Technical Note #47 from Watershed Protection Techniques. 1(4): 184-187

Stream Daylighting in Berkeley,CA Creek

by Prof. Vincent H. Resh, University of California—Berkeley

In the relatively new field of urban stream restoration, the nine-year-old Strawberry Creek project is valuable as a long-term case study, with extensive data collection. Table 1 shows the "prescription" for Strawberry Creek. Strawberry Creek has a 1,161 acre watershed (Figure 1) which begins in the canyons above the University of California-Berkeley campus (Figure 2) and is the focus of open space on campus. The creek then disappears into a pipe for most of its journey through the city of Berkeley until it enters central San Francisco Bay.

Strawberry Creek first began to suffer severe erosion in the late 1800s, as land around its headwaters was cleared for grazing. By the 1880s, check dams were built on campus to prevent further cutting of the streambed and bank erosion. As the watershed urbanized, Strawberry Creek began to suffer the full range of urban stream problems: continuing erosion and flooding, channelization and diversion, deteriorating water quality (because of sewage and illegal discharge, chemical contamination, and runoff), sediment contamination, and loss of pool-riffle sequences (Figure 3). These changes were manifested in a sharp loss of fish and insect diversity in Strawberry Creek. A 1987 stream assessment noted that 40% of the watershed was urban and the lag time between peak rainfall and peak runoff was only 15 to 20 minutes on the central campus.

Although Strawberry Creek is a heavily impacted urban stream, the University chose to actively pursue a goal of ecological restoration rather than merely attempting to prevent further degradation or merely improving the creek's aesthetic value. Pursuit of this goal was especially ambitious given that fish had been totally eliminated from the stream. Restoration elements to be addressed included water quality (both point and nonpoint pollutant sources short of stormwater retrofits), biological communities and habitat, hydrologic conditions/erosion, and education and awareness. The ecological focus led to another unusual feature of the project: the reintroduction of nongame fish and salamanders. Finally, as might be expected, the Strawberry Creek project encountered problems that will be familiar to most stream restoration practitioners, including the need to coordinate among multiple institutions, a lack of funding, few possible stormwater retrofit sites, and difficulty with anchoring check dams.

Prerestoration Conditions

A low-cost six-month study was undertaken in 1987 to draft a management plan and describe the creek's hydrology, water quality, and biological communities as well as its overall setting. An ambient water quality monitoring program was also put in place at this time. While water quality in the canyon areas upstream was similar to unimpacted streams in the region, downstream areas showed signs of nutrient enrichment and bacterial contamination (Table 2). Elevated levels of lead (> 50 ppm), zinc (150 ppm) and mercury (> 2 ppm) were found in stream sediments.

Like many urban streams, wet weather water quality was poor for chemical oxygen demand, suspended solids, nutrients, bacteria, and heavy metals. An outfall survey identified over 100 outfall pipes. Most were storm drain pipes, but some proved to be cooling water, direct discharges from campus buildings, or cross-connections to sanitary sewers. The survey concluded that illegal discharges and illicit connections were in fact contributing to the creek's water quality problems.

To assess the quality of the stream's biological communities, a number of monitoring studies were conducted and historical data were also reviewed. Steel-

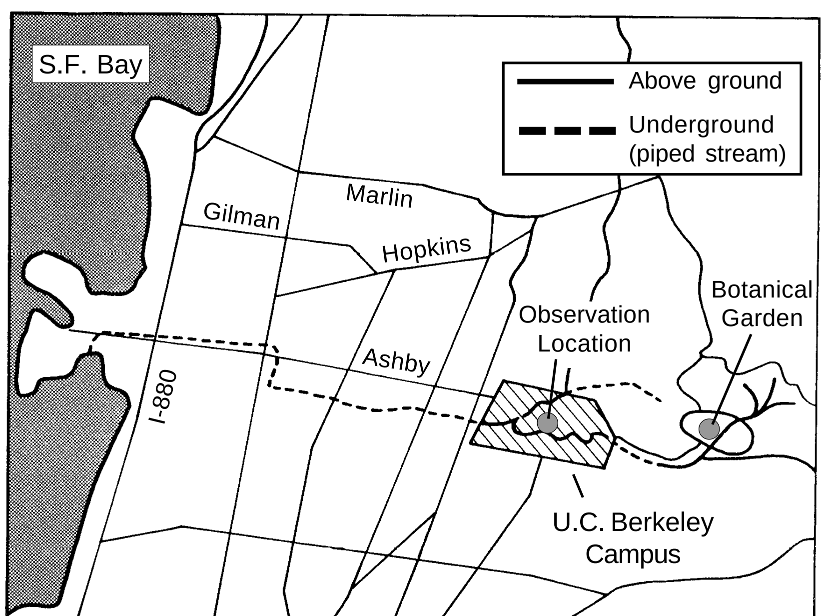

Figure 1: Location Map of Strawberry Creek

Table 1: The Strawberry Creek "Prescription"

