California Regional Water Quality Control Board
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Putting A Price On Riparian Corridors As Water Treatment Facilities

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Abstract: The monetary value of natural riparian environments that provide water quality treatment functions by processing nutrients, storing sediment, moderating temperatures, and other services can be estimated by calculating the costs associated with the construction of "brick and mortar" water treatment plants built to achieve similar functions. A demonstration urban runoff treatment plant built by the City of Santa Monica provides similar water quality services as a 4,000-5,000 lineal foot riparian corridor does, and has annualized costs of approximately $1.3 million per year ($2008) over a 50-year period.

These costs can be compared to the costs of protecting and/or restoring naturally functioning riparian systems. For example, a large, federally-funded, multi-objective urban flood damage reduction project with water quality benefits has costs that are approximately $967,600 per year ($2008). Other urban stream restoration projects for 5,000 lineal feet of stream with riparian habitat can range in cost from $1,900 for fencing projects to $227,000 per year for "typical" restoration projects annualized over 50 years ($2008). While most riparian restoration projects will provide benefits over a 100 year period or in perpetuity, the life spans of the structural plants are generally much shorter, thereby requiring significant replacement costs.

If it can be demonstrated that the water quality treatment services of a "brick and mortar" plant can be equated to similar services provided by naturally functioning riparian systems, then a cost comparison between the "brick and mortar" plant is not only illustrative, but may also provide a benefit measure that can be used to evaluate the economic efficiency of proposed habitat protection and/or restoration projects.

The Policy Context

Ecologically functioning riparian environments are valued because they provide aquatic and terrestrial habitat for fish, amphibians, reptiles, mammals, and birds, and recreational and open space opportunities for the public. Yet little or no research appears to be available on the economic benefits of riparian areas to society for their water quality treatment functions. Riparian areas improve water quality by removing nutrients, improving dissolved oxygen, storing sediment and regulating temperatures among other benefits. These benefits can be achieved by protecting existing healthy riparian environments, or by restoring degraded areas into functioning ecosystems. Protection can

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be achieved by voluntary ecologically sound landowner practices, and/or through regulation, conservation easements, or fee purchase of riparian corridors. Therefore, one purpose of assigning monetary value to these natural systems is to record what society pays to prevent farming or other land uses in these areas, pass protection regulations, purchase easements or full public rights to the riparian land, and/or to restore the ecosystem.

However, in many circumstances, particularly in urban environments, the monetary costs of protecting a healthy system can be difficult to estimate. Therefore, this research focuses on putting the benefits and services of a riparian environment into perspective by describing what we need to pay if we were to substitute these naturally occurring services with a constructed plant.

Santa Monica Urban Runoff Recycling Facility

The first of its kind, state-of-the-art stormwater treatment plant located in Santa Monica, California, gives us the opportunity to compare the benefits and costs of a physical “brick and mortar” stormwater facility with the benefits and costs of naturally occurring or restored riparian environments based upon their respective abilities to affect the quality of stormwater runoff. The Santa Monica Urban Runoff Recycling Facility (SMURRF) collects polluted runoff from the Los Angeles area and reclaims it sufficiently so that it can be re-used for landscape irrigation or dual plumbing systems (Figure 1). The plant came on line in February 2001 and is located near the Santa Monica pier. The building design involved a collaboration of engineers and artists. The plant features interesting architecture, art, and on-going visitor tours with public education about urban stormwater runoff, making this interesting, pioneering engineering facility an engaging tourist attraction. There are proposals to construct similar plants at Lake Tahoe.

Figure 1: SMURRF Plant

This plant is intriguing for reasons other than its merits as a currently one-of-a kind centralized stormwater collection and treatment facility. The presence of a “brick and mortar” plant and the costs associated with its construction, operations and maintenance provides an excellent opportunity to compare its long term costs with the costs of protecting and/or restoring the treatment capabilities of a natural, functioning riparian systems. If we do allocate financial resources to protecting riparian resources or to restoring degraded waterways, this comparison gives us one method for assigning monetary benefit values for these natural system restoration projects based upon the avoided costs of more costly “brick and mortar” plants that would provide similar water quality services.

