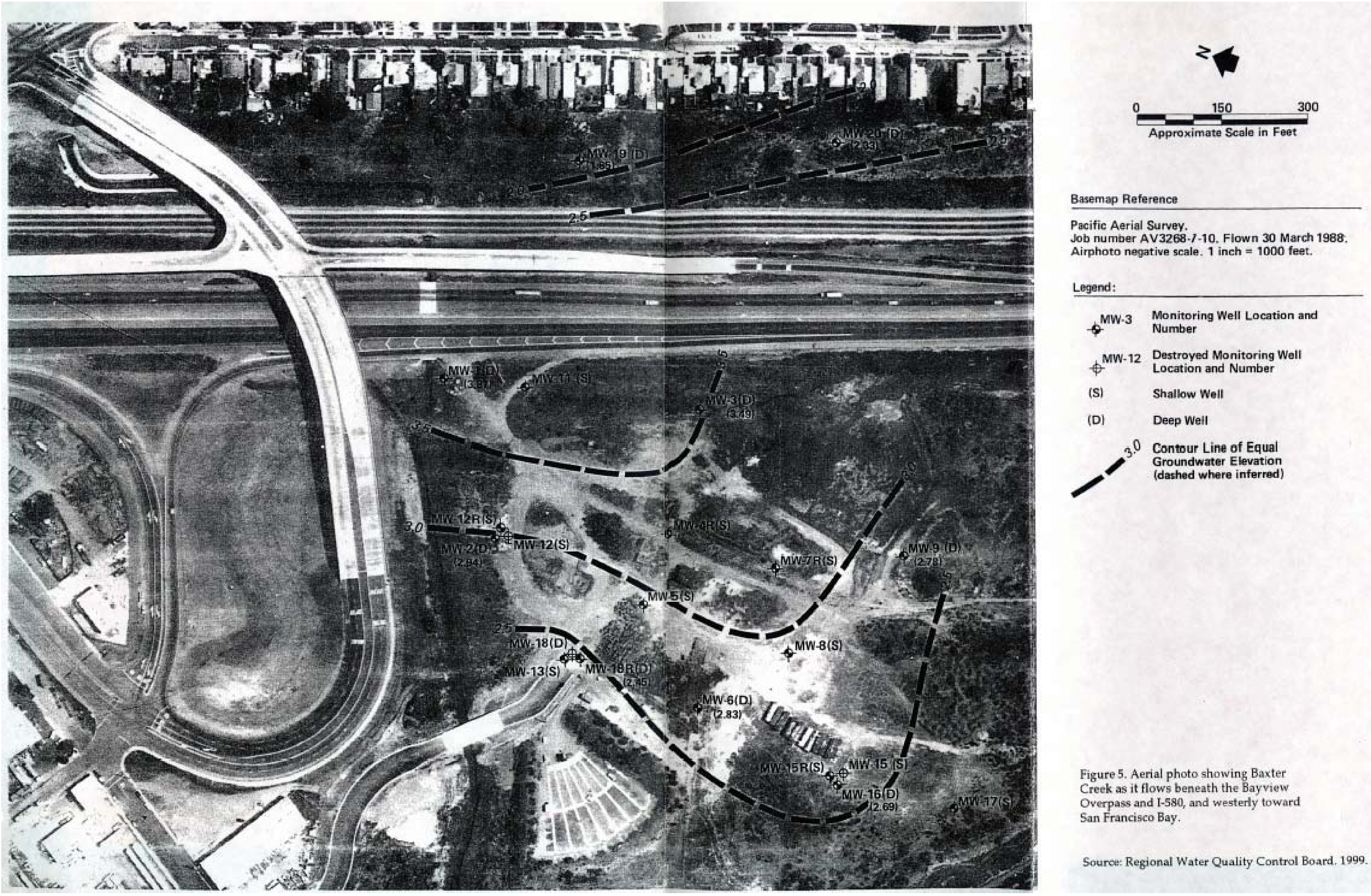


Figure 5. Aerial photo showing Baxter Creek as it flows beneath the Bayview Overpass and I-580, and westerly toward San Francisco Bay.

Source: Regional Water Quality Control Board. 1999.

Showing Baxter Creek as it Flows Beneath the Bayview Overpass and I-580, and Westerly Toward the Bay

Source: San Francisco Regional Water Quality Control Board

Tiny sections of the three branches can be seen above ground in several public parks in the hills, including Canyon Trail and Poinsett Parks in El Cerrito, and Mira Vista Park in Richmond. These branches also flow openly in several spots behind or beside private homes in the Richmond and El Cerrito hills (see Figure 6- 9).

Figure 6. The Poinsett branch flows through backyards (sometimes in strange channels) and in a recently daylighted section in El Cerrito's Poinsett Park (bottom).

Photos by author. 1996-19

Figure 7. The Mira Vista branch flows beside, between, and even beneath homes before daylighting in Mira Vista Park in Richmond.
Photos by author. 1998.

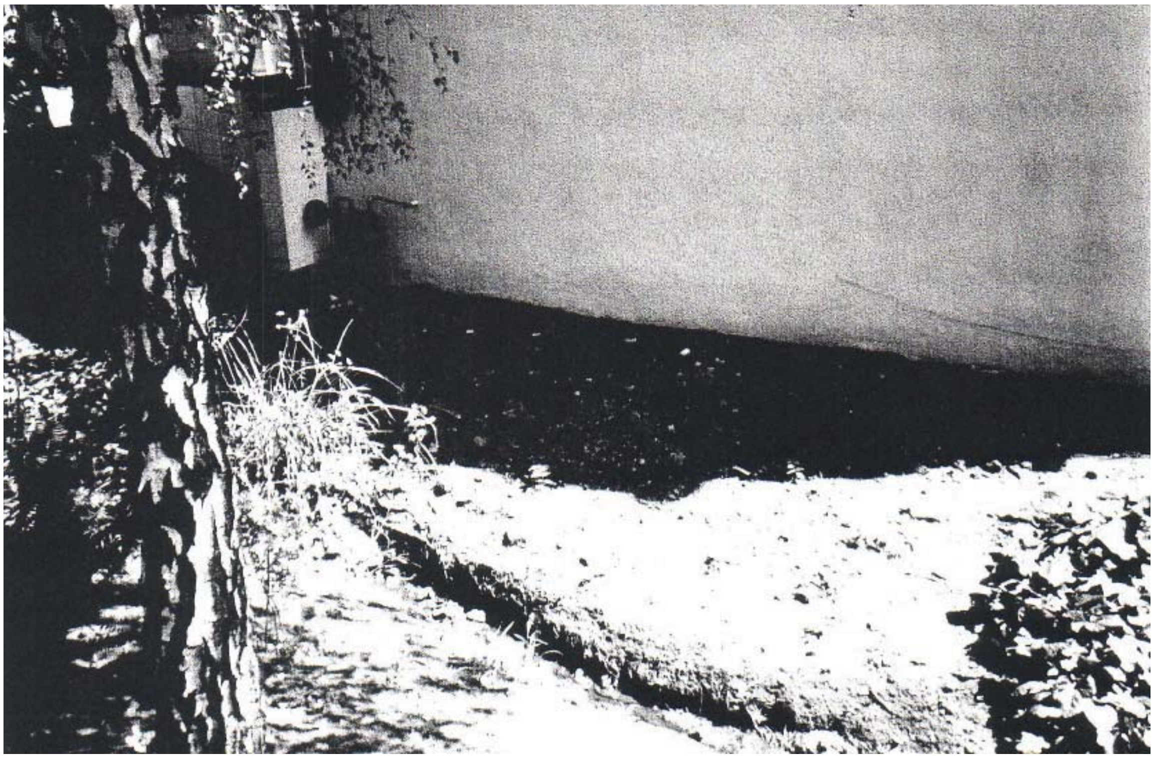


Figure 8. The creek as it flows through Mira Vista Park, before and after volunteers had just planted its banks with some willows.
Photos by author. 1997 and 2000.

Figure 9. The Canyon Trail branch flows openly through Canyon Trail Park where it empties into a man-made pond, then beneath Conlon Street for two blocks before coming above ground again in a field behind a grocery store. It then enters a culvert to flow beneath San Pablo Avenue. Photos by author. 1999.

Figure 10. The creek comes above ground again to the west of San Pablo Avenue, where it is joined by the "Mira Vista" and "Poinsett" branches, then put into a concrete channel to flow southwesterly beneath I-80 and the City of Richmond (in a culvert).
Photos by author. 1998.

With the exception of two small portions to the east and west of San Pablo Avenue near MacDonald Avenue, the small open stretch that parallels the railroad tracks before entering the Bay, the Booker T. Anderson stretch, and the section of the creek that becomes a tidal channel as it flows toward Stege Marsh and the Bay, there are no other open stretches of this creek in the flatlands (see Figure 11). Neither the stretch paralleling the railroad tracks nor the tidal channel is very visible or accessible, although the tidal channel can be seen from the San Francisco Bay Trail and from the side of Interstate 580 (see Figure 12).

Figure 11: The Baxter Creek Watershed Showing Open and Culverted Stretches (approximate). Map by author, USGS map (1993) used as base map.

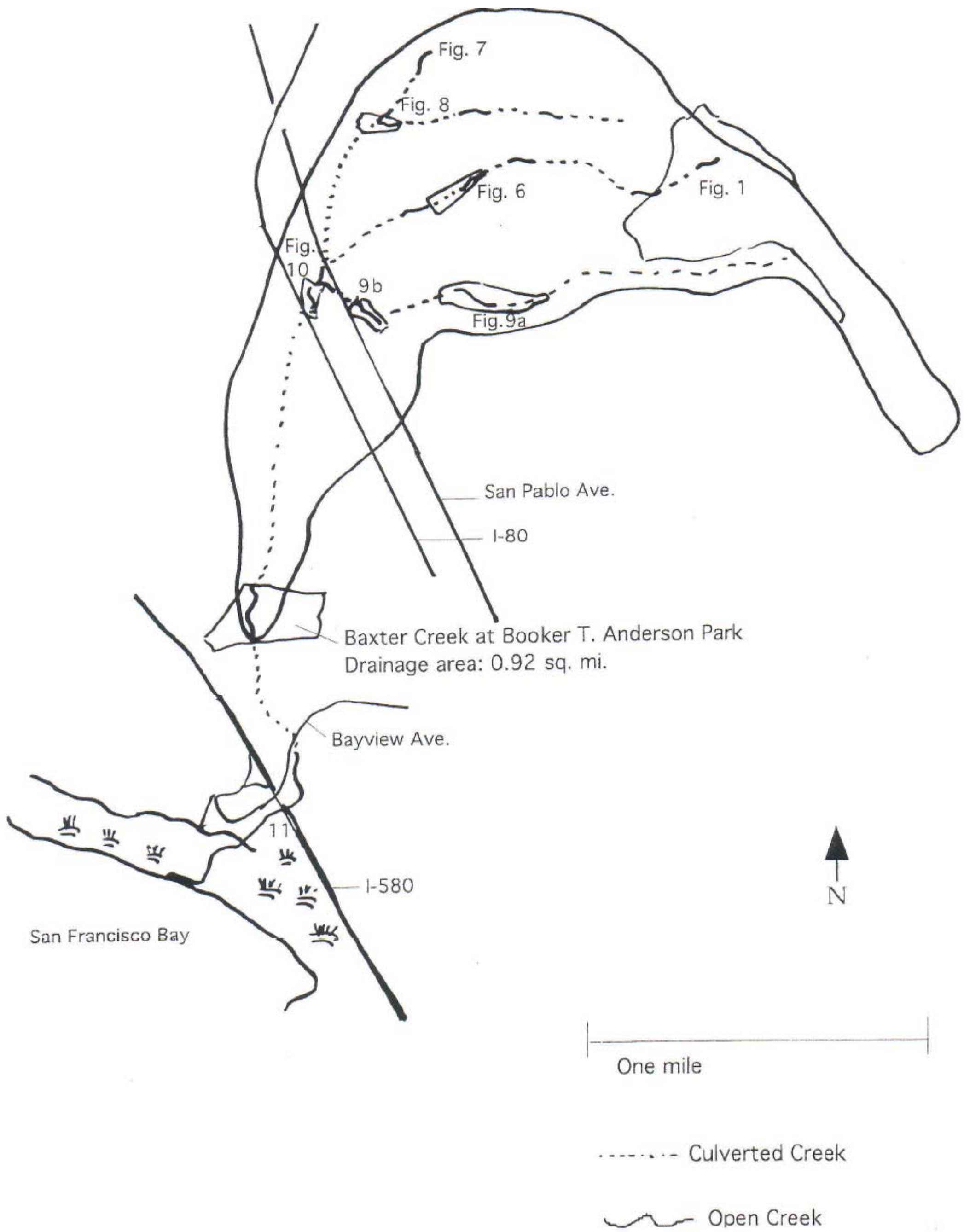


Figure 12: Top: Baxter Creek Flowing West Toward San Francisco Bay (Bayview Flyover shown at the right edge of photo).

Bottom: Baxter Creek as it becomes a tidal channel, seen from near the San Francisco Bay Trail (Bayview Flyover seen in distance). Photos by author. 1999.

CHAPTER 3: BAXTER CREEK IN BOOKER T. ANDERSON PARK

The focus of this project is the 790-foot-stretch of Baxter Creek that flows through Booker T. Anderson Park at 47th and Cypress Streets. Although this stretch of stream has never been put underground, it has been continually modified in other ways, from the time of early European settlement through the very recent past.

A brief land use history

In prehistoric times, Baxter Creek may have been an intermittent stream (CAC 1981). In his 1910 paper on the shellmounds at Ellis Landing, UC Berkeley archaeologist N.C. Nelson found only a "very slight superficial indication of old creeks that once crossed the area . . . one or two of these run between Stege and the Berkeley Hills" (Nelson 1910).[3] Of course, by 1910, grazing and other land-uses had likely already degraded the smaller streams, but it is also possible that Baxter Creek dried up in the summer months. Today, the creek flows year round, fed by runoff from golf course and lawn and garden irrigation, as well as other urban sources.

Ohlone Indians of the Huchiun clan were probably the first to use this and other streams in the area as a source of drinking water and to leach tannins from acorns, which they ground into a gruel (Margolin 1978). Bedrock outcroppings

[3]The Berkeley Hills in the Richmond area are also known as the San Pablo Ridge, and the Mira Vista Golf Course (previously described) lies on the west side of the Ridge, where Baxter Creek originates.

used as grinding stones by the early native Americans and many cultural artifacts have been discovered along the creek, in Mira Vista and Canyon Trail Parks in the upper watershed (CAC 1981), and the entire length of the stream is designated on an inaccessible city of Richmond map as having "high archaeological sensitivity" (Kitchingman 1999). The impact of the early native California residents on the stream was probably negligible, as they relied primarily on the San Francisco Bay estuary and larger streams for food resources, and any dams they may have used to catch fish would have been temporary in nature (CAC 1981; Margolin 1978).

The first major impacts to Baxter and the other streams in the area probably occurred with European settlement. The land through which Baxter Creek flows was part of Rancho San Pablo, a huge land grant of at least 90 square kilometers (CAC 1981) ranging from El Cerrito north to Pinole and east to El Sobrante and Lafayette, which was awarded in 1823 to Francisco Castro, a solider in the Mexican army (Hoover, et al. 1990). Rancho San Pablo was primarily used for growing hay and grazing cattle (Hoover, et al. 1990), and the cattle were watered in the local creeks. Castro's land was contested in legal battles waged by new European settlers to the area. After his death in 1831, his heirs received title to only 200 acres (CAC 1981). The remainder was acquired by other European settlers, often by questionable means (Hoover, et al. 1990; CAC 1981).

In the early 1870s, a gold miner and entrepreneur from Germany named Richard Stege married a wealthy widow and acquired 600 acres of grazing land (Emmanuels 1993; Lane 1984), encompassing what is now the 19.48-acre Booker

T. Anderson Park (Whiting 1972). Stege, his new wife, and her daughter lived in a southern-style mansion near the site of today's Stege Elementary School, at 49th and Cypress. Just to the north of their property were several dairy and cattle ranches which probably used the creek to water their cattle (Whiting 1972; Lane 1984).[4] In the late 1800s, Stege sold large sections of his wife's property to several explosives and chemical manufacturing plants. The small industrial town that subsequently developed and incorporated in 1905 was named after Stege (Rego 1994). A railroad depot was located nearby, near 47th and Carlson, and the industrial community of Stege thrived during the late 1890s and early 1900s. During these years, Richmond was still primarily pasture land, but in 1912 it annexed Stege (Rego 1994).

Richard Stege created elaborate gardens on his estate, planting palms and other trees, roses, violets, and carnations (Emmanuels 1993). He also dammed (and probably straightened) portions of this creek and possibly another one that appears to have flowed through the site to the south of it, to create a series of ponds for rearing frogs (see Figures 13 and 14) (Whiting, 1972).

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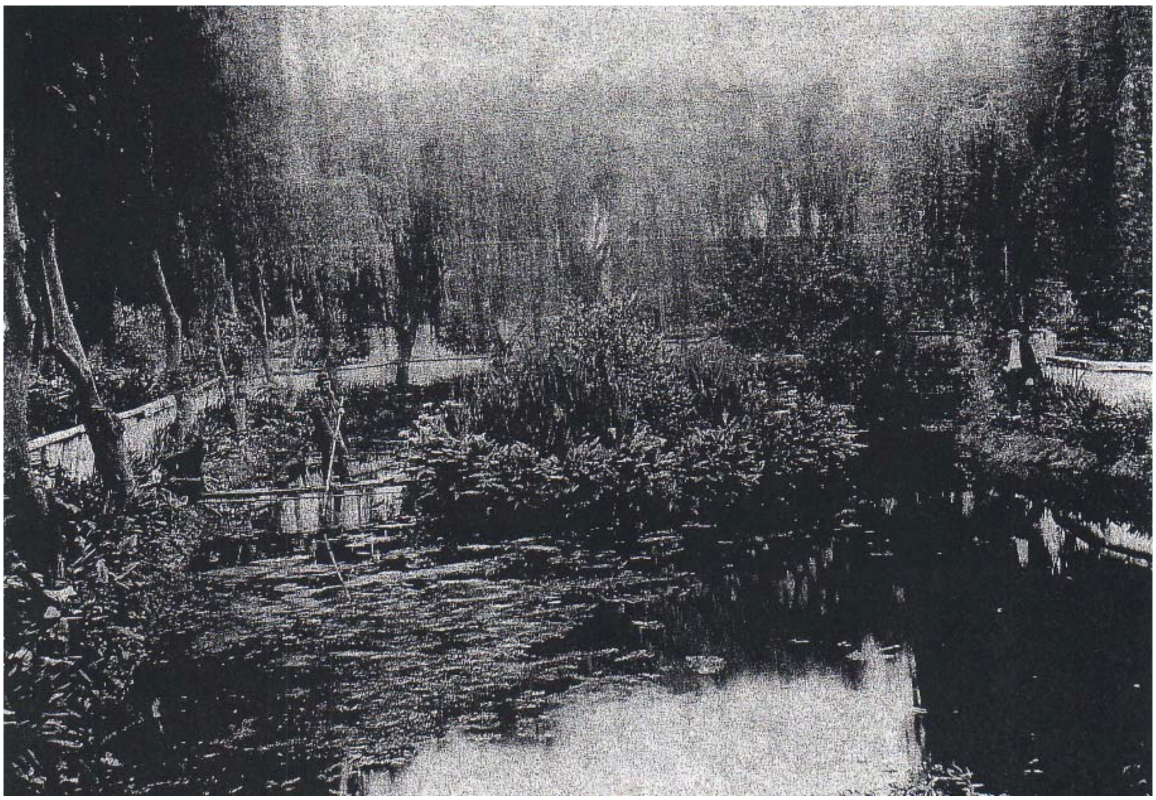
[4]One was owned by San Francisco attorney Thomas Bishop, who leased many of his holdings in the East Bay to farmers for grazing (Emmanuels 1993).

Figure 13: Stege's frog ponds, late 1800s.



Source: Richmond Museum of History.

Figure 14: A walkway on Stege's estate crosses what appears to be a tiny, channelized creek or tributary on his estate, late 1800s.

Source: Richmond Museum of History.

Stege began operating a frog farm, selling frogs for $2 apiece to San Francisco restaurants. His business became California's largest and most successful frog ranch (Lane 1984). (Stege may have unwittingly been an early contributor to the demise of the native red-legged frog, which is now listed as a threatened species. In addition to raising native red-legged frogs, Stege imported bullfrogs (Whiting 1972), which are known to eat young red-legged frogs.) But by 1898, Stege was besieged with competition, and his frog business came to an end.

An 1899 map of land use in 1894 (see Figure 15 under the parcel entitled "Est. of Minna C.C. Stege" just above the railroad—Baxter Creek is the stream on the left)—shows a somewhat sinuous stream. The straightened stream may have been trying to recover its natural meanders, in spite of Stege's dams and other alterations. After Stege's death in 1898, his daughter Edith (his wife had died a few years earlier) continued to live on the estate. In approximately 1912, a small schoolhouse (called "Stege School") was built on the land (Pence 2000). Figure 16 shows the Stege land, Stege School (center of photo, toward the top), and a sinuous, vegetated creek (toward the bottom of the photo). The frog ponds are no longer visible. Shortly thereafter, Edith Stege sold the land to the Eastshore and Suburban Railway, a local trolley line, which turned the area into "Eastshore Park," complete with a popular dance pavilion and skating rink (Whiting 1972).

When the rail company bought the land from her, it further altered the creek, turning the frog ponds into public swimming holes (see Figure 17) (Whiting 1972).

Figure 15: Portion of an 1893 map entitled "Map of the San Pablo Rancho Accompanying and forming a part of the Final Report of the Referees in Partition." Dated September 1, 1893. G.F. Allardt, C.E., Surveyor.

Source: San Pablo Historical Society.