Location: Berkeley, CA
Watershed size: 1,161 acres
Degree of Imperviousness: 50 percent

Restoration Step	Application in Strawberry Creek
Control Urban Hydrologic Regime	
Remove Urban Pollutants	■ Source control pollution prevention efforts (no stormwater retrofit) ■ Elimination of illicit connections
Restore Instream Habitat Structure	■ Create pools/riffles ■ Provide structural complexity
Stabilize Channel Morphology	■ Restore natural channel geometry ■ Stabilize severe bank erosion ■ Stabilize channel to accommodate bankfull discharge
Replace / Augment Riparian Cover	
Protect Critical Stream Substrates	
Recolonize Stream Community	■ Selectively reintroduce pre-disturbance native fish community

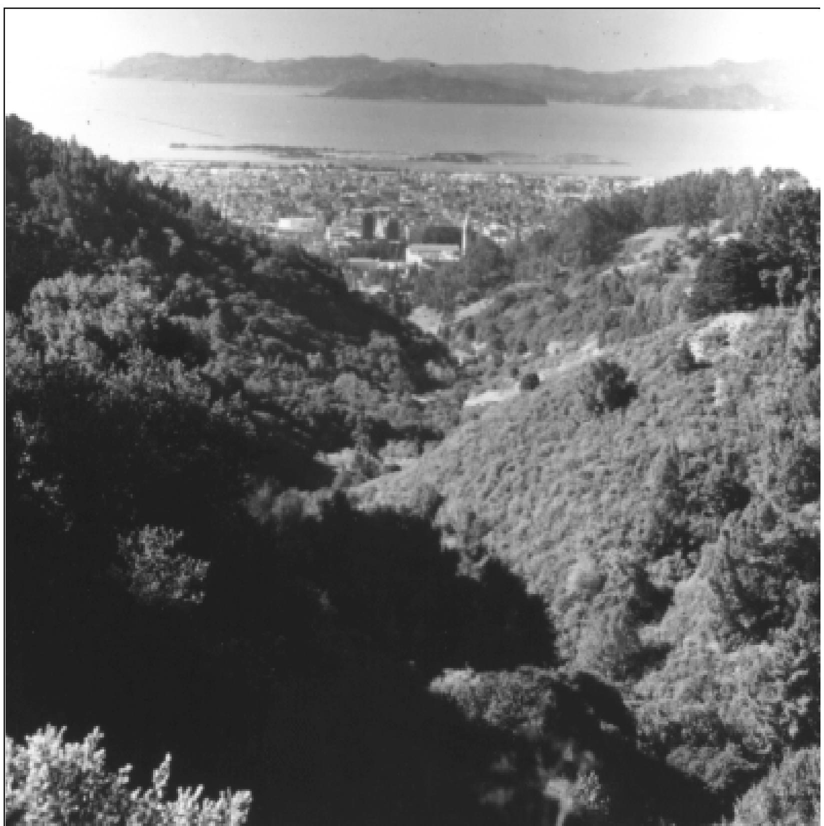

Figure 2: Setting of Strawberry Creek, Berkeley Campus

head salmon had not been seen in the campus reaches since the early 1930s, and in fact no species of fish were found in any of the stream samples for decades. Regular surveys of aquatic macroinvertebrates typically showed five or less families of macroinvertebrates in the central campus reaches, as compared to the 15 to 20 families found upstream. In 1986 (the most sampling-intensive and site-extensive survey), 11 families, many of which are pollution tolerant, were collected on the campus. In contrast, 27 families (including many types usually found in unimpacted environments) were found in sections above the campus. Similarly, wildlife tolerant of urban environments (raccoon, opossum, and rodents) were found on the central campus, but the upper canyon contained many other mammals and bird species. Throughout the creek, the most abundant member of the periphyton (algae, fungi, and bacteria that attach to submerged surfaces) community was the alga *Cladophora glomerata*. This alga grows well in nutrient-enriched waters.

Restoration Description and Findings

The first priority was to eliminate point source discharges, cross-connections, and major sanitary sewer failures. This phase cost almost $500,000 and took place from the fall of 1987 to the spring of 1989. Other projects during the same period included modifying garbage bin wash-down areas (to prevent runoff to the creek), sealing or removing abandoned pipes, and modifying backflushing practices at a large pool complex. In addition, staff was assigned to respond to reports of leaks, spills, and other pollutants (e.g. motor oil). To guard against future spills, floating booms were deployed where the creek entered the central campus. The booms also trapped floating trash and debris.