The SMURRF Plant Functions and Costs

The SMURRF Plant was constructed in 2000. In 2008 dollars, construction costs were approximately $14.8 million dollars and the annual maintenance and operations costs are about $216,900 a year; the plant treats about 320,000 gallons of runoff a day. [2] One function of the plant is to remove fine sediments from the water, which is accomplished with a rotating drum screen. A second chamber removes grit and sand. Oil and grease are then removed in a unit that aerates the water using a compressed air unit (the dissolved air flotation unit). This unit brings the oil and greases to the top so they can be skimmed off.

The next process in the plant is micro-filtration, which helps reduce the turbidity of the water by forcing the water through membranes. The membranes have to be periodically cleaned of pollutant build-up. The final step in the treatment process is to disinfect bacteria and viruses by passing the water under ultraviolet radiation lamps. The basic functions of the plant therefore are to filter sediment, reduce turbidity, trap oil and grease, and treat bacteria and viruses. Removal of sediment can also benefit removal of nutrients and other pollutants that may adhere to it. [3] A separate trash collecting unit, which cost $200,000, catches trash from about 50,000 gallons a day before it enters the plant.[4]

Comparing A Treatment Plant To A Stream

To compare the costs of a “brick and mortar” plant with the costs of protecting and/or restoring a riparian corridor, we need to identify whether the water treatment functions of the plant and the riparian corridor are similar, including an evaluation of the treatment of similar quantities and qualities of stormwater. The SMURRF plant treats approximately 320,000 gallons of water a day. The water treated is not wet weather runoff but dry weather run-off collected from about 5,100 urbanized acres. Stormwater flows from winter rainfall continue to run untreated into the ocean.[5] Theoretically, the plant could be

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[2] City of Santa Monica (2003) and Shapiro (2005) Visit the SMURFF website at: http://www01.smgov.net/epwm/smurrf/smurrf.html
[3] City of Santa Monica (2003).
[4] Shapiro (2005).
[5] Shapiro (2005).

expanded to treat wet and dry weather runoff, but for now it is assumed that the costs per gallon of either dry season or wet season runoff are comparable. It is important to keep in mind that the plant may treat runoff from 5,100 acres but only treats a small portion of the runoff from that acreage. Therefore, we cannot use as a basis of comparison the number of acres served by our "brick and mortar" plant and natural "facilities," but we need to compare systems that can accommodate similar quantities of water. Under perfect research conditions we would collect a wide variety of water quality and sediment measurements for the same discharges in both the field conditions and the plant and compare them. This is challenging to achieve at this time, but a future research project may try to evaluate some water quality parameters at low discharges on Wildcat Creek at the project site.

A stream flowing at 1 cfs (cubic foot per second) produces a volume of water equal to 646,272 gallons per day. The 320,000 gallons treated by the plant equates to about 0.5 cfs flow per day. Using watershed and hydrologic information from a San Francisco Bay Area stream we can estimate the size of the drainage area and creek that would produce a flow of about 0.5 cfs and then evaluate the ability of a stream of this scale to treat stormwater naturally. We can also compare the costs associated with restoring a length of stream that would treat a similar average annual flow to the costs of the stormwater plant providing similar water quality services.

The San Francisco Bay Area creek we will use for a costs and benefits comparison with the plant is Wildcat Creek located in the cities of Richmond and San Pablo, and the East Bay Regional Park system in Alameda and Contra Costa Counties (Figures 2 and 3). The average discharge or average annual flow (the arithmetic mean of the daily flows for the period of the hydrologic record) of Wildcat Creek using twenty years of gage data located on the creek is approximately 7 cfs for the location we are going to evaluate on the lower portion of Wildcat Creek. This twenty-year average for the daily flow takes into account the occurrence of large fluctuations of flows during the year, including very low summer flows where the creek may dry up in places, to high flood flow events—as high as 2,000 cfs or more. Wildcat Creek drains a watershed area of about 11 square miles and the length of the creek is about 11 miles.

Figure 2: Wildcat Creek Floodplain Flows

Figure 3: Wildcat Creek Channel

The length of the Wildcat Creek stream channel is about 5,280 feet for each square mile of watershed drained, and the average daily flow from this square mile is about 0.64 cfs. Using this hydrologic information for the Wildcat Creek watershed we can estimate that a section of creek channel about 4,125 feet long comprising an area of 0.78 square miles of the lower watershed will produce a 0.5 cfs average daily flow on an annual basis. Another way to describe the scale of this watershed is as a 500-acre area. In 2000, the Wildcat San Pablo Creeks Watershed Council completed a restoration project 5,000 feet long on lower Wildcat Creek where the average daily discharge is about 7cfs. The width of the riparian corridor varies from 50 feet to 65 feet. The channel width is 10 feet and the floodplain located outside the riparian zone is maintained in grasses, shrubs, and cattails. The entire corridor is 250 feet wide. If you evaluated this reach of creek in isolation from the rest of the watershed it would produce about 0.6 cfs average daily discharge. The scale of this project and the discharges produced by this reach (if considered separated from other watershed runoff) make it a reasonable case study with which to make comparisons to the SMURRF plant which treats an average daily discharge of 0.5 cfs.