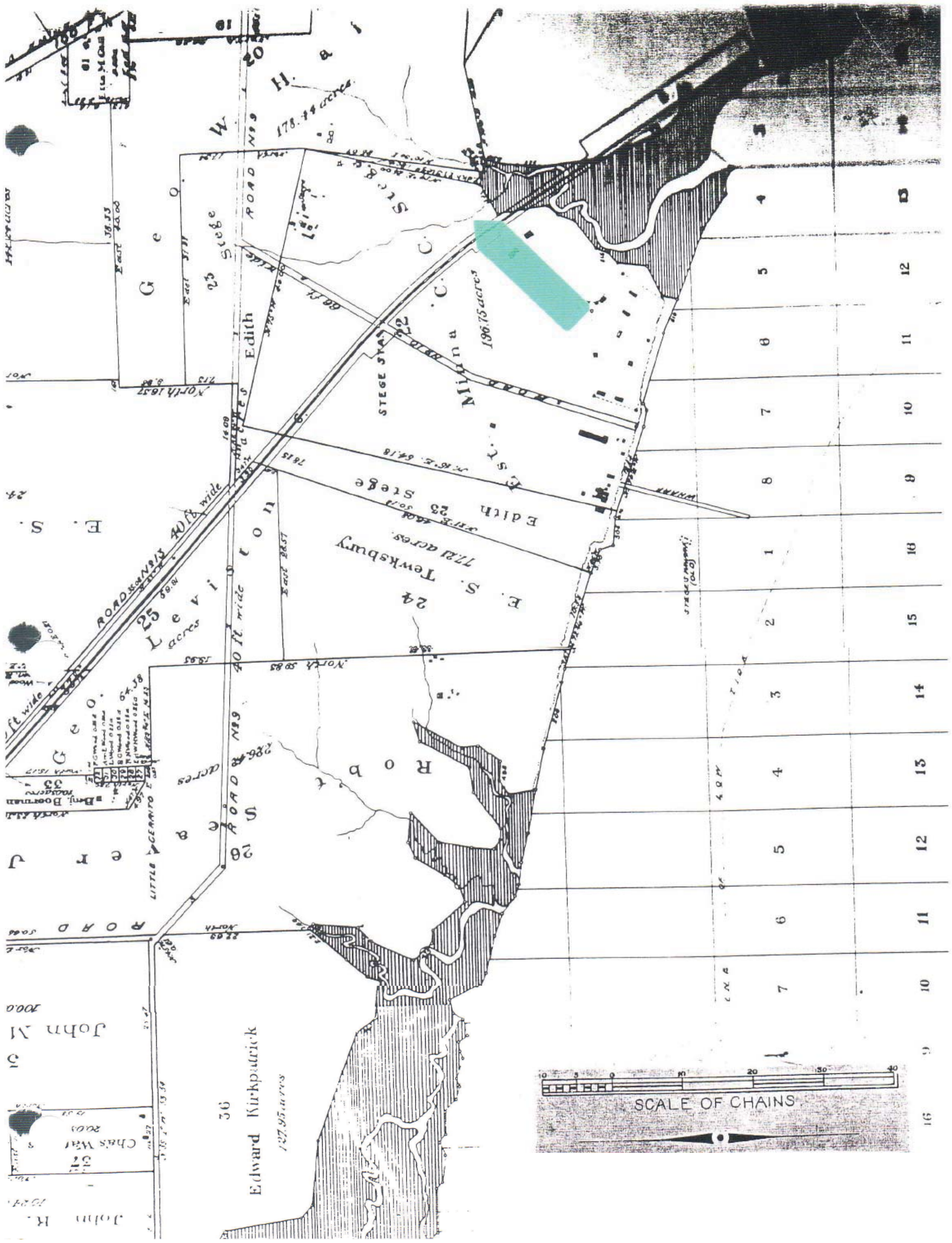
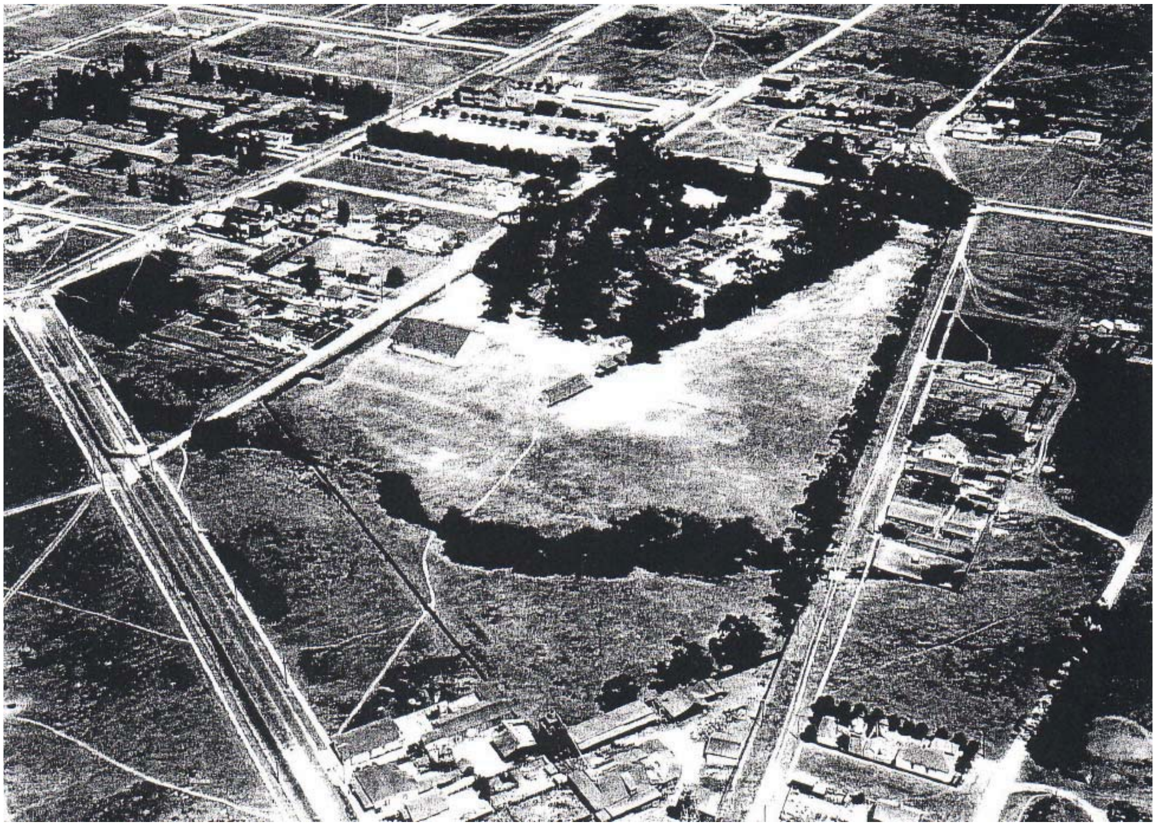


Figure 16. The Stege estate, early 1900s. Note creek at center of photo.



Source: Richmond Museum of History.

Figure 17: A swimming hole on Baxter Creek created by the railroad in East Shore Park (now Booker T. Anderson Park).

Source: Richmond Museum of History

During the Depression, public use of the railway's park declined, and an entrepreneur bought the land, planning to develop it commercially (*Richmond Independent* 1938). However, in the late 1930s, over the objections of many citizens who were concerned about the cost, the city purchased the land for $17,000, demolished the old Stege mansion, and created a new public park (Cole 1980; Whiting 1972; *Richmond Independent* 1938) known as Potrero Municipal Park. In 1943, to serve the women who worked in Richmond's many industrial plants during World War II, the city built a children's day care center just to the west of the creek. At the end of the war, the city leased the building to the Richmond School District, which operated it as Pico Elementary School. Later, that school moved to another location, and the former day care center was converted to Gompers Continuation School (Burkhart 2000), which, despite the fact that the building was put up hurriedly and never designed to be permanent (Burkhart 2000), remained on the site until 1970. At some point during this time, Potrero Municipal Park became known as East Shore Park; in the early 1990s, its name was changed again, to Booker T. Anderson Park, for a minister and former mayor of Richmond.

No evidence is available as to exactly what happened to the creek during the early years under city ownership of the park, although in plans and a 1947 aerial photo, the school/day care center buildings can be seen close to the creek. That photo shows a vegetated stream with an estimated sinuosity of approximately 1.4.[5] But plan drawings for the park show that by 1953, the creek had again been channelized or straightened (see Figure 20).

[5]The aerial photo was made into a slide and projected onto a screen, where sinuosity was measured using the same method described earlier.

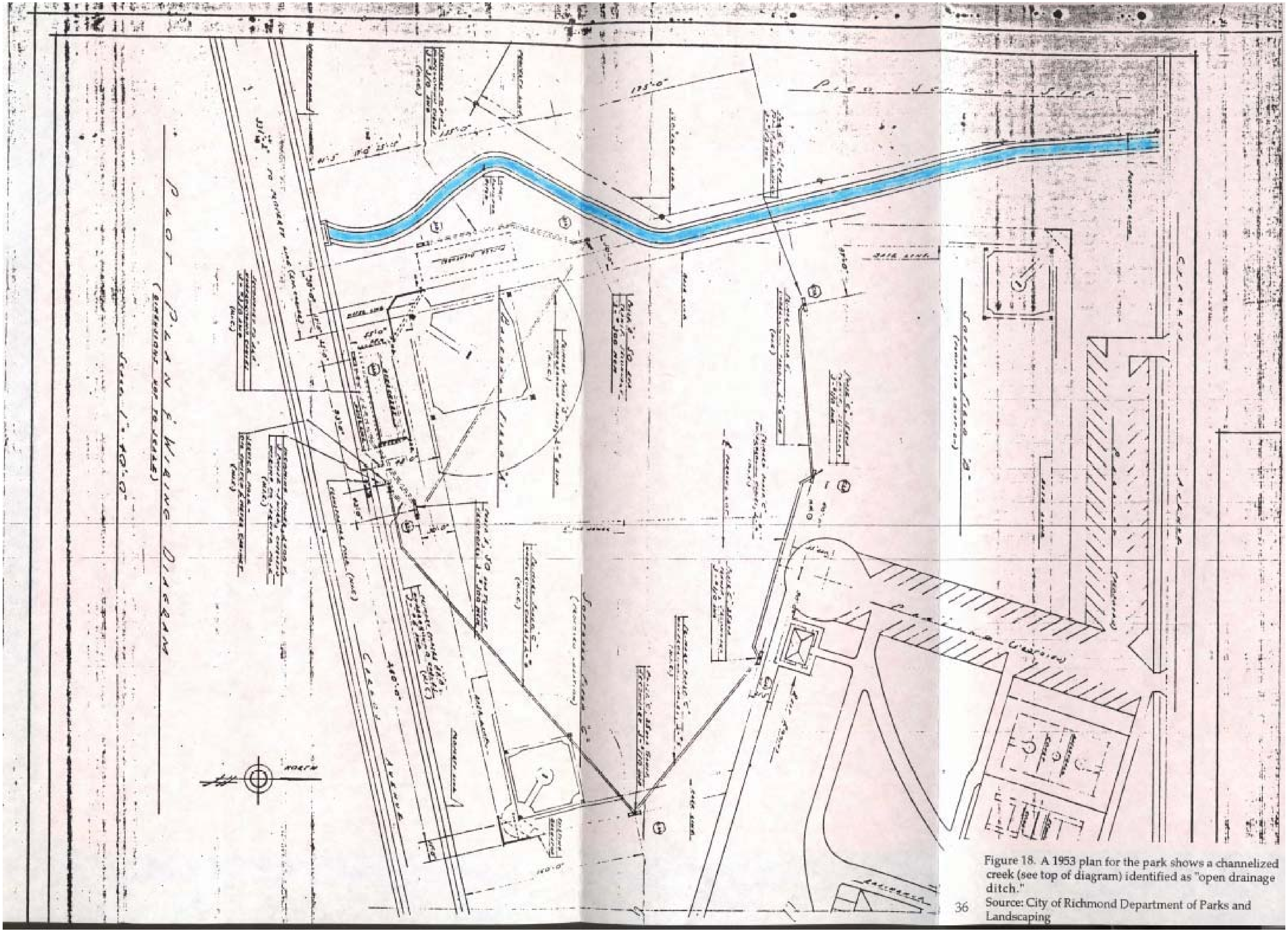


Figure 18. A 1953 plan for the park shows a channelized creek (see top of diagram) identified as "open drainage ditch."
Source: City of Richmond Department of Parks and Landscaping

In 1970, the Gompers School buildings were demolished, and a landscape architecture firm made extensive "improvements" to the creek, widening it and creating a bit more sinuosity in the upstream half of the channel ("Reach 1"), an apparent attempt to accommodate construction of a new parking lot (see Figure 21).

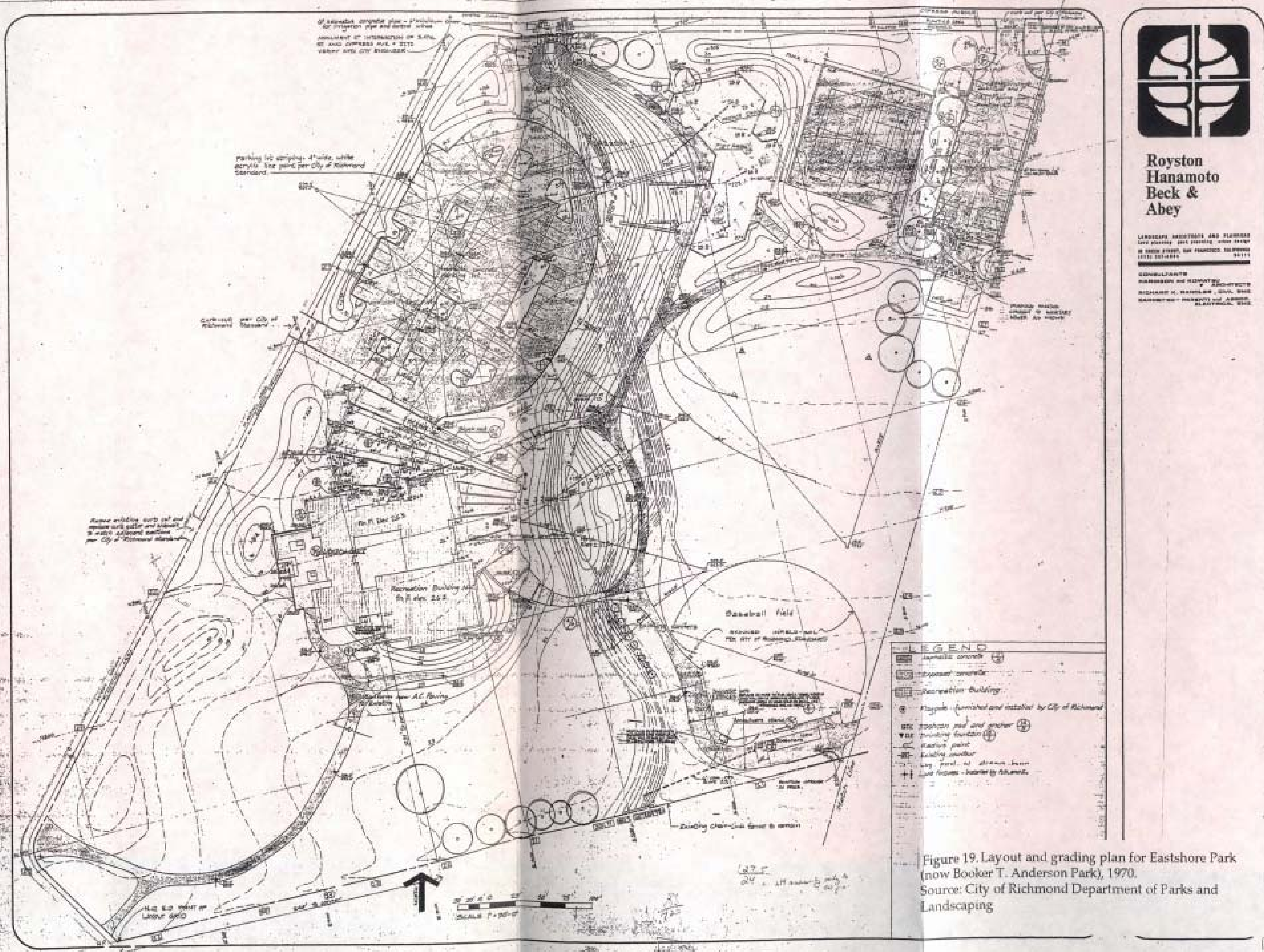


Figure 19. Layout and grading plan for Eastshore Park (now Booker T. Anderson Park), 1970.
Source: City of Richmond Department of Parks and Landscaping

This design was not sinuous enough and overwidened the channel, as evidenced by the large amounts of sediment being deposited in the channel and by comparing its "redesigned" geomorphology with Leopold's data of average widths, depths, and area for Bay Area streams and Riley's adjusted averages for East Bay streams.

From data collected in the field and from gaging stations, Leopold created a graph of the average cross-sectional areas, widths, and depths of Bay Area streams, showing how the bankfull channel—or the channel at bankfull discharge, which occurs every 1.5 years *on average*—is positively correlated with the size of the drainage basin. The bankfull channel is considered the active channel, the channel that does the most work and creates the shape of the stream, one reason defining the active channel is so important in restoration. After comparing her data to Leopold's averages for Bay Area streams, Riley then created her own regional averages for the East Bay (Baxter Creek was not studied by either Leopold or Riley). A comparison of Leopold's and Riley's data and field measurements of Baxter Creek can be seen in Table 1.

Table 1. Comparison of Baxter Creek Cross Sections to Regional Data from Dunne and Leopold and the Waterways Restoration Institute

Cross Section A	Field Measurements	Predicted Geometry Based on Leopold Averages for SF Bay Area	Predicted Geometry Based on WRI Adjusted Averages for East Bay
Area	33'	23'	18'
Width	22'	16'	13'
Depth	1.5'	1.6'	--
Width:Depth Ratio	14.6	--	--

Cross Section B	Field Measurements	Predicted Geometry Based on Leopold Averages for SF Bay Area	Predicted Geometry Based on WRI Adjusted Averages for East Bay
Area	29'	23'	18'
Width	20'	16'	13'
Depth	1.45'	1.6'	--
Width:Depth Ratio	13.8	--	--

Cross Section C	Field Measurements	Predicted Geometry Based on Leopold Averages for SF Bay Area	Predicted Geometry Based on WRI Adjusted Averages for East Bay
Area	17.5'	23'	18'
Width	13.5'	16'	13'
Depth	1.06'	1.6'	--
Width:Depth Ratio	12.7	--	--

Sources: Dunne and Leopold 1978; Leopold 1994; Waterways Restoration Institute 1999; Field measurements taken July 1999.

In 1988, more "improvements" were made to the creek by the same landscape architecture firm. The creek was widened again in sections and the tops of the banks were graded back, creating an even shallower channel. Many sections of the banks were lined with riprap, further disturbing the channel and altering its shape. Huge boulders were placed along the creek's banks; cement and large cobblestones were used to pave the banks at the mouth of the creek where it enters the park from its culvert (see Figure 20).

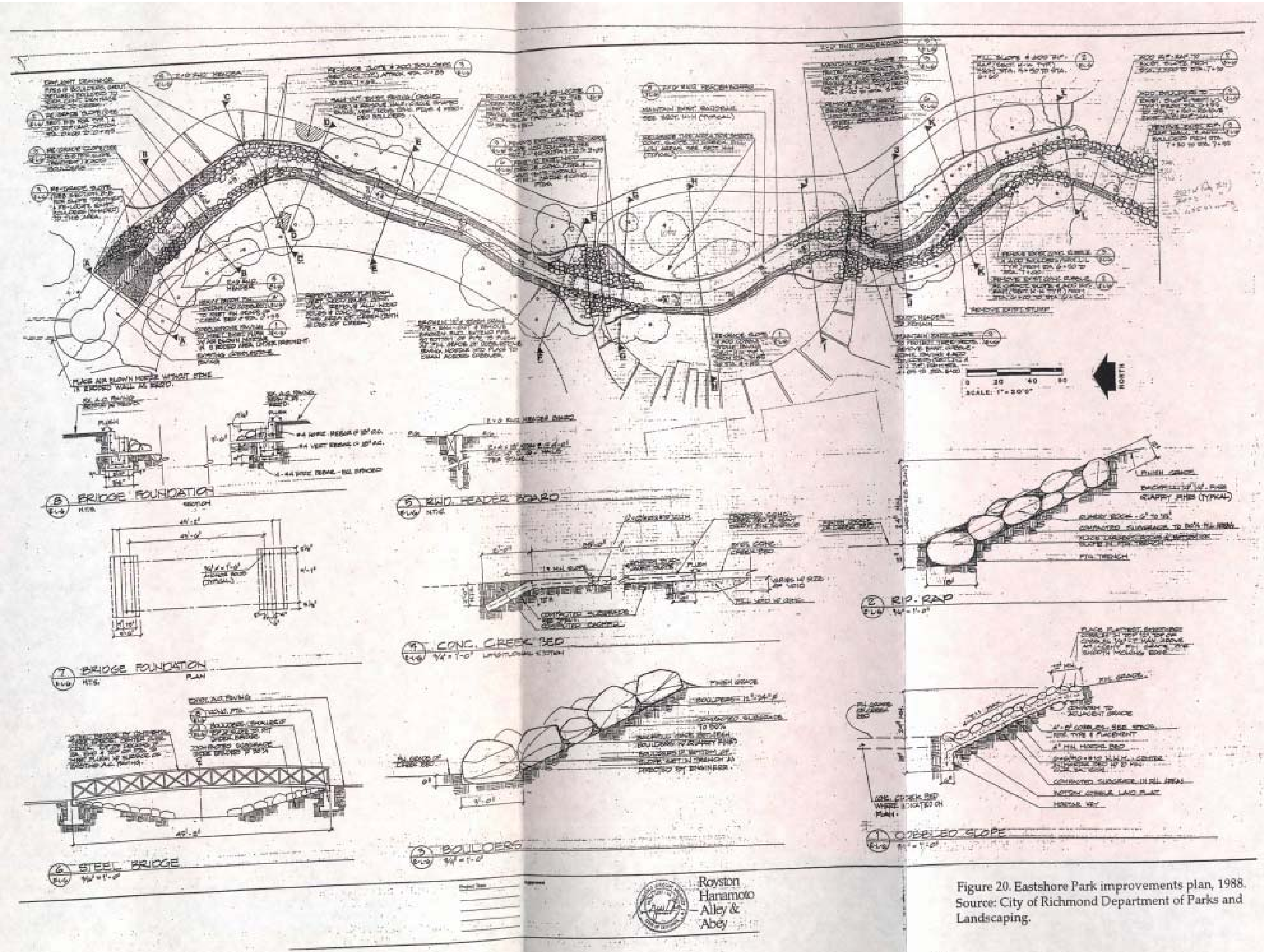


Figure 20. Eastshore Park improvements plan, 1988. Source: City of Richmond Department of Parks and Landscaping.

Comparing field measurements taken in July 1999 to Leopold's and Riley's data confirms that throughout most of its length, the creek in Booker T. Anderson Park is too wide for the size of its watershed (or the area it drains). As a result, too much sediment is deposited in the channel, slowing flows, and in some sections, resembling a shallow bowl rather than a stream channel.

In most sections of the creek, there is little or no vegetation along the banks, which means that the stream is exposed to sunlight, causing algae and weeds—in particular, water parsley—to proliferate, which in turn reduce the amount of dissolved oxygen in the water when they decompose. An oxygen-deprived stream can support little aquatic life except for the few species adapted to survive in such conditions.

The banks beneath the cement rockwork at the creek's "mouth" have been eroded in high flows, leaving a gap between the cement and the banks (see Figure 21). The large boulders placed on the banks have fallen into the creek, where they remain, along with several large chunks of cement, possibly from the old concrete channel of the 1950s (see Figure 21). Several bridges were installed across the creek during the park "improvements" projects. Their footings have have since been undercut and partially destroyed; only one bridge remains intact, and that, too, needs bolstering or replacement. The other bridge and a play structure that crossed the creek have been removed; their remnants can still be seen on the eroded banks (see Figure 22, top). Pipes directing subsurface drainage into the creek have become exposed as a result of erosion, and have formed small gullies (see Figure 22, bottom).

Figure 21: Unsuccessful and unattractive engineering: cobble rockwork at mouth of culvert entrance, Booker T. Anderson Park—note erosion beneath the cement. Large boulders placed on the creek's banks washed or have fallen into the creek bed.
Photos by author. 1999.