Stream restoration priorities included stabilization of banks and the stream bed. In one area where a bank was beginning to undercut an automobile bridge, the solution was to install a redwood crib wall (Figure 4). To protect the stream bed and improve pool-riffle ratios, a series of low check dams (Figure 5) were built. To allow for fish passage, the check dams extend no more than 45 cm from spillway to plunge pool. Existing check dams were also stabilized and repaired. A comparison of before and after creek channel profiles (1988 and 1990) revealed that sediment was being deposited behind most check dams. Some check dams showed signs of failure due to inadequately anchored construction. Erosion control projects in the creek's headwater canyons included: gully repair, improved grading and maintenance of fire roads, and emergency diversion of runoff from heavy winter storms.

As shown in Table 2, most water quality parameters in the downstream reaches improved after the restoration project. Similarly, macroinvertebrate data also improved and the number of families is now close to values for upstream areas. Toxicity testing was conducted to see if it was appropriate to reintroduce fish to the stream. Bioassays using water from the campus segment of the stream showed no acute or chronic effects. The first species selected for reintroduction was the three-spined stickleback: a hardy fish tolerant of frequent habitat disturbance. Several generations have successfully spawned in Strawberry Creek since their reintroduction. Additional fish species (roach, hitch and sucker) as well as the Turrica salamander have also been reintroduced to the creek. Crayfish have migrated to the restored reaches, and snowy egrets have returned to feed on fish in the creek.

Efforts to reduce pollution caused by dumping of unacceptable pollutants in storm drains in the Northside neighborhood of the City of Berkeley included a mailing to 1,000 residents and stormdrain stenciling. Also, the restoration project was successful in garnering press coverage by highlighting the return of fish to the creek after a 50-year absence. As a result, citizen reporting of pollution incidents increased dramatically. In fact, during a dye test of sewer lines, over 50 calls were received. As an indication of the creek's educational value to the University, over 2,500 students use the creek annually as part of their laboratory exercises in 50 different classes. In addition, an interpretive creekside trail has been developed for the portion of the creek that bisects the campus Botanical Garden; 13,000 copies of the booklet, *Strawberry Creek: A Walking Tour of Campus Natural History,* have been produced, and a centralized repository of creek information has been established on campus.

Figure 3: Discharge Into Strawberry Creek at the Turn of the Century

Discussion

Combining several stream restoration steps, the Strawberry Creek project has made a significant difference. Where no fish were present, there are now self-sustaining fish populations. While the reintroduced fish are relatively tolerant species, they are nonetheless present in the stream year round. In addition, the successful salamander reintroduction and the return of crayfish and snowy egrets indicate a functioning stream community. However, it is too soon to tell if greater diversity (and the reintroduction of more sensitive species) can be achieved without additional restoration work.

In fact, many nonpoint source control programs are struggling with questions about whether voluntary source reduction efforts be as effective as stormwater retrofits. The main problem now facing the continued success of restoration is the siltation resulting from extensive construction activities on the campus, and the failure of contractors to implement agreed-upon sediment and erosion controls in local construction sites. This is evident from biotic index scores for benthic macroinvertebrates that indicate a change from "good" conditions immediately after the restoration in 1991 to

Figure 4: Redwood Crib Well Has Since Been Covered With Vegetation

Figure 5: Notched Log Checkdam

Table 2: Strawberry Creek Central Campus Water Quality Data Before and After Restoration

Parameter	S. Fork (before)	S. Fork (after)	N. Fork (before)	N. Fork (after)
Chemical oxygen demand (mg/l)	13	10	<10	30
Dissolved solids (mg/l)	198	170	150	144
Suspended solids (mg/l)	2.9	2.0	12.8	4.0
Turbidity (NTU)	1.9	1.6	9.8	2.0
Oil and Grease (mg/l)	<1.7	ND	8.6	ND
Total Kjeldahl nitrogen (mg/l)	0.34	4.9	0.65	<1.4
Ammonia-nitrogen (NH_3-N) (mg/l)	0.13	0.10	0.22	<0.1
Nitrate (NO_3) (mg/l)	2.0	1.7	3.6	1.3
Total phosphorus (mg/l)	0.24	0.14	0.34	0.19
Fecal coliform (MPN/100 ml)	11,000	5,000	34,500	1,400

"fair" conditions in 1993. This decrease in biological integrity underscores the need for continued vigilance and prevention of impacting activities following restoration. A reevaluation of the biological response to such stresses will be conducted in fall of 1995.

While seven years is a long time in the relatively new field of stream restoration, it's not a very long time period for observing stream responses. What will be the lifespan of the restoration techniques applied? So far, results are positive. Since 1989 the check dams have been subjected to several moderately severe storms (three 10-year events) without significant damage. The continuing monitoring of Strawberry Creek should prove of interest for years to come.

References

Charbonneau, R. and Resh, V.H. 1992. "Strawberry Creek on the University of California, Berkeley Campus: A Case History of Urban Stream Restoration." *Aquatic Conserv.: Mar. Freshwater Ecosyst.* 2:293-307.