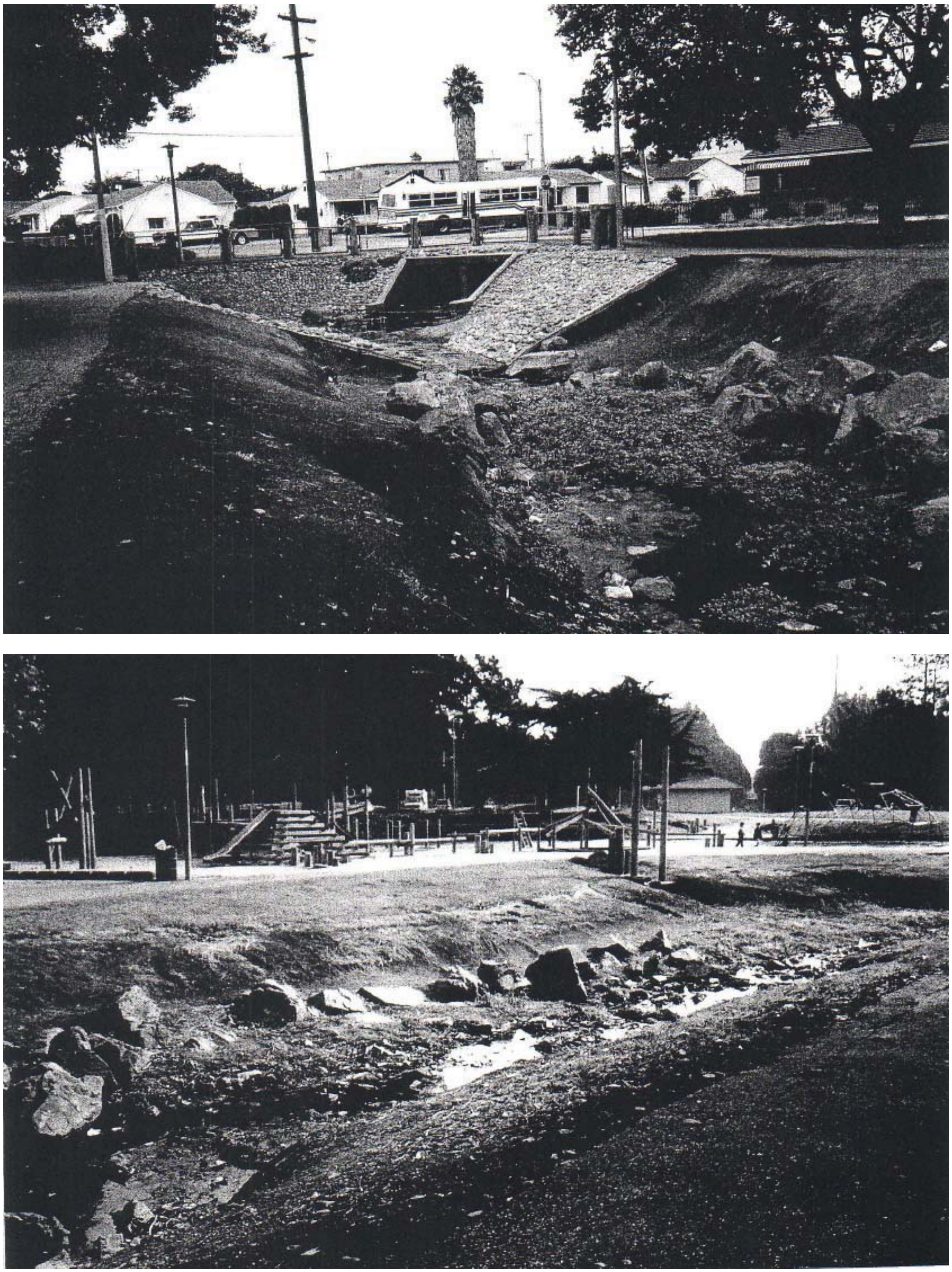


Figure 22: The remnants of an old bridge show how the creek has eroded its banks beneath the bridge footings (top); on one bank, a gully has been created by a pipe directing subsurface flows into the creek (bottom). Photos by author. 2000.

The 1988 grading plan recommended leaving some of the alder-planted sections of bank alone, to "protect the tree roots." These roots have actually stabilized and protected the shape of Reach 2—approximately 300 feet—which has also retained more sinuosity (see Figure 23).

Figure 23: Alder roots have helped hold the banks in place.

Photo by author. 1999.

The erosion beneath these roots could be remedied by installing small willow "baskets" that would trap sediment and help rebuild the banks (Schemmerling 1999). Erosion does not appear to be excessive, however, and this section of channel can be pretty much left alone, aside from some revegetation of the understory and reconfiguration of the meanders to better align with the downstream culvert.

CHAPTER 4: RESTORATION OF THE BOOKER T. ANDERSON STRETCH: CONSTRAINTS AND OPPORTUNITIES

Restoration of the Booker T. Anderson stretch of creek could repair some of the existing geomorphological problems. This restoration would be considered both functional and ecological (according to Riley's definitions, described in Chapter 1). Some of the goals of this project are as follows:

- to improve water quality and provide wildlife habitat, by revegetating the banks and shading the water
- to provide a more functional hydraulic geometry, creating pools and riffles in the stream, which will also provide habitat
- to provide an attractive amenity to the neighborhood
- to provide an educational opportunity for the community and nearby schools;
- to offer a demonstration of the benefits of urban stream restoration in a flatlands area; and
- to create 800 feet of riparian corridor and in doing so, restore a sense of regional ecological identity.

Although restoring a more functional hydraulic geometry to the stream would help restore fish habitat, it is questionable whether fish can migrate from the Bay up into this stretch of stream. Not only would they have to swim a long length of culvert (although many fish do swim through culverts), but the marsh into which Baxter or Stege Creek flows is one of the ten most toxic "hot spots" in San Francisco Bay, according to a March 1999 report by the Regional Water Quality

Control Board. According to that report, the marsh is contaminated with DDT, PCBs, chlordane, and other chlorinated pesticides, as well as arsenic, copper, lead, zinc, and selenium, which found their way there via adjacent settling and evaporation ponds used in the recent past by chemical companies as well as from the industrial activities of the past century (RWQCB 1999). Urban runoff is also suspected to contribute pollutants (RWQCB 1999). Some areas of the marsh are so polluted that sediment samples contained no benthic biota (RWQCB 1999). However, even if fish are unable to reestablish populations in the restored section of stream, restoration will improve the quality of the water that flows into the marsh.

The potential barrier to fish migration presented by the contaminated marsh and the culvert between the park and the marsh is probably the greatest constraint to what might otherwise be considered a complete ecological restoration of lower Baxter Creek. Still, in addition to improving the quality of the water that ultimately flows into the Bay by filtering urban runoff and trapping sediment, restoration would increase and improve habitat for other wildlife, including amphibians and birds. Children playing in the park report catching frogs and guppies in the creek—Pacific chorus frogs have been found in all of the creek's branches—and restoration will provide better amphibian habitat: shaded, cooler water and pools, and protective vegetation. Revegetation of the creek banks will also provide habitat for birds, both resident species and seasonal migrants. The park is already used by a surprising diversity of birds (see Appendix 1), and recent research has shown that newly-restored riparian areas produce a foliage canopy that attracts many insects. Those insects attract birds, particularly insectivores (Otahal 1999). Biodiversity is often greater in newly-restored riparian sites as well. On one such site in Marin County, biologists from Point Reyes Bird Observatory found 22 species of birds, compared to only eight in a degraded, non-restored site (Pitkin 2000).

But birds, frogs, and San Francisco Bay would not be the only beneficiaries of restoration. There are several additional reasons why this site presents an excellent candidate for restoration.

Room to Move

As described in the previous chapter, this creek is quite degraded in terms of its hydraulic geometry (channel shape), the habitat it offers (both instream and along the banks), and its water quality. One fact that makes reshaping and revegetating the channel easier than in many urban settings is that the stream has been given room to meander freely, with a generous floodplain.

Also, in contrast to many project sites, this site also has plenty of space for "staging" a restoration—bringing in excavation equipment, plant material, etc.—and the parking lot makes access to the creek easy.

Beneficial Location

One of the most favorable aspects of this project is its location. The park is frequented by neighborhood children and adults, and by soccer and other sports teams. A restoration project on this site would offer educational opportunities for nearby school children as well as the opportunity to involve those children and neighborhood residents in restoration, maintenance, and monitoring programs. Every time I have visited the creek to take measurements or make observations, children and adults using the park have come up to me and asked what I was doing and what they could do to help. During our surveying work, children followed us constantly, curious and eager to help (see Figure 24).

Figure 24: Three "helpers" from the neighborhood.

Photo by author. 1999.

Booker T. Anderson Park is adjacent to a low-income housing project (Crescent Park) occupied by many families. This project would offer residents a nearby experience of nature, something that would be especially valuable since many of them may not have easy access to regional parks. This area also has an active neighborhood council that could be contacted and invited to participate in workshops and to help the Friends of Baxter Creek and the city in outreach efforts regarding the restoration.

The community center situated at the park's southwestern end would be an ideal setting for a community workshop about the restoration project, and for displays created by students from nearby schools about the creek and its ecology. A workshop could be jointly sponsored by the Urban Creeks Council, the city, and the Friends of Baxter Creek to involve the community in the project and give them a sense of ownership. A slide show depicting other restoration projects and their benefits could be shown, and community input received. An earlier restoration project on the upstream Poinsett Park branch ran into trouble when it did not meet neighbors' expectations of what it should look like, particularly when the willows and dogwoods began to block views of the creek. However, describing the stages the project will go through, from construction and reshaping of the channel through the successional growth stages of the vegetation, will help the community know what to expect, and their feedback can be incorporated into the design, particularly regarding safe access for children.

The park is within two blocks of an elementary school (Stege School), and within 10 blocks of Kennedy High School, making it a perfect spot for field-based science classes. It is also within a five-minute drive of Richmond's non-profit

Aquatic Outreach Institute, which offers the highly successful Kids in Creeks program, a series of workshops for teachers using creeks as the basis for K-12 science education. In these workshops, teachers learn creative ways to incorporate creeks into Science, English, Art, and Math classes. The workshops offer teachers examples of simple projects that can educate their students (and through student projects, the general public) about urban creeks and issues affecting them, such as polluted runoff and trash and how they impact wildlife and water quality. Teachers are taught how to teach students in science classes to monitor aquatic invertebrates and to rate water quality based on the level of pollution tolerance of those organisms, and to analyze other basic water quality parameters like pH, turbidity, temperature, levels of phosphates and dissolved oxygen. The methods are basic and appropriate for elementary school children. Students can also learn to observe and monitor wildlife. Creeks can become the focus of other classes as well. In English and Art, students can write essays or poems, draw, or paint the creek. Classes in some East Bay schools have written their own natural history booklets about their local creeks. Students can also learn basic math skills by measuring creek width, depth, and flows.

According to Kevin Hufferd, a liaison from UC Berkeley to the city of Richmond and member of the Richmond Economic Development Commission and the Stege Schoolside Council, the school is very poor, but its administrators are seeking better ways to teach children field-based science and to involve community volunteers in student education. Stege School is 90 percent African American, with the remaining 10 percent primarily children of Southeast Asian heritage, according to Hufferd, and it is not peforming well by state standards.

Many of the Stege Elementary School teachers I surveyed on January 10, 2000 were enthusiastic about learning more about the creek and participating in a Kids in Creeks workshop. Most of them were also concerned about the creek's water quality, however, and some commented that the creek needed "help" and to be cleaned up. Some were unaware of the creek and therefore couldn't describe it; a few had already used the creek as a resource. One had been teaching first graders to look at creek water under microscopes (and commented that they had seen "very little life" in it); another had raised tadpoles (hopefully of native frogs) and released them into the creek.

The Friends of Baxter Creek, a group of over 500 El Cerrito and Richmond residents founded in the mid-1990s, recently received a grant from the Aquatic Outreach Institute (AOI) for watershed outreach efforts. Part of this grant will be used toward a Kids in Creeks workshop tailored to the needs of the teachers and students at Stege School. Children at Stege Elementary School will be involved in "before and after" activities related to the restoration, such as monitoring changes in water quality, diversity of aquatic invertebrates, wildlife usage, etc. They can also learn to map the path of the creek, which would teach them about urban stream issues and local geography, and familiarize them with their watershed.

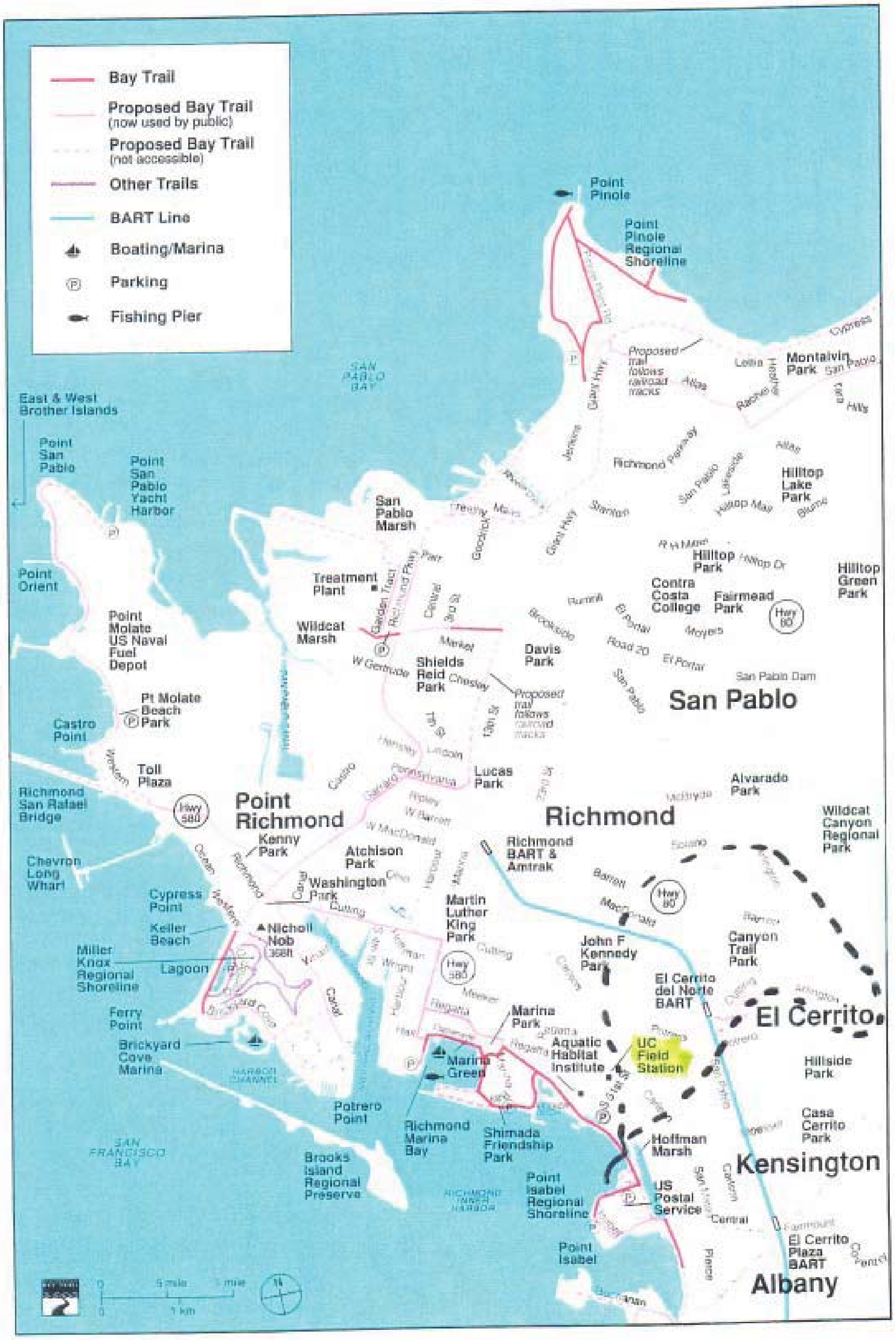
The restored creek could be "adopted" by children at the school, and signs to that effect—as well as signs about the creek's ecology—could be made by the children (perhaps with help from the Friends of Baxter Creek and/or the city) and installed at the project. This would give the students a sense of pride and ownership in the creek and might reduce some of the current problems, such as people dumping garbage in the creek, trampling its banks, and so on. The Friends of Baxter Creek noticed that after a local Brownie troop "adopted" a similarly degraded stretch of creek upstream and painted a sign with the creek's name on it, less trash appeared in the creek, and passersby seemed to have a new respect for it.

Stege Schoolside Councilmember Kevin Hufferd points out that in many ways, the I-580 freeway, completed in 1992, cut the community off from the marsh and baylands areas into which the creek flows, which are now part of the East Bay Regional Parks District. Projects that teach the students about the path of the creek and the history of the area as well as field trips might help reconnect them with these natural areas (Hufferd 2000).

Other Locational Benefits

Eventually, a trail could be created to connect this park with the San Francisco Bay Trail, where the Baxter Creek tidal channel ends up. The trail could traverse the park, follow Carlson Boulevard, cross the freeway via the Bayview flyover, and connect to the Bay Trail entrance at 51st Street (see Figure 25). This park could also possibly be connected via a "spur" trail with the Central Richmond Greenway, a 2.5-mile abandoned railroad right-of-way that a Richmond non-profit, CYCLE, is trying to transform into a greenway that runs through the middle of the city (see Figure 26).

Figure 25: This map of the San Francisco Bay Trail shows the proximity of Booker T. Anderson Park. The park is located beneath the words "UC Field Station." Approximate watershed boundary indicated by dotted black line.
Source: *San Francisco Bay Shoreline Guide.* California State Coastal Conservancy. University of California Press. 1995.



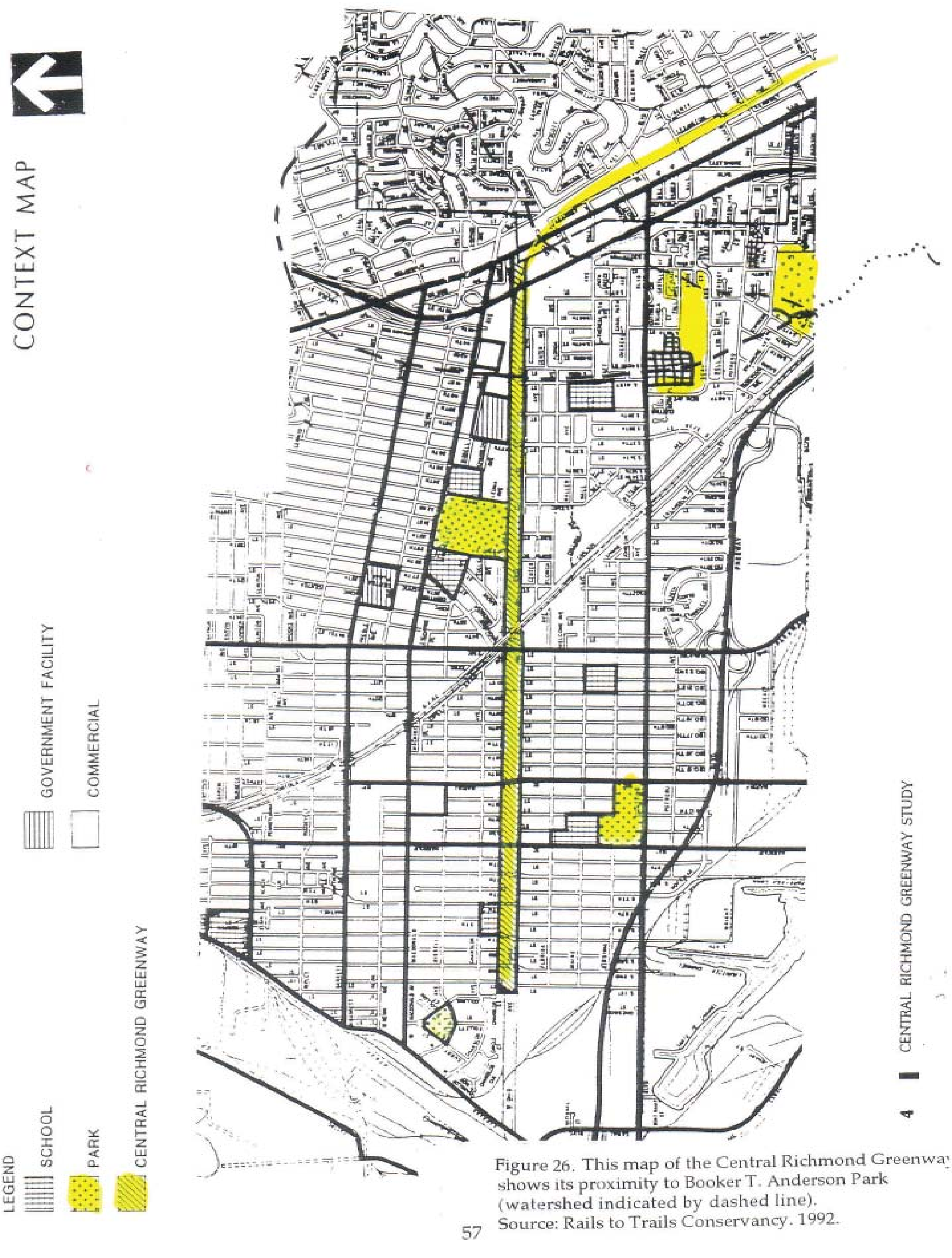


Figure 26. This map of the Central Richmond Greenway shows its proximity to Booker T. Anderson Park (watershed indicated by dashed line).
Source: Rails to Trails Conservancy. 1992.

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Pilot Project

In addition to its educational and community values, a creek restoration project at Booker T. Anderson Park would be an accessible and highly visible demonstration of the multiple benefits of urban stream restoration. The 250-foot stretch that was daylighted in El Cerrito's Poinsett Park in 1996 lies in the midst of a small, quiet neighborhood, and is not as immediately accessible to urban residents as the Booker T. Anderson site. Baxter Creek in the flatlands at Booker T. Anderson Park is also the longest stretch of this creek that still flows above ground (approximately 792 feet), with the possible exception of the branches that flow through Canyon Trail Park in El Cerrito and Mira Vista Park and neighboring back yards in Richmond. While the branches in those parks would also greatly benefit from restoration, those parks are not as visible or used by as diverse a public as Booker T. Anderson Park. In most urban areas in the East Bay, the creeks in the flatlands have been put underground: this project would be a positive example of what restoration in the urban flatlands can look like and has to offer.

Restoration at Booker T. Anderson Park would also provide an "on-the-ground" way to educate people about their watershed. So far, the Friends of Baxter Creek have focused their efforts in the upper watershed, working to prevent a large grocery store chain from building on top of one of the few open sections of creek (near San Pablo and MacDonald Avenues). The group is also trying to develop community awareness of the watershed, a challenge because of the fragmented nature of the creek, and to encourage the cities of Richmond and El Cerrito to implement better measures to protect this and other creeks.

In June 1999, the Friends of Baxter Creek and the Urban Creeks Council gave a tour of the creek in conjunction with the Richmond Art Center's exhibit of environmental artists. Participants on the tour were shocked, as the group moved from one of the few remaining open stretches of creek to another, to discover that they were observing the same stream, but in very different—and disconnected—locations. Most of the people on the tour, including several Richmond city planners, hadn't realized that the Booker T. Anderson stretch was connected in any way with the open stretches in the upper watershed. Teaching people to look at urban streams in terms of their watersheds, rather than the political boundaries they cross, is a challenge.

Most of the tour participants commented that the Booker T. Anderson site needed help and would be a good candidate for restoration. Restoration at this site will help the Friends of Baxter Creek in its efforts to increase public interest in restoring more of the watershed; this demonstration project could build broader community support.

Cost and Funding Sources

Another compelling reason for restoration of this site is that the cost is relatively low. As detailed in the following chapter, this stretch of creek can be restored for less than $100,000, which represents primarily the cost of grading, Conservation Corps labor, and purchase of mature container stock. This is still less costly than daylighting a shorter length of creek (daylighting is usually around $200 per linear foot, plus other, miscellaneous costs incurred, such as hauling soil offsite, relocating utility lines, etc.) (Riley 2000). Because the creek flows through a city-owned park, no land needs to be acquired in order to perform the restoration, which is another big cost in many projects. In May 2000, the Urban Creeks Council received three grants to fund the project, from the state Coastal Conservancy, the California Department of Water Resources, and the San Francisco Foundation. Richmond's Parks Department has also designated funding for restoration of this stretch of creek in its capital improvements budget.

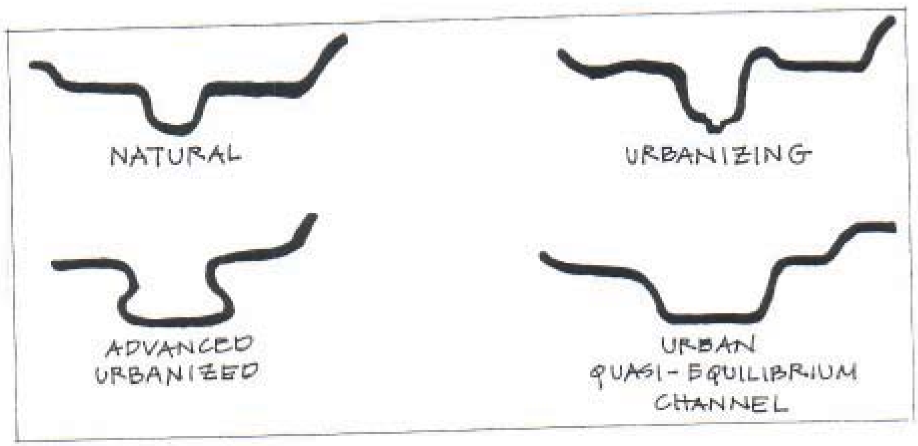
CHAPTER 5: RESTORATION DESIGN

We will probably never know exactly what Baxter Creek looked like before humans began altering it. To design a restoration plan for the Booker T. Anderson stretch, in addition to studying available historical information, we must examine the current landscape (Riley 1999a) and base our design on a mixture of the past and present. This advice is particularly applicable to this project, since the park's topography has been altered several times, by grading and construction.

Watershed size and stage of urbanization

Some of the first steps in designing a restoration plan are to determine the size of the watershed, the stage of urbanization of the watershed, and what percent of the watershed consists of impervious surfaces. These parameters help predict what types of flows to expect in the creek and could help explain the shape of the channel (although the Booker T. stretch has been modified so greatly, the stage of urbanization is probably less applicable than it might otherwise be). Based on historical, USGS, and City of Richmond Department of Public Works storm drain maps, and consultations with the Waterways Restoration Institute, I calculate the Baxter Creek watershed at Booker T. Anderson Park to be approximately .92 square miles, 40 percent urbanized (or impervious), and 90 percent culverted (see Figure 11). Because the watershed is "built-out"—it was largely developed by the mid-1950s—this stream appears to be in Riley's "Urban Quasi-Equilibrum" stage (Figure 27), which means that the channel has probably finished enlarging in response to the increased discharges and sediment transport from urbanization.

Figure 27: The generalized stages of an urbanized stream.



Source: Riley 1998.

Channel geometry and reference reach

One of the next steps in designing a restoration project is to try to determine the bankfull—or "active" channel that is formed during storms that occur (on average) every 1.5-2 years (Leopold 1994). In July 1999, Josh Bradt of the Urban Creeks Council and I surveyed three cross-sections and a profile of the creek's slope in Booker T. Anderson Park and attempted to identify a reference reach—a reach that appears to be in balance, neither excessively eroding or depositing sediment, and one that has not been severely altered by riprap or concrete. Identifying the bankfull channel is critical to designing the correct shape for the creek since the bankfull channel does most of the stream's "work," carrying and depositing sediment, and thereby shaping the channel. Identifying and creating the correct width and depth for the bankfull channel helps prevent excessive erosion, deposition, or downcutting. The bankfull channel is also important in designing the revegetation plan, since it is important not to constrict the active channel by planting in it (Goetting 1999). Drawings of the cross-sections are shown in Figures 28 -30, with the estimated bankfull channel indicated in Figure 28.

Figure 28: Cross-section A, Baxter Creek at Booker T. Anderson Park, July 1999.

Drawing by author.

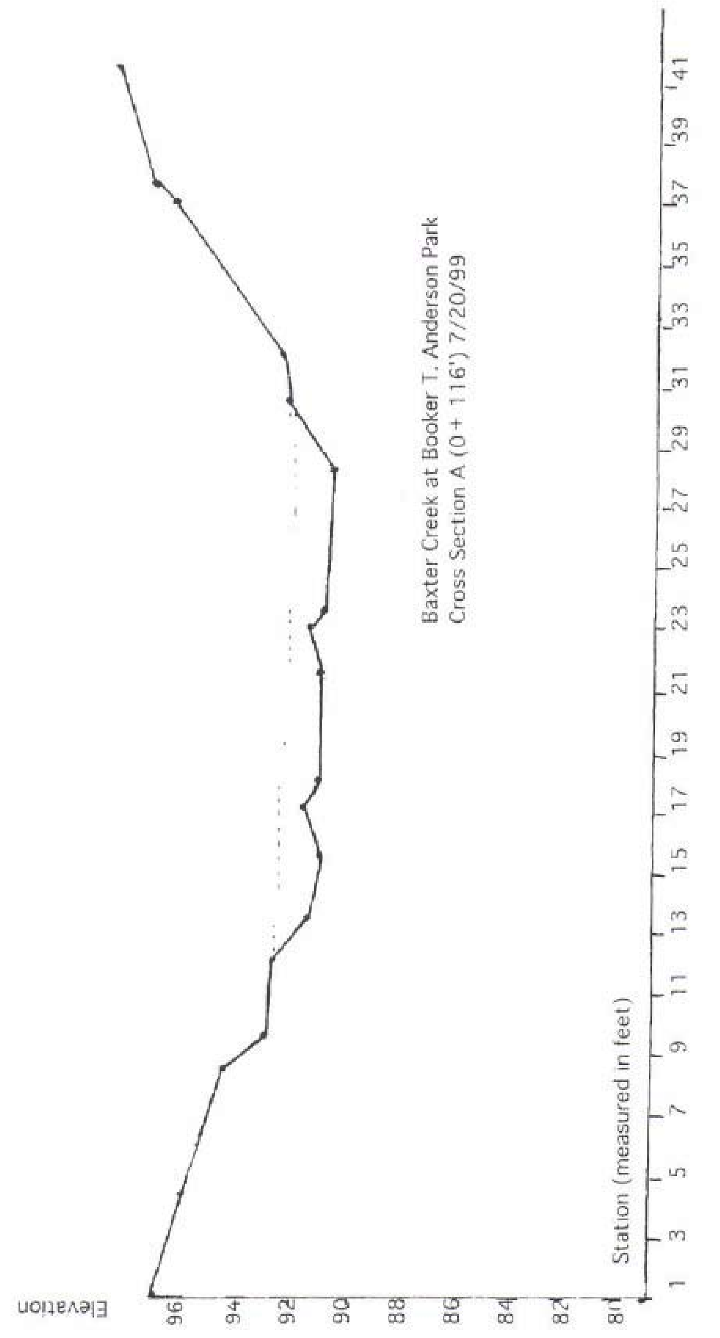


Figure 28. Cross-section A, Baxter Creek at Booker T. Anderson Park, July 1999.
Drawing by author.

Figure 29: Cross-section B, Baxter Creek at Booker T. Anderson Park, July 1999. Drawing by author.

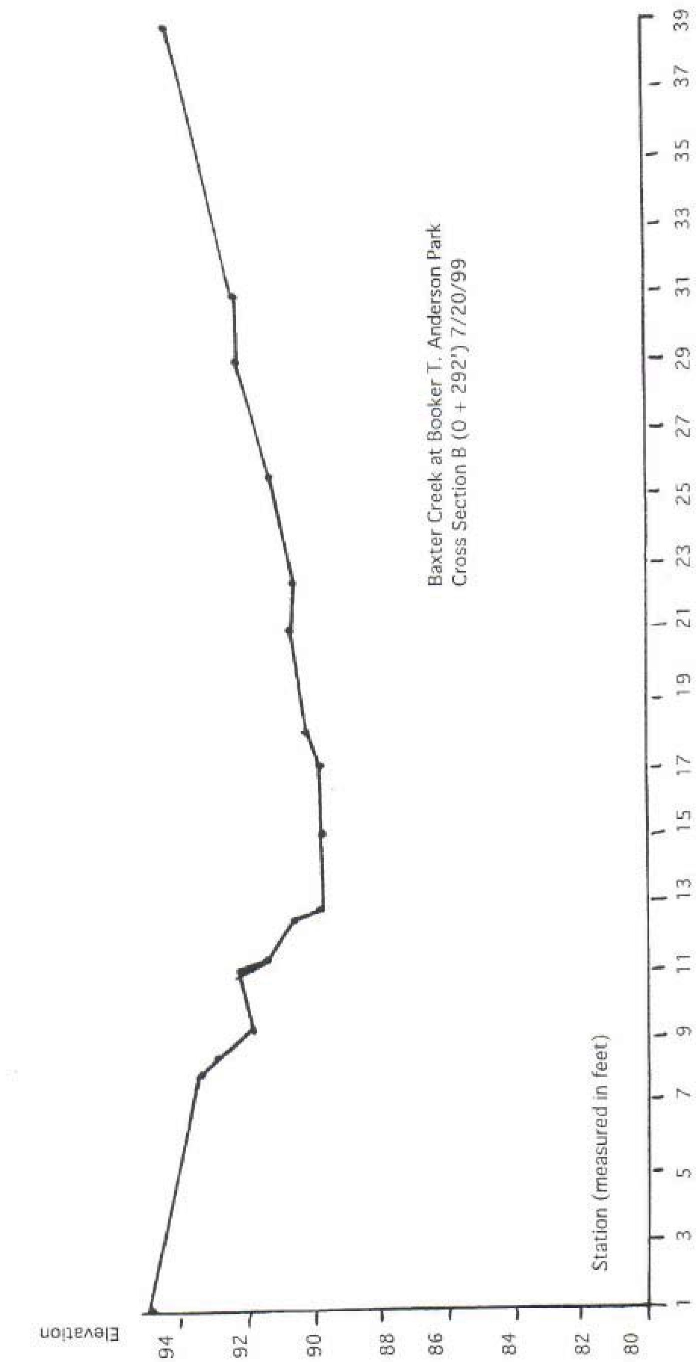


Figure 29. Cross-section B, Baxter Creek at Booker T. Anderson Park, July 1999.
Drawing by author.

Figure 30. Cross-section C, Baxter Creek at Booker T. Anderson Park, July 1999. Drawing by author.

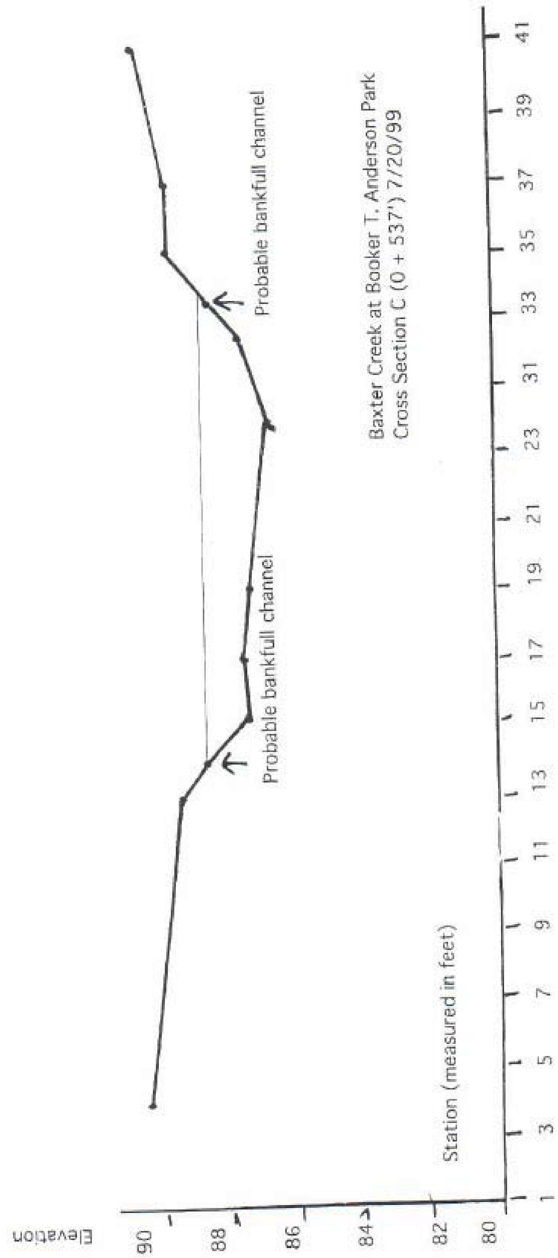


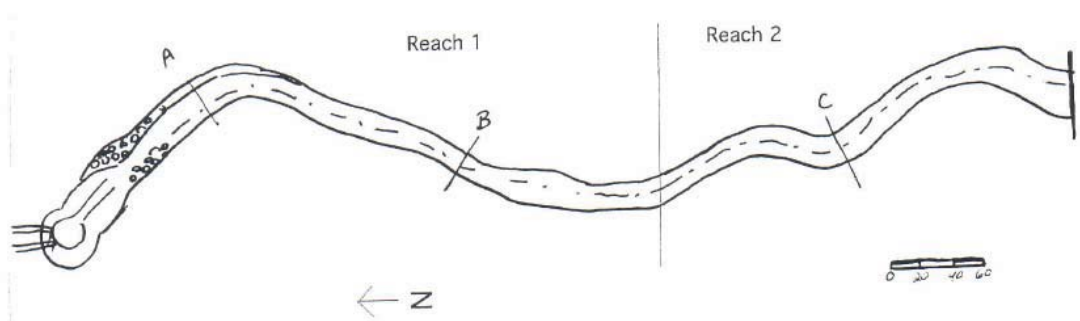
Figure 30. Cross-section C, Baxter Creek at Booker T. Anderson Park, July 1999.
Drawing by author.

Cross-sectional data are shown in Table 2 below, and the locations of those cross sections in Figure 31.

Table 2. Cross-sectional measurements of Baxter Creek in Booker T. Anderson Park, July 1999.

Cross-Section	Mean depth	Width	Area
A	1.5'	22'	33'
B	1.45'	20'	29'
C	1.06'	13.5'	17.5'

Figure 31: Plan view of Baxter Creek at Booker T. Anderson Park showing location of cross-sections.



Drawing by author. 1999.

In designing the new shape of the creek, we take into account these field measurements, identification of a reference stream or reach (with similar average annual rainfall, geology, valley slope, etc.), the calculations of drainage area, the regional data compiled by Luna Leopold, the stream classification systems of Dave Rosgen, and data from recent restoration projects performed by the Waterways Restoration Institute in the East Bay (WRI 1999). The reference stream or reach can be particularly useful. According to Goetting, if the reference reach is stable and functioning (not excessively eroding or depositing), it is the most valuable piece of information to take into consideration in designing a restoration plan.

As mentioned earlier, few East Bay creeks still flow openly (not in culverts) as they near the Bay. Sections of Wildcat Creek in Richmond, and Village Creek in Berkeley flow through the flatlands and have been restored recently by WRI, but those creeks have flatter slopes and very different watershed sizes than this creek (Wildcat is much larger; Village much smaller). In this case, we identified cross-section C (see Figure 31) as the most likely reference reach for this creek, and compared our data on width, depth, and cross-sectional area to regional data from Leopold and the Waterways Restoration Institute. At 13.5' wide, cross-section C is in fact very close to Riley's adjusted averages for the East Bay (13' wide), although it may be a bit shallow.[6] (See Table 1 for a comparison of these data.) This section of channel appears stable and functioning: it is also the most

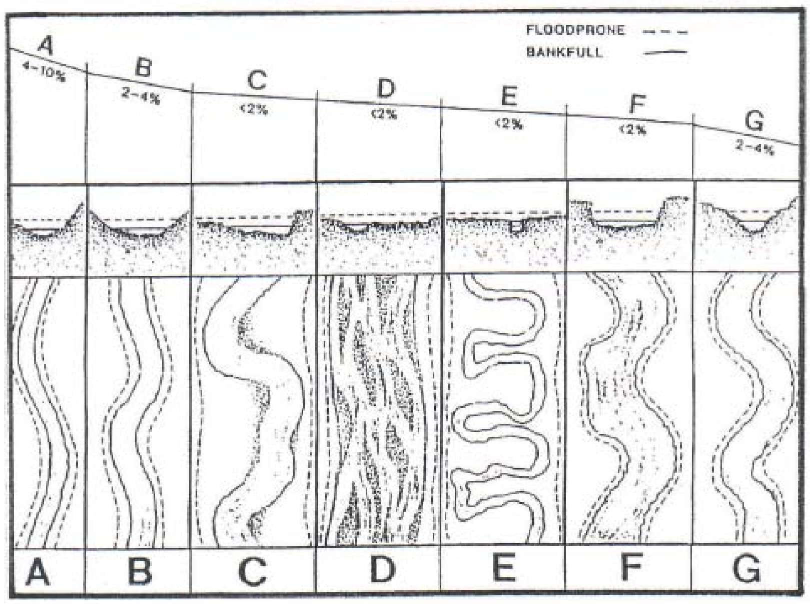
[6]Average depth seems to be the parameter that is least comparable to the regional averages, according to Riley (September 1999).

sinuous section. As discussed earlier, this may in part be a result of the mature vegetation and root systems helping hold the banks in place.

Channel Type and Sinuosity

Another useful tool in designing a restoration plan is the Rosgen classification system (Goetting 1999). Rosgen is a well-known hydrologist and river restorationist based in Colorado who has designed a nationally-used system for classifying streams according to their morphology. Rosgen's approach to restoring a disturbed channel basically asks 'what type of a stream *should* this be?' Rosgen's classification system is based on decades of data collection and observations of river systems. Streams are divided into seven main types ("A" through "G"), according to characteristics such as valley type and landforms, channel slope, sinuosity (degree of meandering), width to depth ratio, and entrenchment ratio (Rosgen 1996) (see Figure 32). Although not every stream or stretch of stream fits neatly into one of these types (some may be "hybrids" of two types, for example), the system can be used as a guide in restoration (Riley 2000).

Figure 32. Longitudinal, Cross-Sectional, and Plan Views of Rosgen's Seven Basic Stream Types



Source: Rosgen 1994.

After determining the valley to be Type VIII under the Rosgen system, defined as having a wide, gentle valley slope with well-developed floodplain, and after surveying channel and localized valley slope, measuring the stream's cross-sectional areas and width-to-depth ratios, and studying historical maps and photos, it appears that the section of creek in Booker T. Anderson Park is currently a C-type channel under Rosgen's system. The soil type (clay) further delineates it as a C6 channel (numbers 1-6 refer to soil types).

Based on the profile survey we conducted, the creek's current sinuosity appears to be only 1.1 (almost straight).[7] To determine what the sinuosity should be

[7] Calculated as stream length (measured along the thalweg, or deepest part of the stream) divided by distance (792/720=1.1).

according to the current landscape (using Riley's method), I divided valley slope (.010) by overall channel slope (.007),[8] which indicates that the channel should have a sinuosity of approximately 1.4, rather than 1.1. Sinuosities for C6 channels are usually 1.4 or greater (Rosgen 1996). The width to depth ratio of Cross-Section C is 12.7; however, after restoration, this ratio would probably be closer to 9, as the stream may get a little deeper. The width-to-depth ratios of Cross-Sections A and B would be more affected by the restoration design, and would be reduced from their present ratios of 14.1 and 13.8 respectively, to 9. By narrowing the stream and reducing the width: depth ratio, the stream should be better able to transport its sediment load (Riley 1998. Similarly, their widths would be greatly reduced, from 22 feet (Cross-Section A) to 13.5 and from 20 feet (Cross-Section B) to 13.5. This new width to depth ratio is closer to that of an E-type channel than a C-type channel. According to Riley, however, this change in width to depth ratio should not be problematic for the channel capacity, since the generous floodplain can easily accomodate heavy storm flows (Riley 2000). In fact, Reach 2, which is used as the basis for the design channel, handled the storm events of February 2000 easily, without topping its banks.

To design the restoration sinuosity, I used Step No. 7 in Riley's "Steps to Designing an Urban Stream Restoration Project" (Riley 1999e), which is based on regression equations from Leopold and Wolman's paper "River Meanders" (*Geological Society of American Bulletin* Volume 71, 1960). Those equations can be seen in Table 3, below.

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[8] Valley slope was calculated by dividing the change in elevation over the length of the valley measured (7.5'/720'=.010). Channel slope, measured as the drop in elevation between the two culverts—5.17 feet—over a distance of 720' = .007)

Table 3. Regression Equations from River Meanders, *Geological Society of America Bulletin*, Leopold and Wolman 1960.

Meander Length to Channel Width	Amplitude to Channel Width	Meander Length to Radius of Curvature
$L=10.9(w)^{1.01}$ (Meander length ranges from 7-10 times the channel width)	$A=2.7(w)^{1.1}$	$L=4.7(Rm)^{0.98}$

L=Meander length (wave length)
A=Amplitude
Rm=Mean radius of curvature

One potential meander design is shown in Figure 33, and an explanation of the calculations on which it is based in Table 4.

Table 4: Calculations for and Explanation of Meander Design

L (meander or wave length) = $10(13.5)^{1.01}$=138.5 (13.5=stream width)
R/M (mean radius of curvature) = 2.3(13.5)=31.05
A (amplitude)=$2.7(13.5)^{1.1}$=47.2

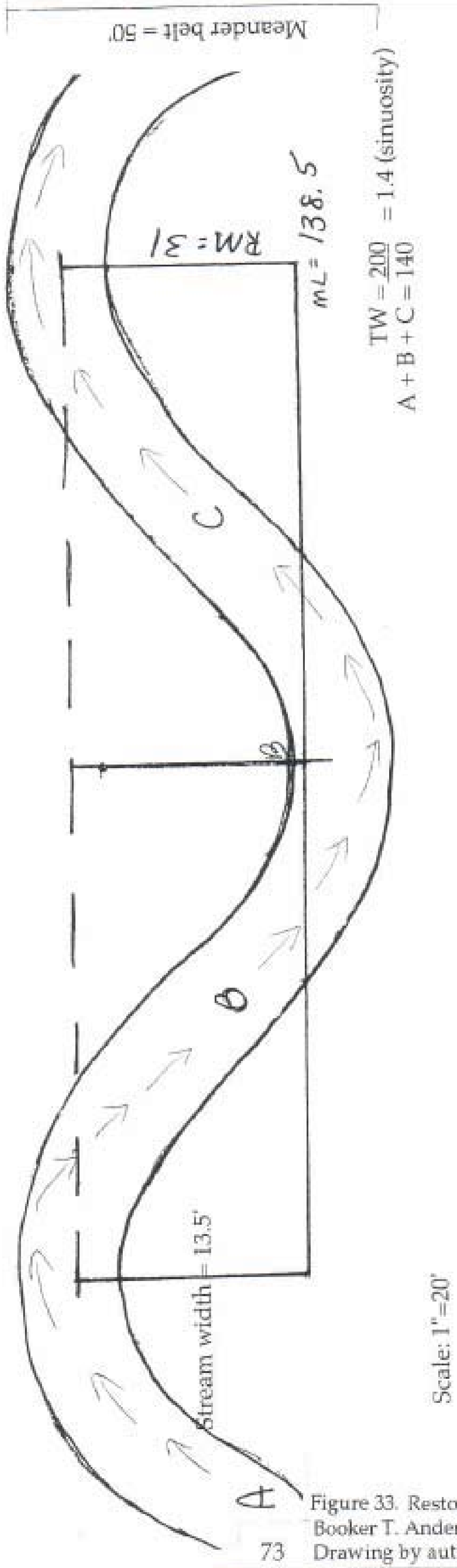


Figure 33. Restoration sinuosity design for Baxter Creek in
Booker T. Anderson Park.
73 Drawing by author. 2000.

Based on the slope of the creek, historical records, Rosgen's classification system, and consultations with Waterways Restoration Institute and Urban Creeks Council staffs, I recommend that sinuosity in the Booker T. Anderson stretch of stream be restored to 1.4. With such a sinuosity, the creek will need room to meander 165' (in stream length) in 120' (or 140' in 100') (see Figure 31). The width of its meander belt (the creek's lateral corridor, including the creek and its floodplain) will be 50 feet. This width is similar to existing conditions, so no additional lateral room will be needed, although existing banks may be regraded somewhat. The average width of the stream (as designed) throughout the reach will be 13.5,' with an average depth of 1.5' and an average width to depth ratio of 9 (see Figure 34). Making a channel narrow and deeper, with a lower width to depth ratio can help produce the energy needed to transport the stream's sediment load (Riley 1998), which should help return balance to this overwidened stream and prevent the current problem of the channel filling in with sediment.

While sinuosity needs to be restored to the first 500 feet of the stream (Reach 1), the second reach (approximately 300') has retained or regained much of its sinuosity. Reach 2 currently has more vegetation on its banks as well (see Figure 35), although planting an understory here could help reduce erosion and make this stretch more attractive as well. Shade-tolerant natives, such as dogwood and currant, should be used since the alders have already created a canopy here. A plan view for the restored stream with a draft planting plan is shown in Figure 36.

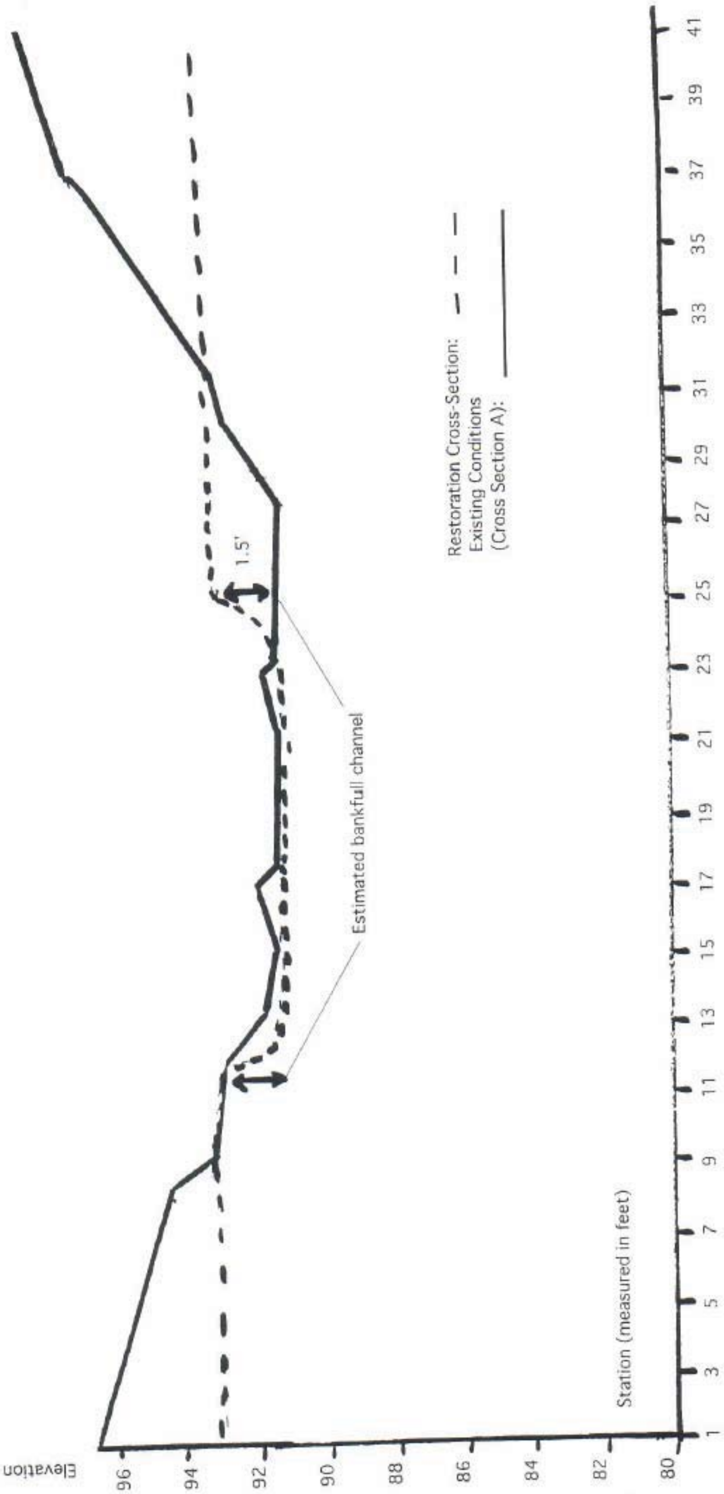
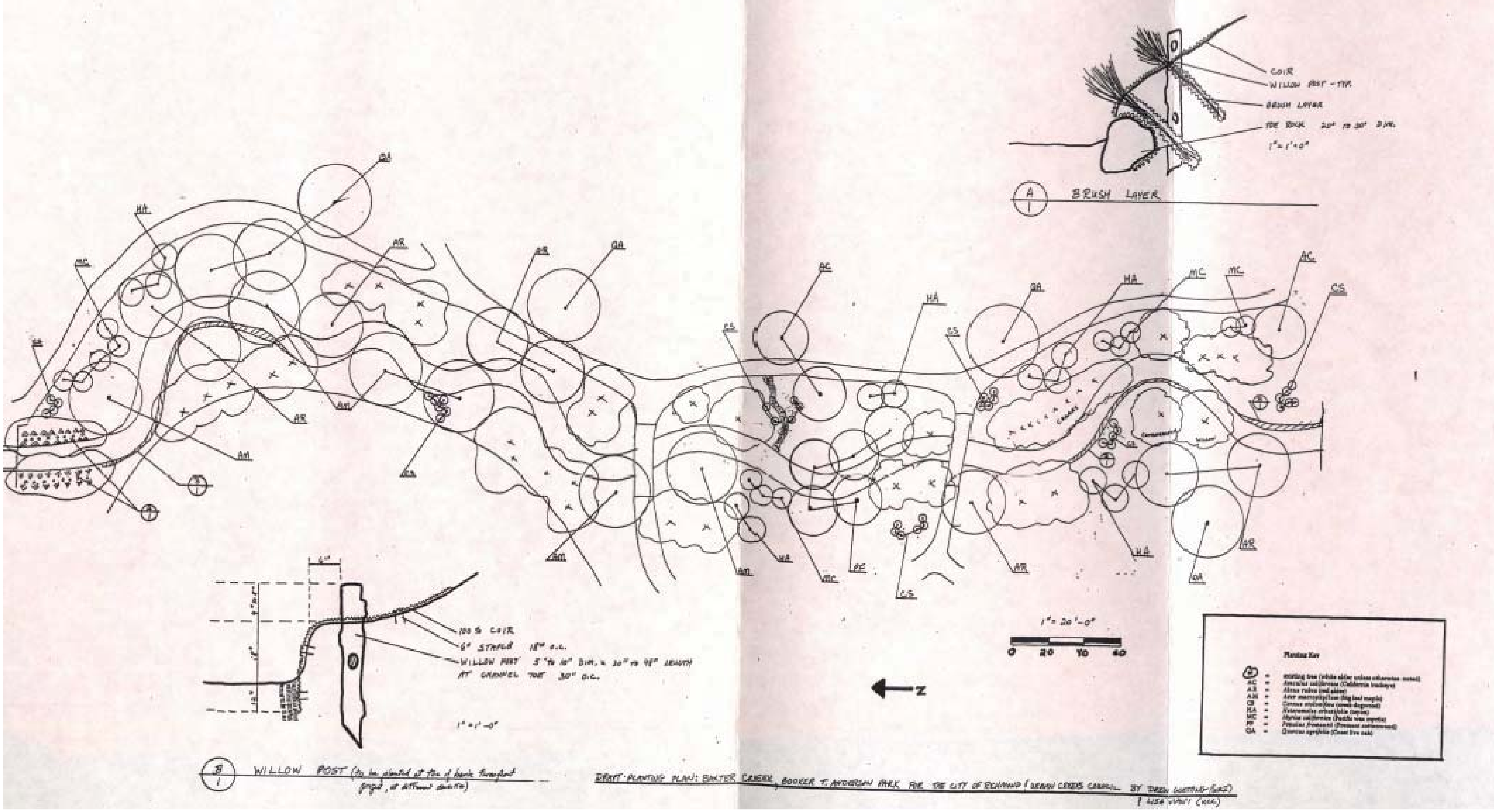


Figure 34. Restoration cross-section design for Baxter Creek in Booker T. Anderson Park.
Drawing by author. 2000.

Figure 35: Reach 2 starts approximately at the alders, and is much more vegetated (and sinuous) than Reach 1.

Photo by author. 1999.

Figure 36. Draft planting plans



Other Considerations in Channel Design

Currently, the creek flows out of its culvert and straight into a riprapped wall to the west (see Figure 37), which deflects flows back toward the east, toward a playground area. This pattern is probably a result of attempts to divert the creek around the parking lot. In our restoration design, the riprapped wall will be removed, the new bank stabilized using soil bioengineering techniques, and the creek allowed to flow further south before meandering back toward the east, to better align the flow with the culvert. To accomplish this reconfiguration, some of the asphalt path on the right bank (looking downstream) may need to be removed. The trail can be reinstalled once the bank is rebuilt using soil bioengineering.

Figure 37: The creek as it exits its culvert into the park needs to be allowed to flow further toward its right bank (left side of photo) before meandering back toward its left bank (right side of photo).
Photo by author. 1999.

Channel Capacity

Another goal of restoration is to ensure that the design channel can handle high flows. Using Rantz multiple regression equations from Water in Environmental Planning (Dunne and Leopold 1978) (see Table 5), I created a theoretical flood frequency curve by calculating the estimated discharges for this section of creek at various recurrence intervals (see Figure 38), based on average precipitation of 25 inches per year ("p") and a drainage basin or area ("A") considered 40 percent urbanized (or developed) and 90 percent sewered (percent of channels culverted)[9], using Figure 3 from S.E. Rantz' *Suggested Criteria for Hydrologic Design of Storm-Drainage Facilities, San Francisco Bay Region* (USGS Open-File Report, November 24, 1971), which adjusts for urbanization (see Figure 39). The equations using the above assumptions and the adjustments for urbanization are shown in Table 6, along with the results—the estimated discharges in cubic feet per second (Q) for Baxter Creek in Booker T. Anderson Park.

Table 5. Regression Equations Used to Predict Discharges at Various Recurrence Intervals (Source: Rantz 1971)

Recurrence Interval (years)	Multiple Regression Equation	Coefficient of multiple correlation
2	$Q2=0.069(A^{0.913})(p^{1.965})$	0.964
5	$Q5=2.00(A^{0.925})(p^{1.206})$	.976
10	$Q10=7.38(A^{0.922})(p^{0.797})$	.977
25	$Q25=16.5(A^{0.912})(p^{0.797})$	.950
50	$Q50=69.6(A^{0.847})(p^{0.511})$	.902

[9]These numbers were chosen in consultation with Drew Goetting of the Waterways Restoration Institute, after analyzing the watershed.

Figure 38. Flood Frequency Curve Showing Calculated Discharges for Baxter Creek at Booker T. Anderson Park, Based on Rantz Regression Equations.
Graph by author after Riley 1998.

Figure 38. Flood Frequency Curve
Showing Calculated Discharges for Baxter Creek at Booker T. Anderson Park, Based on Rantz Regression Equations.
Graph by author after Riley 1998.

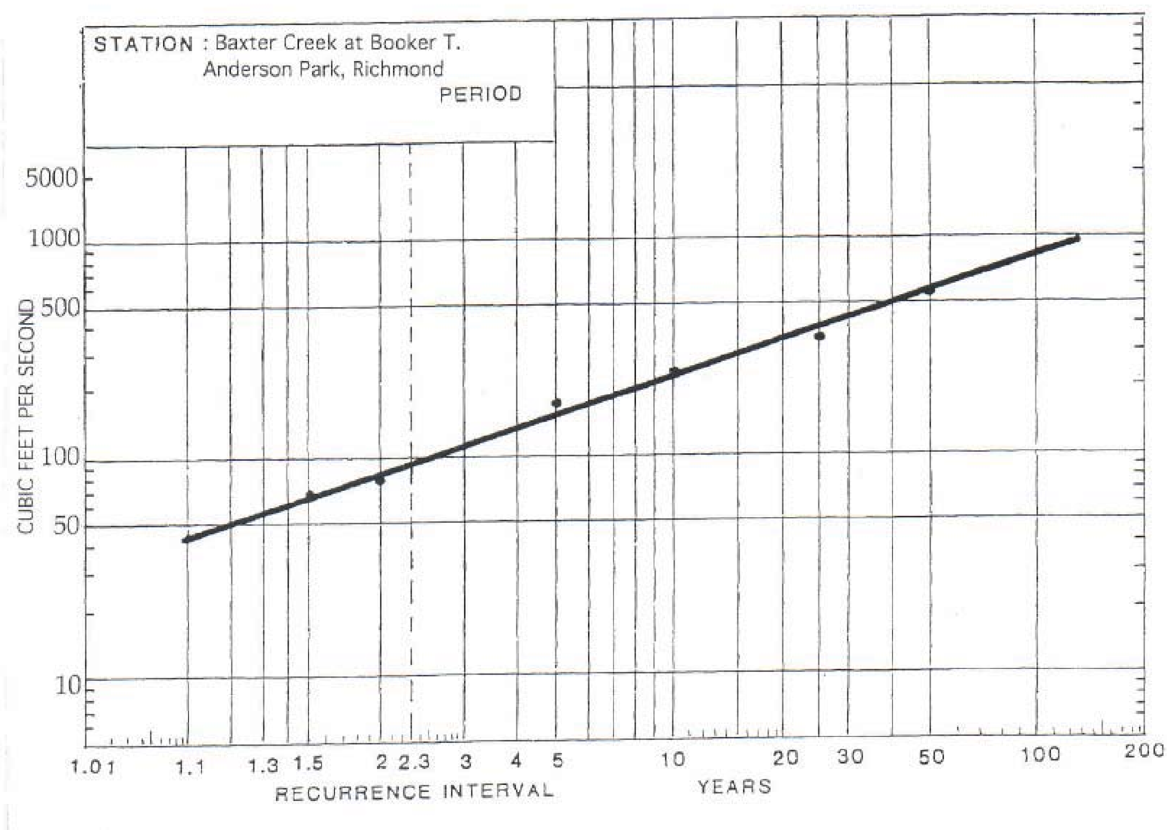
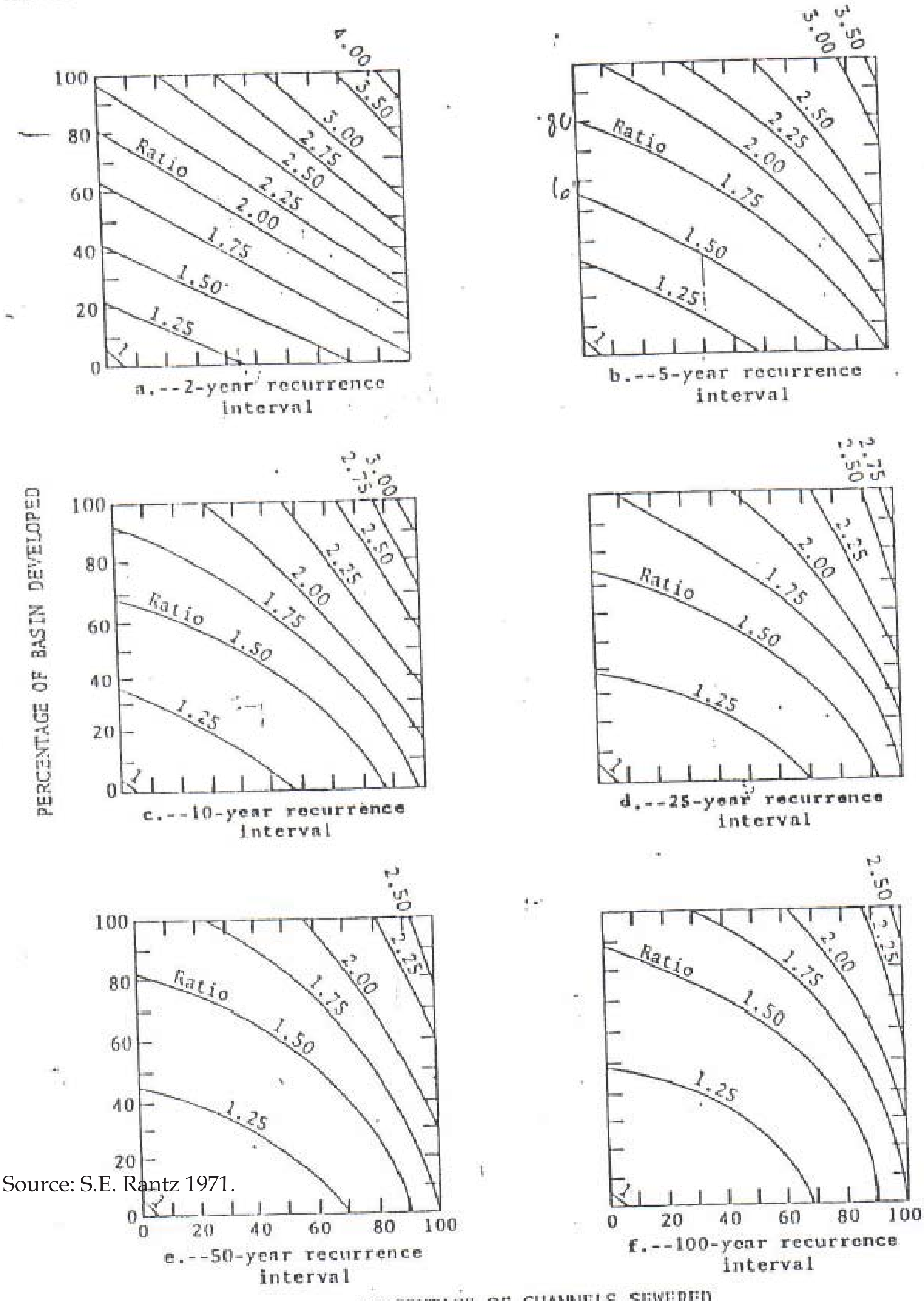


Figure 39. Ratios of Flood-Peak Magnitude for Urbanized Basins to That for Unurbanized Basins—For Use with Flood-Frequency Method



Source: S.E. Rantz 1971.

Table 6. Predicted Discharges at Baxter Creek at Booker T. Anderson Park at Various Recurrence Intervals

Recurrence Interval Discharge	Regression Equation and Adjustment for Urbanization	Predicted Discharge in Cubic Feet per Second
1.5 Year Q		65 (extrapolated from curve in Figure 38)
2 Year Q	069 $(.92^{.913})(25^{1.965})$ =.069(.927)(558.4)=35.7 CFS Urban adj.=35.7 x 2.25=	80
5 Year Q	2.00 $(.92^{.925})(25^{1.206})$ =2.0 (.925)(48.5)=89.8 CFS Urban adj.=89.8x2=	179.6
10 Year Q	7.38$(.92^{.922})(25^{.928})$ =7.38(.926)(19.83)=125 CFS Urban adj.=125x3=	270
25 Year Q	16.5$(.92^{.912})(25^{.797})$ =16.5(.927)(13)=198 CFS Urban adj.=198x1.75=	346
50 Year Q	69.6$(.92^{.847})(25^{.511})$ =69.6(.93)(5.18)=335 CFS Urban adj.=335x1.75=	586

According to these calculations, the discharge forming the active or bankfull channel (on average, the 1.5-year storm event), is approximately 65 cfs. Although I had hoped to compare that number with any the City of Richmond may have had, the city does not keep any records of discharges or flows on Baxter Creek (Davidson 1999).

In January and February 2000, I performed a rough field test of velocity in Cross-Section C using the procedure described in Leopold's "Backyard Hydrology" in *A View of the River* (1994). The process involves measuring the time (in seconds) that it takes a float of some kind (an orange peel in this case) to travel a measured distance. The measurements were taken at the same location each time. I used the equations in *Trout and Salmon Culture*, by Earl Leitritz, California Department of Fish and Game (Fish Bulletin No. 107, 1959) to calculate flows. The equation is as follows, with calculated discharges shown in Table 7:

Volume (or rate) of flow

Formula: $R = \frac{WDAL}{T}$ where

R= volume of flow in cfs
W= average width of stream in feet
D = average depth in feet
A = constant factor for substrate (I used 0.9 for smooth clay)
L= length of stream measured
T= time in seconds for float to travel the measured distance

Table 7. Baxter Creek Flows, Booker T. Anderson Park, January and February 2000.

Date/notes	Estimated average width and depth of measured reach	Flows in cfs
Jan . 17 (light rain)	13.5′ wide; 1.5′ deep	12.6
Jan. 30 (light rain)	“ “	22.75
Feb. 11 (light rain)	“ “	23.4
Feb. 12 (light rain after 2 days of steady rain	“ “	47.38
Feb. 14 (moderate rain)	“ “	44.4
Feb. 23 (light rain after day of steady rain); ground appeared to be saturated	“ “	50.7

On February 12, the creek appeared to have reached bankfull stage (see Figure 40); however, the discharges I observed and calculated above suggest that flows are not as great as predicted by the Rantz equation for a 1.5-year storm. Although there is a difference between my field observations and the flows predicted using the Rantz equation, we can say, based on the two methods, that the 1.5-year flows are somewhere between 50.7 and 65 cfs. If field observations are correct, the creek does not overtop its banks in the 1.5-year storm, and the design channel would appear adequate for conveying greater than bankfull flows. A more precise reading of velocity could be taken by installing a stream gauge; the field measurements taken above were intended to be used as a rough, on-the-ground check of the Rantz calculations.

As another, further method of checking the capacity of the design channel, I performed Manning's and continuity of flow calculations on Cross-Section C, which is very close to the hydraulic geometry of the design channel. Manning's equation uses the hydraulic radius ("R") of a stream channel cross-section (cross-sectional area divided by wetted perimeter of the channel) and channel slope as well as a roughness value to solve for velocity ($V=1.49\ R^{2/3}\ S^{1/2}/n$). After consulting with Drew Goetting as well as the USGS publication, *Roughness Characteristics of Natural Channels*[10] (a pictoral guide to roughness commonly used by engineers and hydrologists in designing projects), I chose .04 as an approximate roughness coeffecient for the reference reach of Baxter Creek. This number is often used by the Waterways Restoration Institute in East Bay stream restoration projects, and is considered a conservative estimate within a wide range of possible roughness coefficients. I determined the hydraulic radius for Cross-Section C to be 1.25 (cross-sectional area of 17.5/wetted perimeter of 14). The equation is shown below:

$V = 1.49(1.25^{.66})\ (.007^{.5})/n=.04$
$V= 1.49(1.15)(.084)/.04$
$V= 0.143/.04$
V= 3.5 feet per second

[10] Harry H. Barnes, USGS Water Supply Paper No. 1849, U.S. Government Printing Office 1967, Washington, D.C.

Based on the continuity of flow equation (Q=VxA) or (3.5 x 17.5), capacity of the design channel would be 61.2 cfs. Again, based on field observations of flows in Cross-Section C during what was likely a 1.5-year storm, the design channel should easily accomodate 1.5-year storm event flows and the generous floodplain larger storm events. Predicted discharges and field measurements are shown in Table 8 below.

Table 8. Predicted Versus Actual Discharges/Channel Capacity for Bankfull Conditions in Baxter Creek at Cross-Section C.

Discharge (predicted)	Discharge (actual according to field measurements)
Rantz: 65 cfs	50.7 cfs
Manning's Equation/Continuity of Flow Equation: 61 cfs	50.7 cfs

Figure 40: Baxter Creek at probable bankfull stage, February 2000.
Photos by author. 2000.

Figure 41 shows another field indication (taken in the January light rain) of what I believe to be the bankfull channel—note the change in soil color at the arrow.

Figure 41: Possible field indicator (change in soil color) of bankfull stage on Baxter Creek, January 2000.

Photo by author. 2000.

Reshaping the Channel

With a design and grading plan in hand, how will the actual reshaping of the channel be accomplished? In many urban stream restoration projects, land use has infringed upon the floodplain, constricting the channel and sometimes causing flooding. Where possible (where there is room), the creek banks are graded back to a more gentle slope. In this case, we have exactly the opposite situation. Plenty of room has been allowed for a floodplain, which is good, but the creek has been overly widened and straightened. In this instance, we will need not only to recreate the channel shape, making it more sinuous (as discussed above) by using excavation equipment to carve out the meanders, but will also need to narrow it throughout its length (see Figure 34).

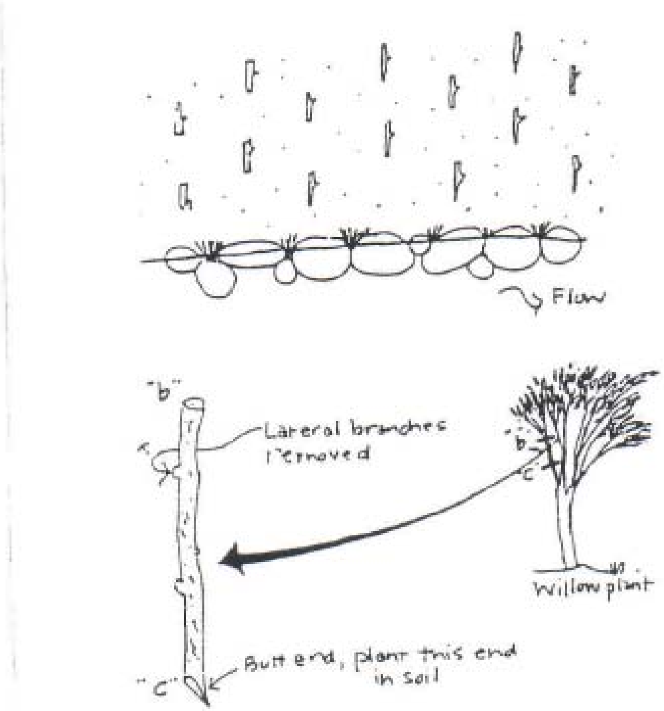
Soil excavated from the meanders can be used to help build the new banks, as can the soil bioengineering techniques of brush layering and willow and dogwood posts and cuttings, described below.

Soil bioengineering

Soil bioengineering is the practice of using plant material—both live and dead—to help stabilize stream (or other) banks. The benefits are numerous. Dead plants add roughness to the banks, acting as a sediment trap during overland flows, preventing bank erosion. Meanwhile, the live, growing plants help filter urban runoff, provide wildlife habitat, and shade the stream, while their roots stabilize the soil. The tensile strength of some plant roots has even been found to exceed that of concrete (which provides no habitat and can sometimes exacerbate flooding problems). According to Gray and Sotir, willow roots have tensile strengths of up to 35 megapascals (MPa, a measurement of stress) (or 5,000 psi) (Gray and Sotir 1996). The ordinary strength of concrete, according to Paolo Monteiro, concrete expert and professor of civil and environmental engineering at the University of California at Berkeley, is around 30 MPa (Monteiro 1999).

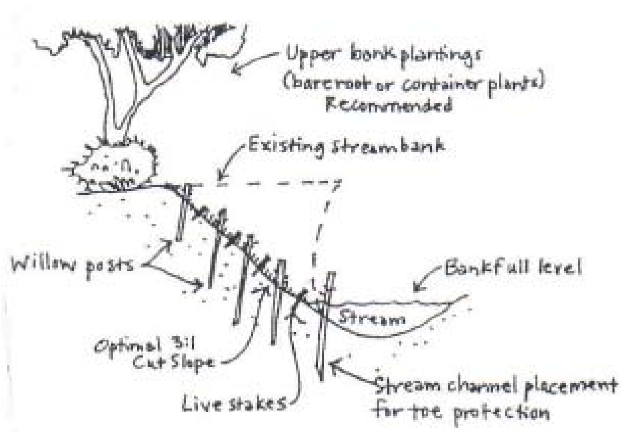
Cuttings and poles—actual cuttings, large and small—of live riparian plants like willows, dogwoods, and cottonwoods are the "workhorses" of soil bioengineering. Cuttings, usually one to three inches in diameter and up to three feet long, are sometimes also referred to as "live stakes," and are used to hold other (usually dead) vegetation in place, or just on their own to help stabilize the banks. Willows and dogwoods, which tend to survive better from cuttings than some other species, develop roots and grow into mature trees (see Figure 42). Poles are simply large cuttings, up to six inches in diameter and ten feet long; willows and cottonwoods make the best poles. Although their larger size can make them more difficult to install, especially in hard soils, poles are very effective in protecting the toe of the streambank and in revegetating a site. When the ground is very hard, both cuttings and poles are installed by first making a hole in the ground using rebar or construction stakes (see Figure 43). The cutting or pole is placed into the hole with its bottom or "butt" end first, cut at a sharp angle, and with the lateral branches having been removed, so that most of the plant's energy can go toward establishing a root system. Both poles and cuttings root better when most of their length is put into the ground, leaving only a few inches above ground.

Figure 42. Cuttings or "live stakes"



Source: Riley 1998.

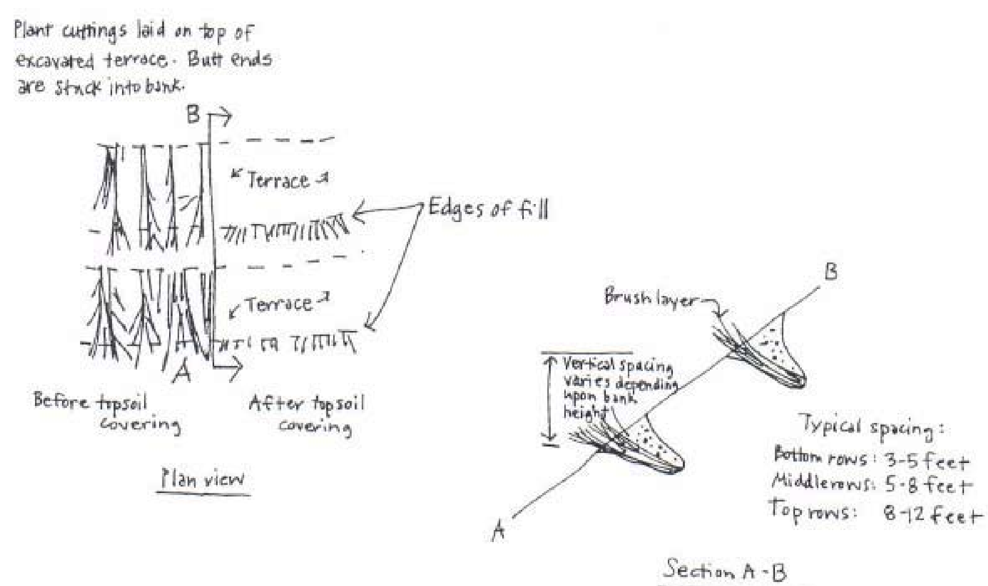
Figure 43. Installing poles



Source: Riley 1998.

Brush layering is a method used to rebuild and revegetate streambanks that have been regraded or are severely eroded. Terraces are dug into the bank, and live and dead plant cuttings are stuck, criss-crossed, into the trench as far as possible, butt-ends first (see Figure 44). Excavated soil is used to cover the cuttings, which are then walked or stamped on so that they are pressed into place as firmly as possible. The plant material adds roughness to the bank; soil washed down the bank by rain and overland flows is trapped in this new, textured slope, helping to rebuild the bank. Meanwhile, with rain (or regular watering), the cuttings sprout and grow, revegetating the banks, providing habitat for birds, and shading the stream.

Figure 44. Brush layering



Source: Riley 1998

Fabrics are sometimes used in conjunction with soil bioengineering techniques, stapled into the soil to help prevent erosion. Although not necessary in a heavily-planted project, these fabrics can be useful in an urban park setting, especially if a more "finished" look is desired immediately after the project is installed (see Figure 45), or where foot traffic is heavy. Coconut fiber fabric—"coir"—has been used with the most success in East Bay restoration projects; it resists rot, has high tensile strength, and can withstand high stream flows (Schemmerling 1999).

Figure 45: The 1996 daylighting of Baxter Creek in Poinsett Park used coir erosion-control fabric to achieve a more "finished" look. In the foreground of the bottom photo, the first few willow poles installed can be seen.
Photos by author. 1996.

In this project, soil bioengineering will also replace the cobble riprap basin (at the upstream culvert), which has been undermined and should be removed. The banks will be recreated and replanted, again using brush layering and willow posts. These same techniques can be used to rebuild the “sack-crete” banks at the downstream culvert end (see Figure 46). The gullies and erosion caused by the subterranean discharge pipes can be repaired by "planting" them heavily with poles and cuttings (Bradt 2000). Near the downstream end during a heavy rain, I observed another gully beginning to form on the left (facing downstream) bank, also visible in Figure 46. Water sheets off of a paved area behind the playing field, runs down the bank, and is eroding the soil beneath the roots of some cedars there. This problem should also be remedied before it worsens, with the use of poles and cuttings and/or some brush layering.

Figure 46: The downstream end of Baxter Creek in Booker T. Anderson Park showing the gully being created, as well as the banks bolstered with “sack-crete.”

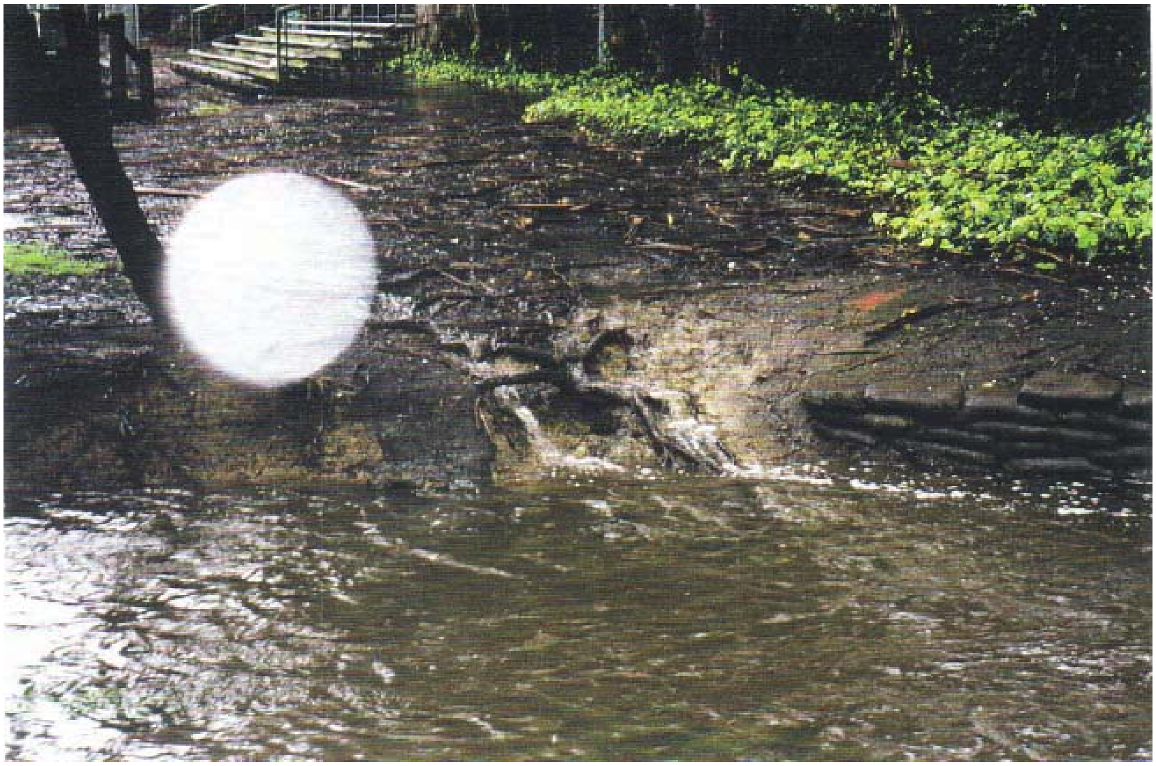
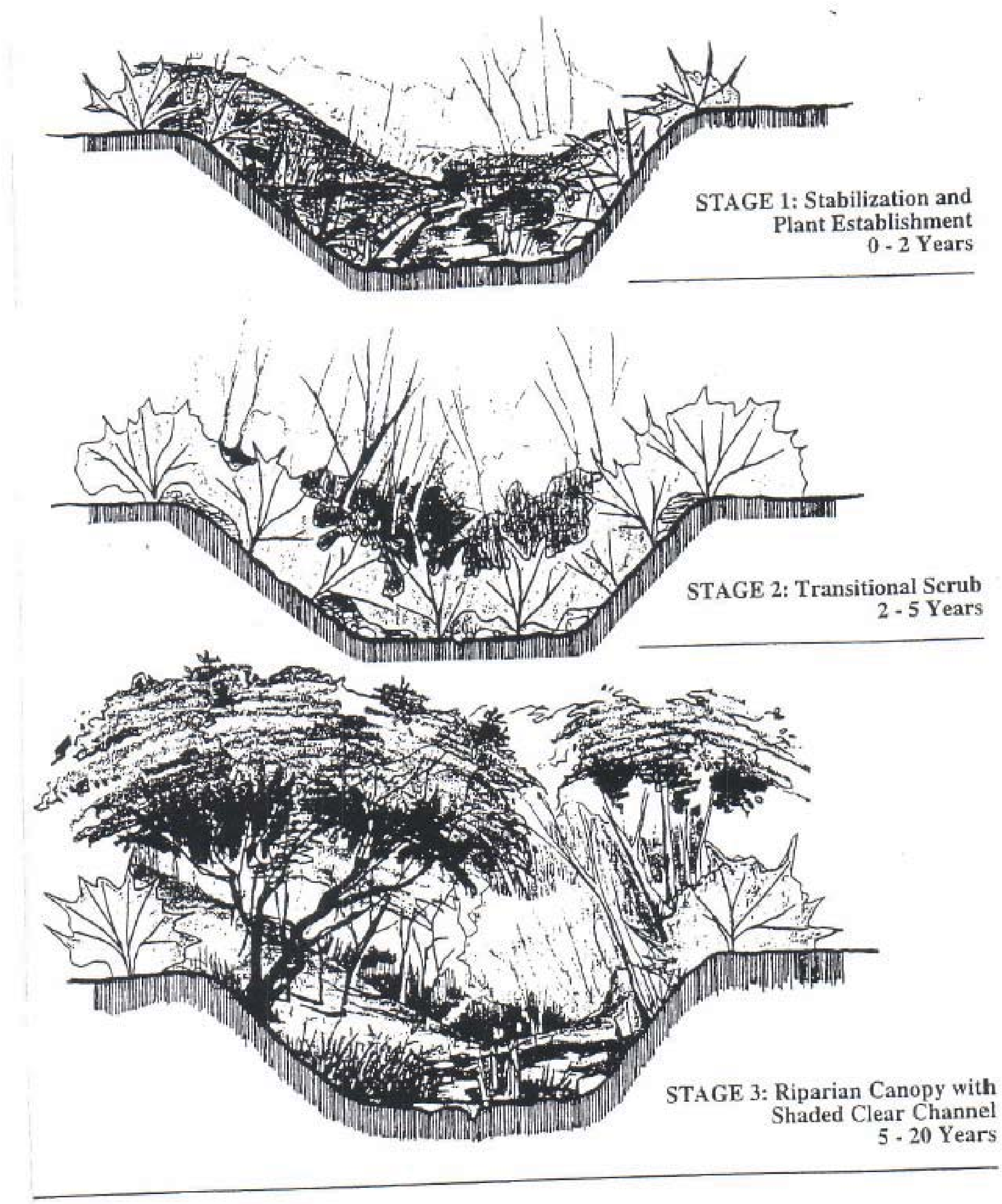


Photo by author. February 2000.

Stages of a Soil-Bioengineered Restoration Project

In restoration projects using soil bioengineering techniques, the revegetated banks go through several successional stages (Figure 47). The transitional stage—or the "scruffy teenage years" as Ann Riley calls that stage—needs to be explained to community members before the project is installed. In several East Bay restoration projects, neighbors grew disgruntled when, during this stage, they could no longer see the creek. The photographs in Figure 48 show this stage of a restoration project on Blackberry Creek in Albany.

Figure 47: Conceptual drawing of changes in channel character with age of riparian vegetation.



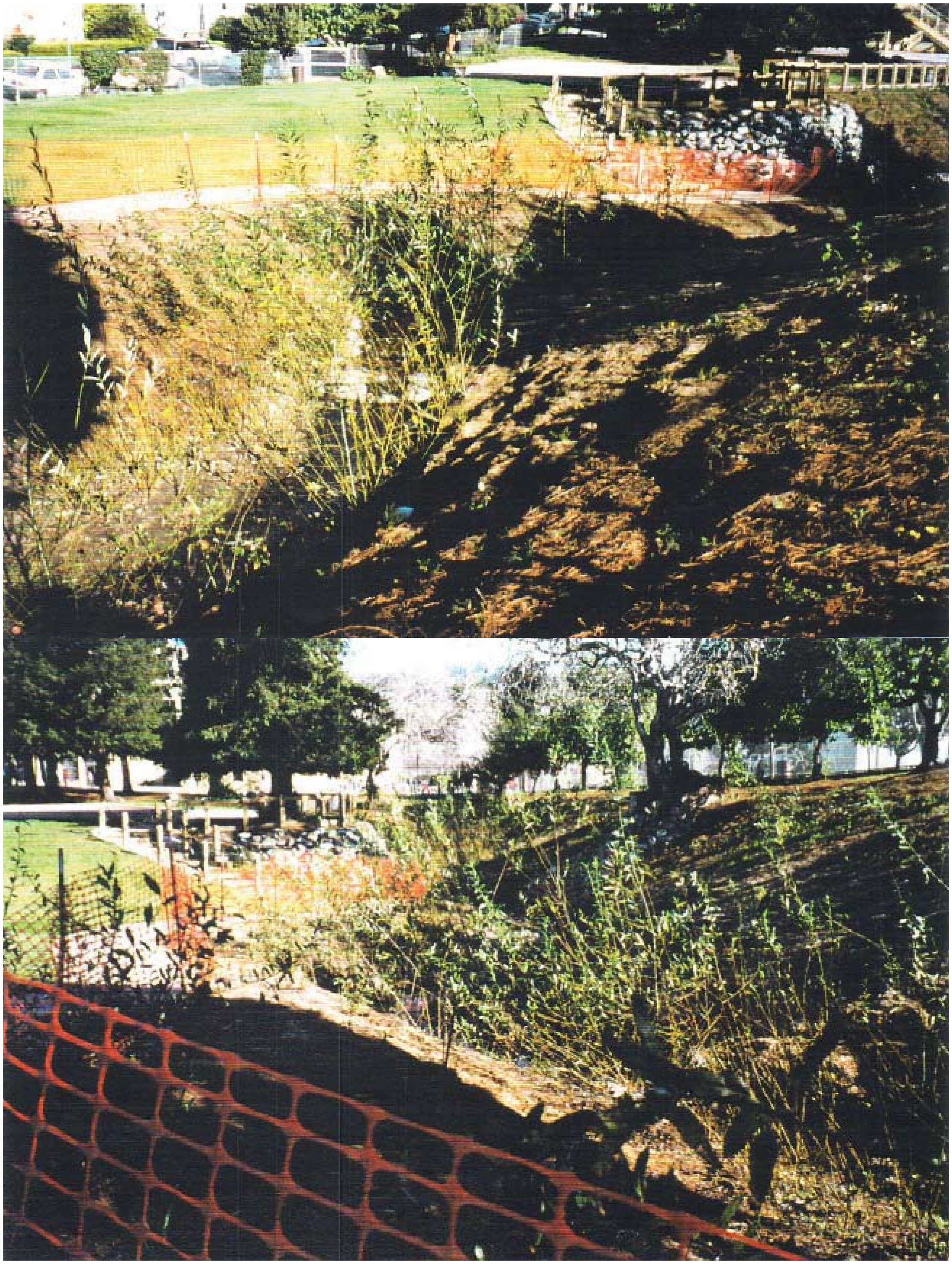
Source: Wolfe Mason Associates.

Figure 48: Restored Blackberry Creek at Thousand Oaks School in Albany, almost four years after installation. Photos by author. 1999.

Part of the reason for conducting a community workshop as part of the project, is to inform neighbors in advance of what to expect. In a small survey I conducted in 1996 after a restoration of an upstream section of this same creek in the El Cerrito hills, neighbors expressed fears about safety because they would no longer be able to see across the street once the riparian vegetation began to grow. That restoration took place in a small park between two streets, with homes facing each other across the park. Although there might be similar fears about visibility with this project, the creek is located in a much broader, more open area. Also, in contrast to the restoration in the upper watershed (which was a daylighting project and raised fears about open water) the Booker T. Anderson Park area residents have lived near an open channel for a long time.

Because this project is taking place in a heavily utilized park, we plan to use more container stock than in some projects, in addition to the willow and dogwood cuttings and poles, to achieve a more finished look and to shade the water more quickly, and as a kind of "mitigation" in case many of the younger plants are vandalized or trampled. To discourage vandalism or inadvertent destruction, the revegetated area should be fenced off temporarily with highly-visible, orange plastic fencing (see Figure 49).

Figure 49: The daylighted and soil-bioengineered Blackberry Creek, just after completion of the project, showing use of temporary fencing. Photos by author. 1995.



Revegetation

Table 8 lists native riparian plants that have been successfully used in East Bay creek restoration projects in addition to willows. Shaded boxes show those that are more appropriate for the micro-climate in the Booker T. Anderson Park area, which is near the Bay, and/or species that will probably be most durable in an urban park setting. In addition to these species, another attractive shrub I recommend trying is wax myrtle (*Myrica californica*). Although wax myrtle may not be native to the area and hasn't yet been used in East Bay restoration projects, it is native to streambanks within the coastal fog belt, grows well in Richmond, provides excellent wildlife habitat[11], and offers another attractive, ornamental (yet native) option for an urban park setting.

Table 8. Species, Zones, and Growth Forms of Native Plants Used in East Bay Restoration Projects (after Goetting 1999)

Common name	Latin name	Zone	Cut-ting	Con-tainer	Seed	Sap-ling	Ground cover
White alder	*Alnus rhombifolia*	A,B		x			
Red alder*	*Alnus rubra*	A,B?	x?	x		x	
California Bay	*Umbellularia californica*	A,B,C		x		x	
Big leaf maple	*Acer macrophyllum*	A,B		x		x	
California blackberry	*Rubus vitifolius*	B,C	x				x
California buckeye	*Aesculus californica*	B,C			x		
Coast live oak	*Quercus agrifolia*	C			x	x	
Cottonwood	*Populus fremontii*	A	x		x		
Coyote bush	*Baccharus pilularis*	C			x	x	
Currant	*Ribes sanguineum*	A,B		x			
Dogwood	*Cornus stolonifera*	A,B	x				
Elderberry	*Sambucus caerula*	A,B			x	x	
Gooseberry	*Ribes vitifolius*	A,B,C		x			

[11]Yellow-rumped warblers (*Dendroica coronata*), which migrate through this area in large numbers every winter and have been seen in the park, eat the waxy coating off of the berries of wax myrtle bushes.

Hazelnut	*Corylus cornuta*	B,C			x	x	
Honeysuckle	*Lonicera hispidula*	B,C	x		x		
Honeysuckle	*Lonicera involucrata*	B,C	x				
Ninebark	*Physocarpus capitatus*	A,B,C	x				
Snowberry	*Symphoricarpus albus*	A,B		x	x		
Toyon**	*Heteromeles*	C				x	
Wild rose	*Rosa californica*	A,B		x			
Willow, Red	*Salix laevigata*	A	x				
Willow, Pacific	*Salix lasiandra*	A	x				
Willow, Arroyo or White	*Salix lasiolepis*	A	x				

Zone A	Edge of active channel, at toe of slope
Zone B	Mid-bank to top of channel
Zone C	Top of bank and outer edge of meander belt

**This species has not been used in East Bay restoration projects to date. However, historically red alder may have grown along this creek (CAC 1981), so including it here might be a worthwhile experiment. Whether it will grow from a cutting or must be planted from container stock is not known.*

***Toyon was evidently once more predominant in this area (CAC 1981) and would be a good choice for the tops of banks as well as an attractive, ornamental planting for an urban park setting.*

Project Costs and Schedule

Table 9 presents a detailed budget for this project. The California Department of Fish and Game will not allow any instream work between October 1 and April 15 (Bradt 1999). All necessary permits (Regional Water Quality Control Board, California Department of Fish and Game, and U.S. Army Corps of Engineers) should be obtained by June[12], with excavation and grading work to begin in August (Bradt 1999). Revegetation and soil bioengineering will not take place until late November/early December when the rains begin. The park has an

[12] These permits can take up to three months to obtain, so they need to be acquired well in advance of the project (Bradt 1999).

irrigation system in place, which would probably need to be supplemented with a temporary system to ensure the success of the soil bioengineering project, at least during the first few years.

Table 9: Restoration and Outreach Budget for Baxter Creek at Booker T. Anderson Park

Activity	Details	Cost
Planning: Urban Creeks Council (UCC)	for restoration logistics and community/neighborhood outreach workshop; flyers: creating, copying, and distributing	2,500
Planning: UCC	work with Stege Elementary School to create interpretive signs about soil bioengineering and wildlife using the riparian corridor	2,500
Grading Plan (UCC)		1,100
Excavation (Wallace "Mike" Riddle Construction, Martinez)	Recreation of meanders; re-use of soil onsite; removal of riprap and boulders; relocation of boulders onsite; grading supervision and flagging	22,400
Erosion control	hay and delivery equipment (Bobcat, one day) coir fabric, staples, and delivery labor (UCC) labor (East Bay Conservation Corps (EBCC)	1,650 190 4,760 1,100 1,760
Planting*	Container stock, tree stakes and/or cages	3,300
Plant collection	EBCC: 10 days x $800/day Supervision by UCC Truck rental for plant collection (two weeks)	8,800 1,100 1,100
Installation of cuttings, container stock, and erosion control fabric*	EBCC: 3 weeks @ $4,000/week UCC: 3 weeks @ $2,000/week	13,200 6,600
Other equipment	Excavator for scouring and breaker for pole plantings	1,540
Irrigation system (uses existing hookups at park)		3,300
Irrigation system installation	UCC: 3 days	1,650
Permits	Regional Water Quality Control Board; U.S. Army Corps of Engineers; California Department	1,500

	of Fish and Game	
Permit preparation	UCC	2,200
Post-project monitoring, three years	UCC: channel cross-section and profile surveys; wildlife and aquatic insect surveys	10,000
Project Total:		***$92,250***

Other Possible Costs/Considerations

One item not included in this budget would be the redesign of the corner of the park at 47th and Cypress. This area looks out onto the creek and as it exists now, is not very attractive or inviting (see Figure 50). It could be redesigned to call attention to the creek, and even to explain the restoration, including the soil bioengineering, local wildlife, and habitat values of riparian areas, etc. An example of an attractive interpretive sign explaining a soil-bioengineering project is attached as Figure 51. Students from Stege Elementary or Kennedy High School could design or help create interpretive signs and other artwork, to create a more attractive gateway to the park and creek. Once the creek is redirected to flow more in line with the culvert it comes out of, as recommended, the chainlink fence could be removed to allow the reinstalled trail on the right bank to connect from the sidewalk. This would in turn allow people to better see and enjoy the creek. Right now, the chainlink fence precludes access from the sidewalk to the right side of the creek (looking downstream) and does not "invite" people into the park. A mural or other children's artwork and signs could be funded through a private foundation, possibly in conjunction with the Richmond Art Center. I have not addressed those ideas in detail in this paper.

Figure 50: The not-so-inviting "entrance" to Booker T. Anderson Park at 47th and Cypress Streets.

Photo by author. February 2000.

Figure 51: Sample of an interpretive panel explaining soil bioengineering.

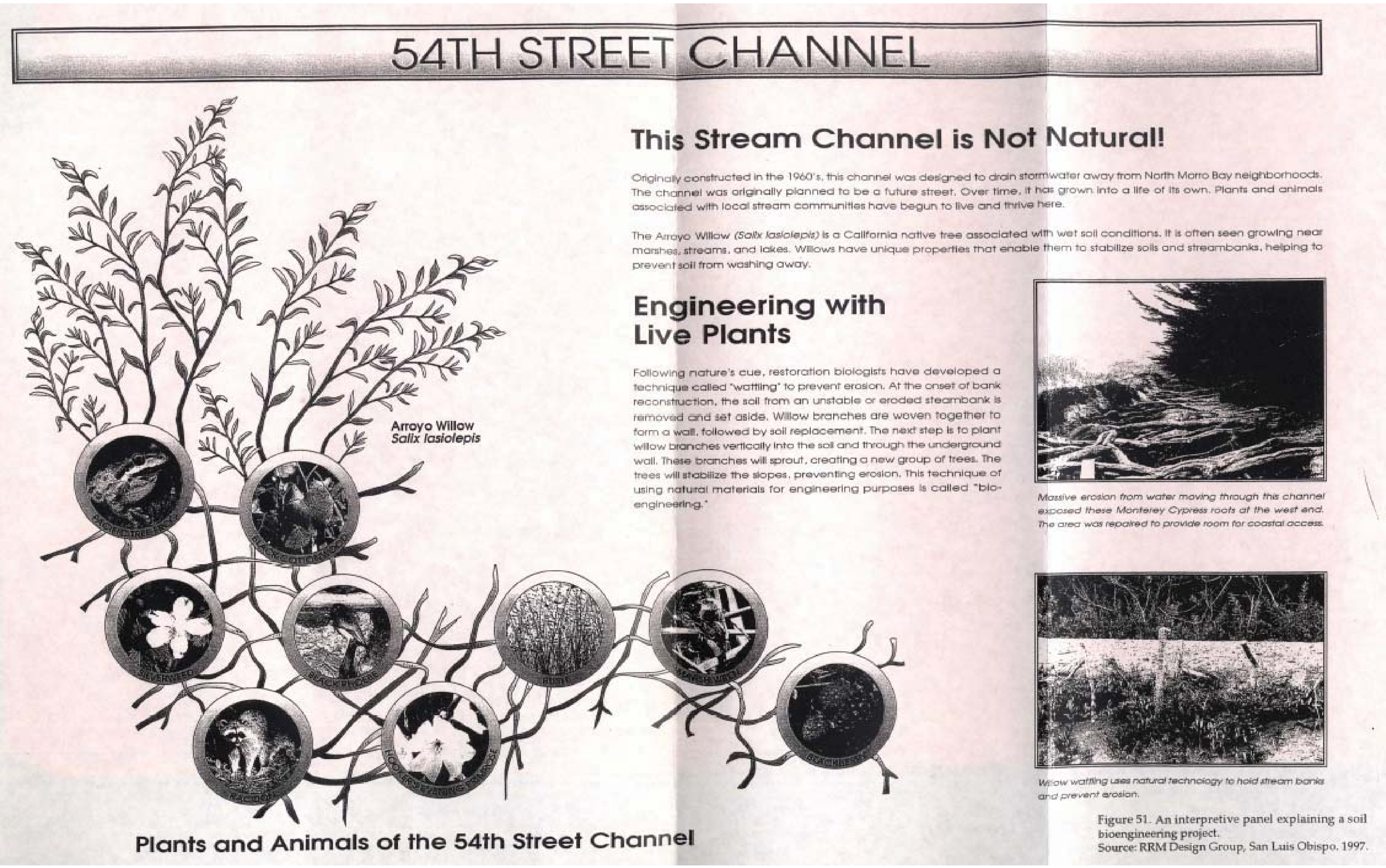


Figure 51. An interpretive panel explaining a soil bioengineering project.
Source: RRM Design Group, San Luis Obispo. 1997.

Another issue and expense that I have not detailed in this paper is that of installing bridges to cross the creek: the existing bridge will need to be torn down, and at least one bridge will need to be rebuilt, according to Tony Norris, Superintendent of Parks and Landscaping, to provide a crossing for adults, and people with bicycles or dogs. The city will need to set aside or find funds in addition to the amounts listed in the budget above. A more informal crossing could be created out of some of the extra boulders, so that children could cross the creek and play in it. In downtown San Luis Obispo, several large, flat boulders allow children to play in, cross, and otherwise access the creek.[13] This was also done in Strawberry Creek in Berkeley's Strawberry Creek Park (there, the boulders were actually chunks of cement taken from the old concrete culvert). In one section of the Baxter Creek planting plan, in a mini-"grove" of cottonwoods near the large, existing weeping willow, we have envisioned a path of crushed gravel giving children access down to the creek, since they play in that area already (see Figure 36).

[13] Here the boulders have been set into the stream bed in concrete, however. Ours will be carefully placed without using concrete.

CHAPTER 6: SUMMARY

Achieving the physical and habitat goals of this project is a challenge, but not an insurmountable one. Correct design of the stream channel shape will help achieve the goal of providing instream habitat and improving flows, while revegetating the banks with native riparian species will help achieve the goal of shading the water, improving its quality, and providing wildlife habitat. By using native riparian species that "occur with the least effort and provide the greatest sustainability and variety," a small piece of bioregional identity will be restored as well (Houck 1990).

Together, these activities will achieve the goal of providing an attractive neighborhood amenity. Restoring the stream and teaching teachers how to use the stream as a tool will provide educational opportunities for the community, as will community workshops and other outreach events. And all of these activities help achieve the goal of demonstrating the benefits of urban stream restoration.

Ultimately, this restoration will be self-sustaining in terms of its geomorphological function and habitat values. However, to ensure its overall success, especially in this heavily-used urban setting, three additional elements must be addressed: monitoring, maintenance, and stewardship. These elements are interconnected, as monitoring and maintenance activities can be used to help develop stewardship.

Monitoring

In addition to wanting to know how well the project functions and whether or not any problems arise, another reason to monitor is that urban stream restoration projects are often criticized for their lack of post-project monitoring (Kondolf and Micheli 1995). Recommendations for post-project monitoring, including opportunities for developing stewardship of the site where possible, are set forth below. While all of these activities will be conducted by Urban Creeks Council personnel with funding that has been included in the grant proposals, high school and elementary school students could be taught some of these monitoring techniques and could contribute valuable data as part of an environmental education program.

Monitoring Recommendations

1. Evaluate geomorphological changes to the stream channel at least once a year for the first five years after restoration, using visual observations and photos. Three cross-sections should be surveyed annually during the first three years, performed in the same location each time. Longitudinal profiles should be surveyed during the first, second, and fifth years. Although Urban Creeks Council personel will perform these monitoring activities, these techniques could also be taught to students at Kennedy High, as part of developing a stewardship program with that school.

2. Evaluate bank stabilization techniques used, and monitor their effectiveness at least once a year for the first five years after restoration. If

problems are discovered, solutions can be implemented early on. Urban Creeks Council personnel should perform this monitoring.

3. Evaluate plant growth and survival using visual observations and photos, at least once a year for the first five years. Evaluation should include overall survival rates (what percent of plantings survived overall); species' survival rates; and possibly vegetation growth rates. This is another activity that students from Kennedy High or even Stege Elementary could engage in. In science classes, students can make observations about plant growth, including height, diameter, and percent cover, etc., and compare observations about one species' growth patterns and rates to those of another. These observations in turn could be turned into science reports and posters, and passed on to the next year's class.

4. Evaluate wildife usage of the riparian habitat through visual observations and photos several times a year, particularly in spring and fall, for the first five years, since there will be seasonal changes in usage as migrant birds pass through and residents may use the habitat for nesting and other activities. For example, three years after the daylighting of the upper branch in Poinsett Park mentioned earlier, I noticed the first bird's nest being built in the fork of a willow. At that point the canopy had become thick and tall enough to invite birds to nest, although birds had used the restoration site for feeding and resting from the very beginning. Birds are a good indicator species because they are easy to see and respond rapidly to changes in the environment (Hoss 2000). Although this monitoring will be performed by the Urban Creeks Council, students can

assist in wildlife observations. With bird guides and binoculars (these could probably be obtained through the Golden Gate Audubon Society or a grant), both older and younger students can learn to identify and record the birds they see on the site, and their activities.

5. Evaluate water quality changes and instream habitat quality by conducting aquatic insect surveys at least once a year for the first five years. One easy way to evaluate changes in instream habitat is by conducting "before and after restoration" aquatic insect surveys. Through the program we are establishing at Stege Elementary School, the students there will be able to help provide basic data on life in the stream and water quality before and after restoration.

6. Resident satisfaction with the project should also be monitored, by conducting door-to-door surveys and/or surveys of park users. Especially if performed annually, these surveys would give the Urban Creeks Council an ongoing opportunity to address concerns about the project that may arise, particularly as the vegetation goes through different growth stages. The 1999 survey by Purcell, et al. of residents near the Poinsett Park project, found a greater rate of satisfaction with the project three years after my 1996 survey, which was conducted just three months after implementation. Purcell found that some residents continued to have concerns about water quality. Such concerns could be addressed in conjunction with perception surveys. Perception surveys could also make an interesting project for high school students as part of environmental or social studies or geography classes.

Maintenance

While the project's vegetation will eventually be self-sufficient, during the first few years it will need supplemental watering from the temporary irrigation system to encourage plant growth, as well as occasional pruning. Initially, the irrigation system should be checked at least once or twice a month, as should the response of the vegetation and weed growth. An irrigation schedule will need to be established with park maintenance personnel, who should be trained to selectively prune the vegetation, although the Urban Creeks Council prefers to conduct those maintenance activities itself or with some assistance during the first few years after project implementation. The city of Richmond recently resolved to stop using herbicides in riparian areas, so weeding will need to be be performed by hand. Both pruning and weeding could be conducted with help from the East Bay of California Conservation Corps, as is done at other city parks, or with help from various citizen groups, and some funding has been written into the grants for maintenance.

Table 11. Summary of Monitoring and Maintenance Activities

Monitoring or Maintenance Activity	When to Conduct	Method and Timing of Monitoring	By Whom?
Evaluate geomorphological changes to the channel	During first five years post- restoration	Annually (cross-sections); first, second, and fifth years (profile)	UCC
Evaluate bioengineering/ bank stabilization	During first five years post restoration	Annually: inspect visually for erosion	UCC
Evaluate plant growth and survival	During first five years post-restoration	Annually: document with photos	UCC with assistance from high school students
Evaluate wildlife usage	During first five years post-restoration	At least bi-annually: Area surveys of birds; visual observations of all wildlife	UCC with assistance form high school students
Monitor water quality and instream habitat	During first five years post-restoration	Annually: Aquatic invertebrate sampling; test for dissolved O2, temperature, etc.	UCC with help from elementary school students; high school students
Evaluate resident and park user satisfaction	During first five years post-restoration	Annually: Personal interviews	UCC with help from high school students
Maintenance of temporary irrigation system; vegetation	Irrigation system-during first two years post-restoration; vegetation should be pruned only after three years of growth	Monthly visual inspections during first two years (during irrigation season); Annually, three years post-restoration	UCC with city maintenance personnel; Conservation Corps; CYCLE

Long-Term Stewardship

Probably the most important aspect of developing a successful, ongoing stewardship program with the elementary school will be the ongoing involvement of personnel from the Urban Creeks Council and/or volunteers from the Friends of Baxter Creek. Rather than one "hit and run" workshop, there needs to be continued involvement from a restorationist and/or creek advocates, particularly since teachers and students change from year to year. A recent UC

Davis evaluation of an urban wildlife preserve created near an elementary school, with one goal the establishment of an environmental awareness program at that school, recommends reintroducing the preserve to the school on an annual basis, by sending a letter of introduction about the preserve and its potential for educational and extracurricular activities to all new and returning teachers (UC Davis Center for Design Research 1998). The study also recommends displaying well-designed posters about the project in the multipurpose room, lunch room, and main office at the school, to reinforce awareness of the project and promote stewardship. Similar efforts would probably also be useful at Stege Elementary School. The Urban Creeks Council staff could continue its involvement with the school by making presentations about the creek to different classrooms at the start of each school year, by offering additional Kids in Creeks workshops in conjunction with the Aquatic Outreach Institute each year, and/or by sponsoring other creek-related activities, such as bird-watching field trips and censuses and perhaps even simple classroom activities such as growing willow cuttings.

Both Save the Bay and the San Francisco Estuary Project, through its CreekKeepers program, also work with high-school students in hands-on restoration and monitoring projects. Since the Urban Creeks Council is very short-staffed, it could form alliances with these two organizations to implement such a program at Kennedy High. The Estuary Project already works with students from Richmond High on Wildcat Creek, and Save the Bay has expressed an interest in expanding its environmental education program to include more inner-city, urban areas; to date, its programs have primarily involved suburban high schools (Latta 2000). Just as the restoration project will ultimately be self-sufficient, so too might stewardship of the site. At Richmond High School, for example, one teacher developed a "Teacher Cadettes" program in which her students learned about urban streams and then subsequently visited nearby elementary schools and taught younger children what they had learned. The same type of program might be possible between Kennedy High and Stege Elementary, and would encourage continued and ongoing stewardship and enjoyment of the creek by local children.

On Saturday, May 13, 2000, I worked with two staff members from the Aquatic Outreach Institute to hold the first Kids in Creeks workshop at Stege Elementary. Six teachers and the principal attended. During the workshop, we took the teachers to the creek and taught them how to perform aquatic insect surveys as well as to measure pH, water temperature, and dissolved oxygen. Not surprisingly, the only aquatic insects we found were pollution-tolerant macroinvertebrates, such as aquatic worms, snails, leeches, and mosquito larvae. We found no pollution-sensitive species. Water temperature in the unshaded portions of the creek—70 degrees Fahrenheit—was almost as high as the air temperature of 71 degrees. Despite our dismal findings, the teachers were enthusiastic about the activities and plan to begin using them in their classrooms. Most of the teachers admitted they will be more likely to use the creek as a classroom tool once it is restored.

On June 28, the Urban Creeks Council sponsored a community workshop attended by 28 members of the community, including neighbors of the park, some city council members and park representatives, and several members of the Friends of Baxter Creek (see Appendix 2). During the workshop, we explained what and who the Urban Creeks Council and the Friends of Baxter Creek are and showed several slides of other restoration projects undertaken by the Urban Creeks Council. We explained the project's different phases, the heavy equipment that will be used in Phase 1, and Stege Elementary School's involvement in the creek. The general consensus among all attending the workshop was that the creek "needed help" and that anything that could be done to make it nicer would be appreciated. The only concern raised by any of the neighbors was that we not disturb the large (historical) weeping willow on the left (facing downstream) bank.

Project Implementation

In August, Phase 1 of the project was implemented after surveying eight additional cross-sections of the channel and designed a grading plan (see Appendix 4). As we began working on the grading plan, we realized that the upstream culvert (entering the park) had created a deep plunge pool, altering the creek's slope for the first hundred feet. Because of that altered slope, to achieve the sinuosity as designed, we would have had to lift the grade of the creek bed by importing fill material (Riley 2000). In order to avoid this expense and more "engineered" approach, we decided to alter our sinuosity design to slightly less than 1.3 (see Appendix 4) a sinuosity that closely approximates the downstream reach, which we believe to be in equilibrium.

We did have to install two rock weirs to smooth the grade change between a hidden concrete lip discovered upon excavation and the stream's natural bed. Although the excavator was able to remove the cobble and the top layer of concrete that had been poured into the channel, he felt that the layer underneath would be too difficult and costly to remove, so we allowed it to remain and worked around it. For the length of that concrete bed, we allowed the stream to keep a fairly straight course (albeit in better alignment with the culvert), and began the meanders downstream of the concrete.

Although the new channel ended up being slightly less sinuous than historical data suggested it once was, the effects of the culvert on the slope—and the desire to avoid a more "engineered" approach to restoration—led us to perform less of a "historical" restoration than a restoration based on an urbanized landscape, which will, nonetheless, restore habitat and ecological values to a very degraded stream.

During the second week of August, the streambed was temporarily dewatered (pursuant to our permit requirements) by rerouting the water via tubing and pipes from one culvert to the other (see Figure 52) The new channel pattern was delineated with flagging and excavated according to our revised design. Using a laser level, we measured bed elevations as the new channel was being excavated (see Figure 53), to ensure that we were achieving the correct profile.

Figure 52: Dewatering the Stream.

Photo by author. August 2000.

Figure 53: Surveying profile elevations.

Photo by author. August 2000.

During the second week of excavation, the East Bay Conservation Corps installed coir fabric along the banks, which will help prevent erosion until the project is planted (see Figure 54) and rebuild the banks in several spots using brush layering. (see Figure 55).

Figure 54: Installing coir.

Photo by author. August 2000.

Figure 55: Brush-Layering a bank. Photo by author. August 2000.

Phase 2 of the project will take place in early December, when we will plant willow and dogwood cuttings and poles to stabilize the banks as well as native shrubs and trees from containers. At that time, we plan to hold a “Planting Day” event involving children from Stege Elementary School, as well as several city officials.

While the creek should be more balanced in terms of its new fluvial geomorphology, it will face the same challenges other urban streams face: trash dumped in its waters, pollutants from upstream, and possible damage to the vegetation, among other concerns. As we worked on the project, local residents frequently stopped and asked us about it. The most common question asked was “Are you cleaning up the creek?” In response, we explained that we were trying to improve the creek’s functioning and restore it to a more natural type of stream but that we would need their help keeping it clean. The next most frequently-asked question was what would happen to the tadpoles that had been in the creek. We explained that we hoped to improve conditions for tadpoles and any other aquatic organisms by eventually providing more shade and improving water quality. Many people asked whether we were going to introduce fish into the creek, and in response we tried to explain the constraints of an urban stream and that this stream probably would not support steelhead (for example), in part due to the extensive culverting both up- and downstream of the park. Most people we spoke to had no concept of the creek flowing to the Bay or that it was open in other places upstream. We also explained to passersby that while we wouldn’t be introducing anything into the stream, we hoped that if conditions improved, there would eventually be more life in the stream and that it would be used by more wildlife. People also asked us if we would be putting the creek into concrete. We explained that we were attempting to return the stream to a more natural condition using plants, which would also help stabilize the banks.

Several residents have told us that they plan to “keep an eye” on the project. Throughout Phase 1 of the implementation, we experienced minor problems from vandalism (particularly to the temporary fencing); to avoid damage to any of the heavy equipment, we hired a security guard to watch the site between the hours of 4:00 p.m. and 7:00 a.m. As discussed in earlier chapters, our hope is to instill a sense of stewardship in the children who live and play nearby, which may help prevent some of the problems the creek has experienced in the past. With its grant from the Aquatic Outreach Institute, the Friends of Baxter Creek will begin holding monthly meetings this October, to which residents of the Booker T. Anderson Park area will be invited. Still, more effort will probably be needed to keep the creek in good condition. The Urban Creeks Council will attend some of the monthly meetings held by the neighborhood council that encompasses the park area, to talk about the project and listen to their ideas about how to develop stewardship of the site. The interpretive sign, which will use children's artwork, should also help demonstrate community pride in the project.

Next spring, when the cuttings and container stock have begun to grow, we plan to hold an outdoor "ribbon-cutting" ceremony in the park with food, balloons, music, etc. Hopefully this event, too, will lead to more community participation and the stewardship that the creek will continue to need in the future.

APPENDIX 1: List of Wildlife Observed in Booker T. Anderson Park

Birds

American crow (*Corvus brachyrhynchos)*
American goldfinch (*Carduelis tristis)*
American kestrel (*Falco sparverius)*
American robin (*Turdus migratorius*)
Anna's hummingbird (*Calypte anna*)
Black phoebe (*Sayornis nigricans*)
Bushtit (*Psaltriparus minimus)*
California towhee (*Pipilo fuscus)*
Canada goose (*Branta canadensis)*
Cedar waxwing (*Bombycilla cedrorum*)
Chestnut-backed chickadee (*Parus rufescens)*
Cliff swallow (*Hirundo pyrrhonota)*
Dark-eyed junco (*Junco hyemalis)*
Downy woodpecker (*Picoides pubescens)*
Great egret (*Casmerodius albus)*
Mallard (*Anas platyrhynchos)*
Red-Tailed hawk (Buteo jamaicensis)
Ruby-crowned kinglet (*Regulus calendula)*
Sharp-shinned hawk (*Accipitar striatus)*
Western tanager (*Piranga ludoviciana)*
Yellow warbler (*Dendroica petechia)*
Yellow- rumped warbler (*Dendroica coronata)*

Amphibians
Pacific treefrog (*Hyla regilla)*

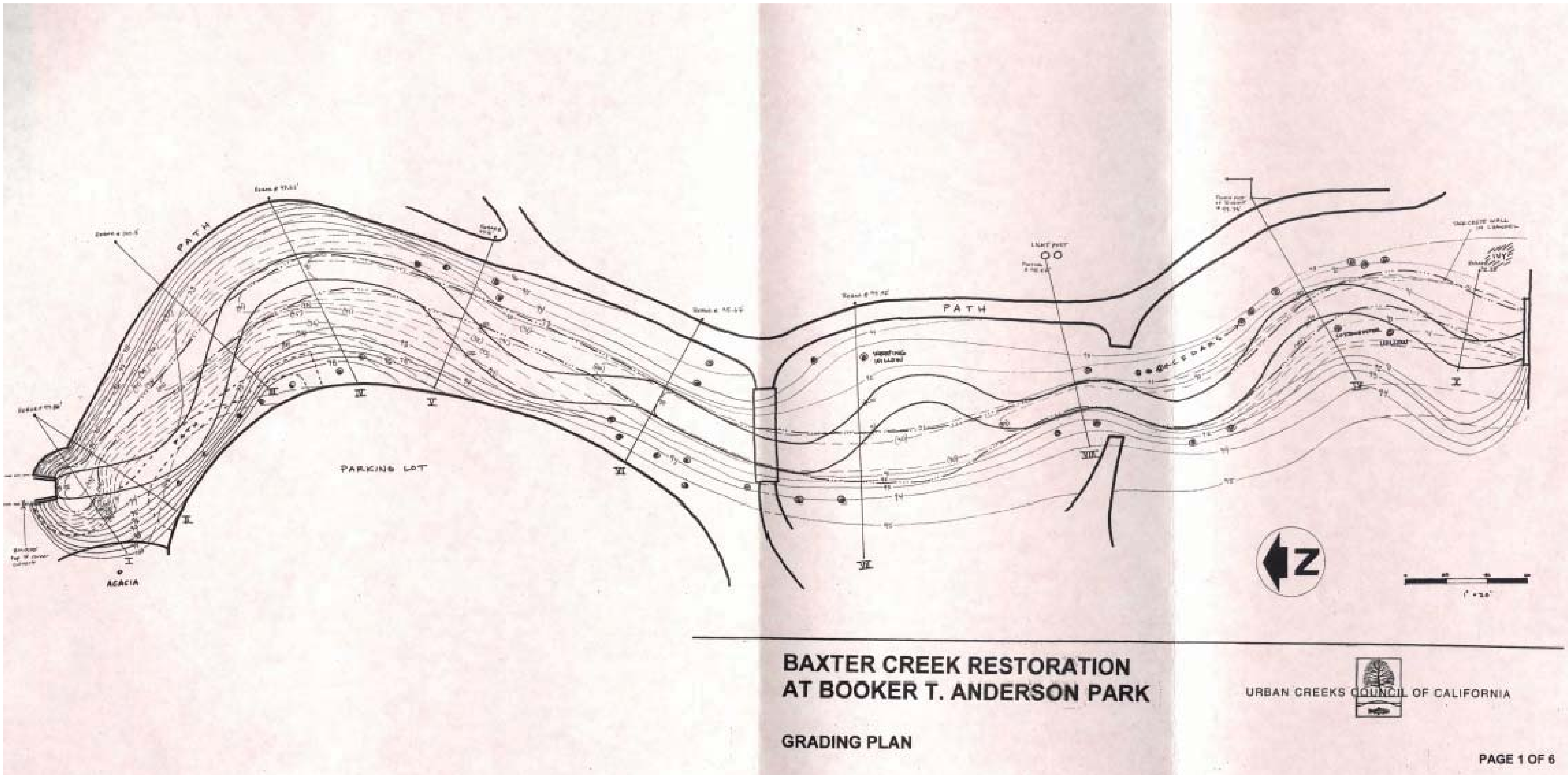
Mammals
Eastern fox squirrel (*Sciurus niger)*

Other mammals likely found in this park include striped skunks (*Mephitis mephitis),* Virginia opossums (*Didelphis virginiana),* and common raccoons *(Procyon lotor)*

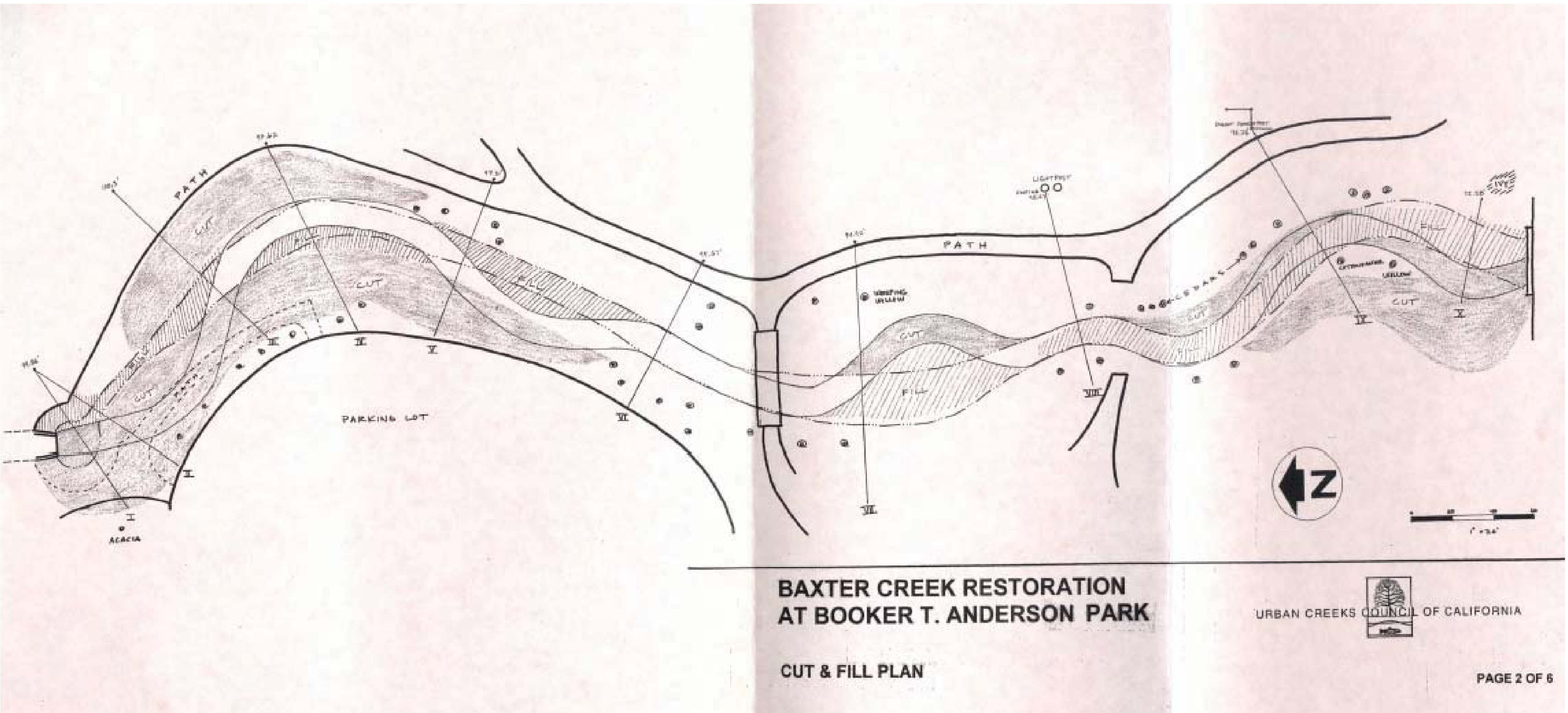
APPENDIX 2: June 24, 2000 Article from the West County Times

APPENDIX 3: Flyer for June 28 Community Workshop

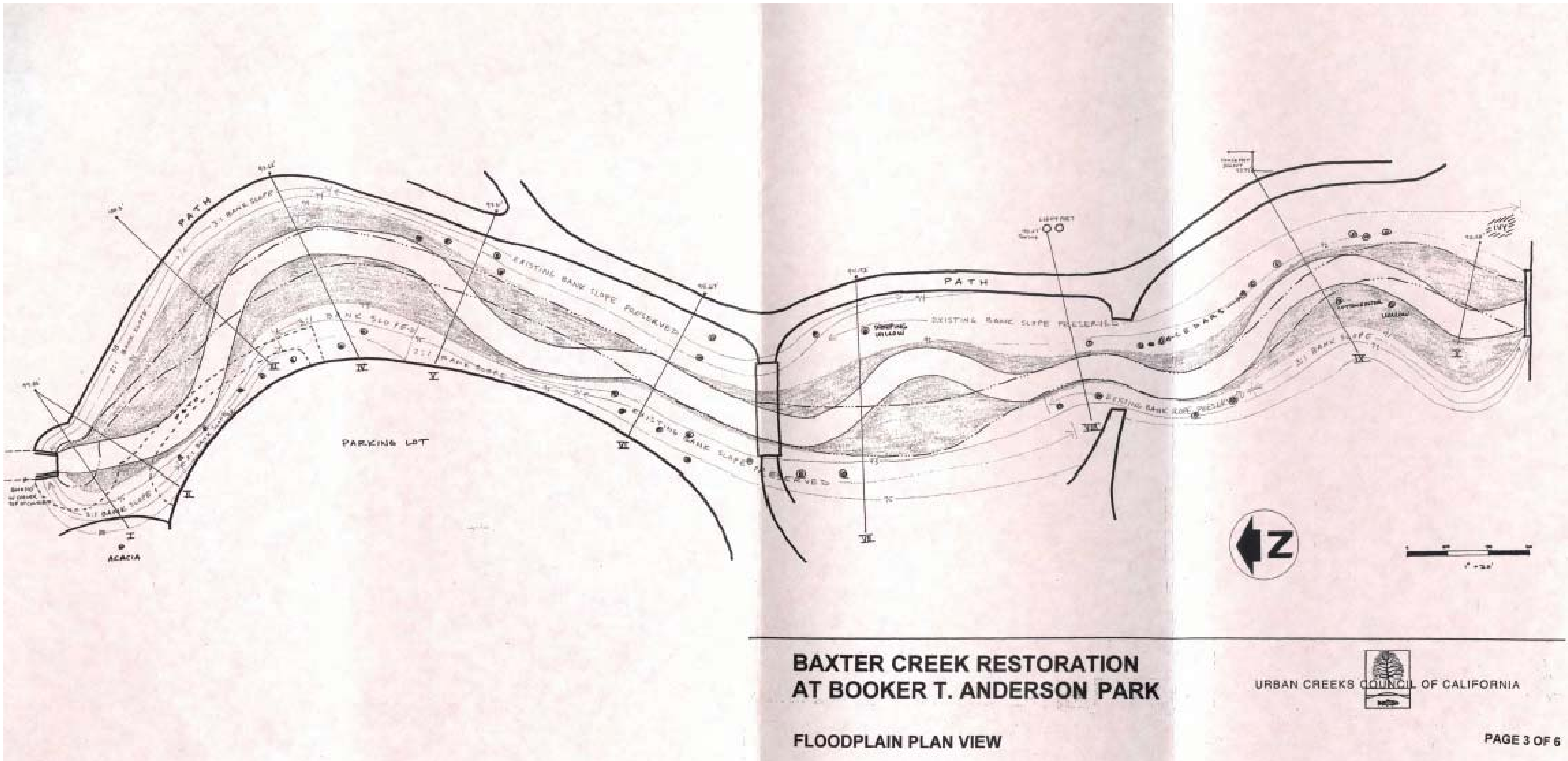
APPENDIX 4: Final Design and Grading Plans; Cross-Sections (Page 1 of 6)



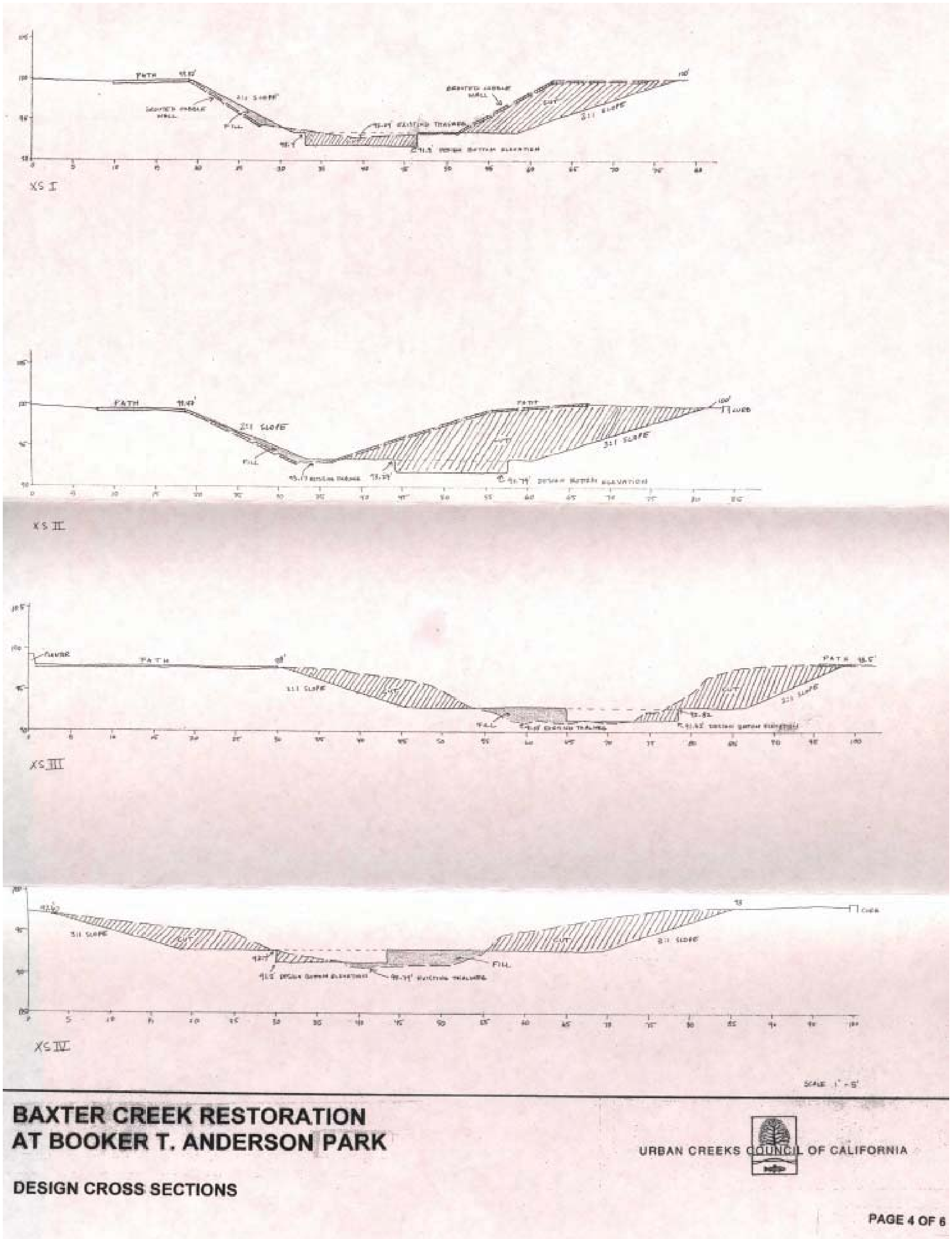
APPENDIX 4: Final Design and Grading Plans; Cross-Sections (Page 2 of 6)



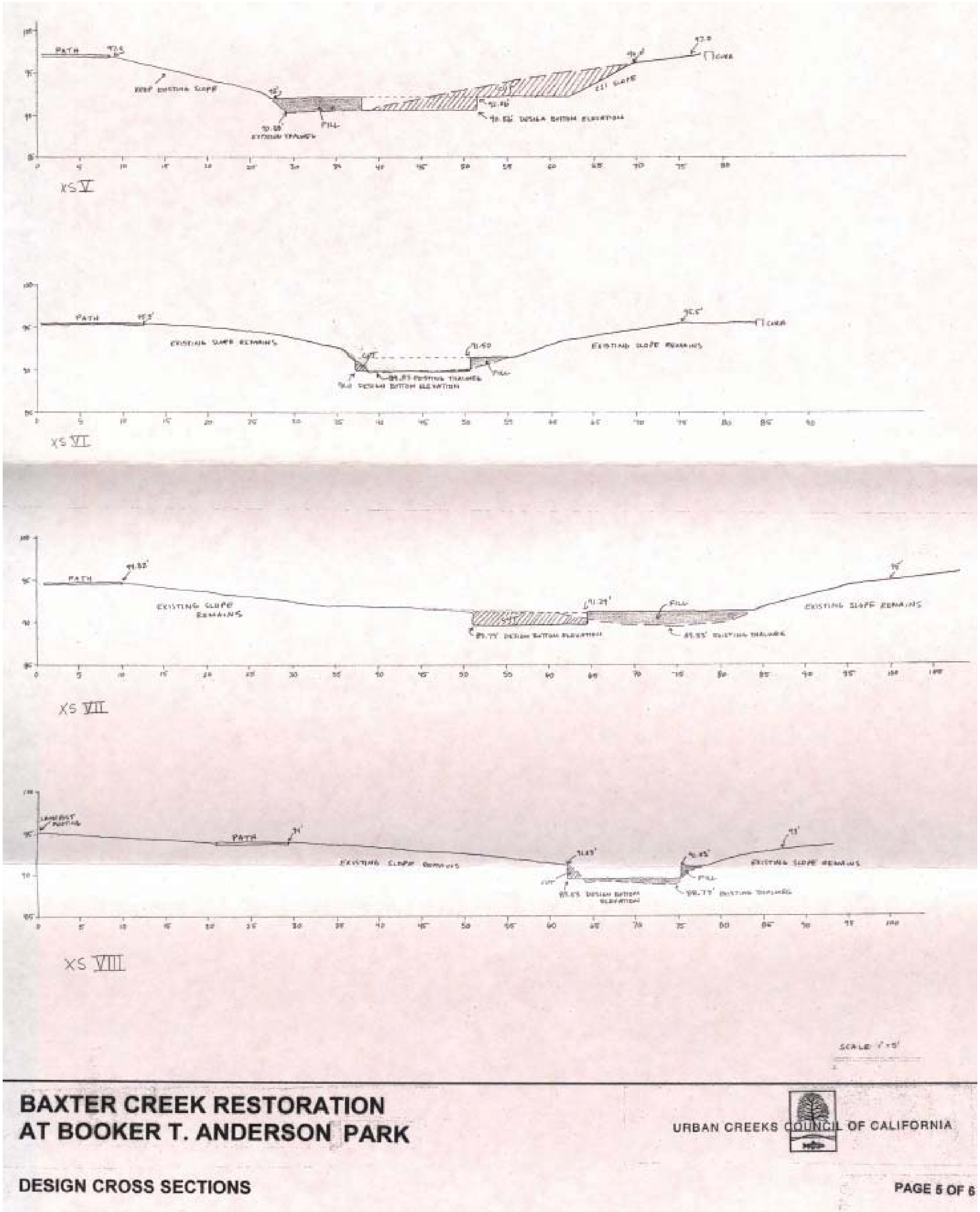
APPENDIX 4: Final Design and Grading Plans; Cross-Sections (Page 3 of 6)



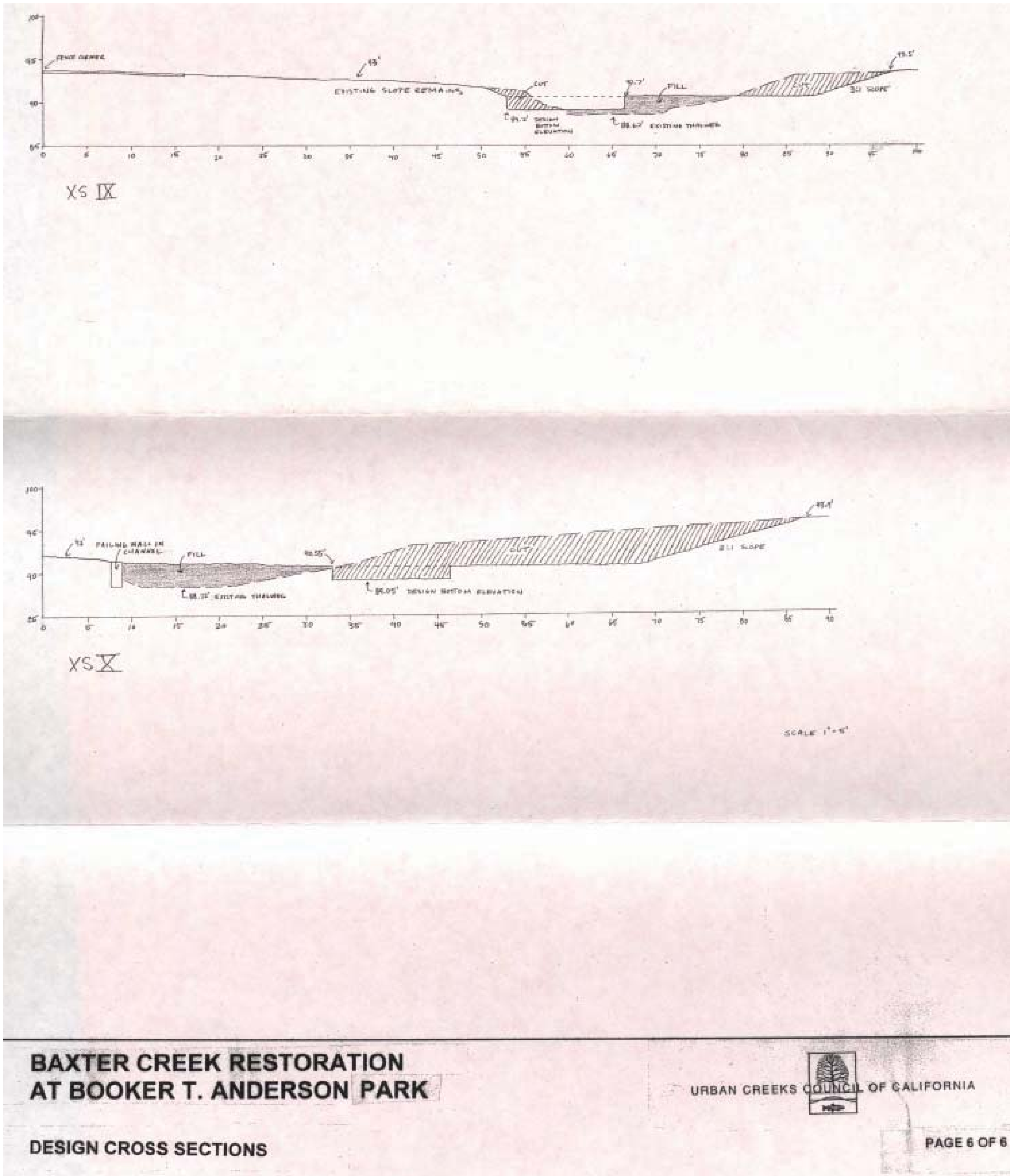
APPENDIX 4: (4 of 6)



APPENDIX 4: Final Design and Grading Plans; Cross-Sections (Page 5 of 6)



APPENDIX 4: Final Design and Grading Plans; Cross-Sections (Page 6 of 6)



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