Natural Riparian Systems Functions

Research and collected field data is now available that addresses the issue of not only the water treatment functions riparian systems perform but also the area of the natural systems that produce the treatment results. A significant body of water quality research details the ability of riparian systems to store sediment, and retain and transform excess nutrients, pesticides, and toxic substances.[6] The literature represents a wide range of environmental conditions and landscapes and therefore produces a range of quantifiable findings. For example, researchers in Corvallis, Oregon found that 60 to 80 percent of the sediment generated from forest roads were captured by less than 250 feet of a healthy riparian system in point bars and pools, and their measurements indicated that stream systems could store sediment for as long as 114 years.[7] A study in the Southern Appalachian Mountains indicates that phosphorous- and nitrogen-containing compound ammonium traveled less than 65 feet downstream before being removed from the water by riparian areas.[8] First order headwater streams in the northeastern United States have been found to be responsible for 90 percent phosphorus removal.[9] A mathematical model based on research in 14 headwater streams throughout the country shows that 64 percent of inorganic nitrogen entering a small stream is transformed within 3,000 feet of stream channel.[10]

[6] Meyer et al. 2003; Klapproth and Johnson 2000); Wenger 1999; Osborne and Kovacic 1993; Peterjohn and Correll 1984; Chagrin River Watershed Partners 2006;Perry et al 1999; Mayeret.al 2005
[7] Meyer et al. 2003.
[8] Meyer et al. 2003.
[9] Meyer et al. 2003.
[10]Naiman et al. 1997.

In general, riparian areas are found to be efficient at processing organic matter and sediments, and sediment bound pollutants carried in surface runoff are deposited effectively in riparian forests and floodplain areas. The finer sediments are removed from runoff as a result of deposition and erosion, infiltration, dilution, and adsorption/desorption reactions with woodland soil and litter.[11] Riparian systems are known to have significant impacts on water temperatures and microclimates.[12]

Scientist have described how the oxidized hyporheic water from the stream bed mixes with the interstitial water flowing from riparian zones, which reduces the transfer of inorganic nitrogen and phosphorous to stream water. Ecological process that occur in the hyporheic zones have strong effects on water quality in which bacteria, fungi, and other microorganisms living in stream bottoms consume nutrients and convert them to less harmful, more biologically beneficial compounds. [13] Riparian areas and their floodplains have been measured to remove 80 to 90 percent of the sediments contributed by agricultural areas.[14] Plant uptake can be an important mechanism for nutrient removal in riparian forests in both intermittent and perennial streams.[15] The width and length of riparian corridors needed to act as chemical filters for nitrogen varies by stream environment, but researchers have found that riparian areas as narrow as 48 feet were effective in removing it.[16] A project involving fencing a 5000 lineal foot corridor that is 45 feet wide and planting some willow posts resulted in downstream benefits with a measured significant increase in benthic insect taxa richness and increase of the presence of family taxa typically not found in polluted and degraded conditions.[17] Even smaller headwater areas have been found to rapidly take up and transform nutrients within just hundreds of lineal feet.[18]

Researchers have also found that the loss of riparian areas to clearing and channelization not only equates to a loss of these treatment functions but may also result in the disturbance of areas that have served as nutrient sinks for sediment and sediment associated nutrients, which then causes the export of the nutrient sink accumulated over many years.[19] Removal of wooded areas and the subsequent changes in the peak discharges and shortening of runoff lag time typically results in geometric increases in sediment loads being transported by streams.[20]

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[11] Bhowmilk et al. 1980;Lowrance et al 1984; Lowranceet al 1986
[12] Naiman et al.1997;
[13] Naiman 1997;Korum 1992
[14]Cooper et al. 1987.
[15] Karr and Schlosser 1978.

[16] Cooper et al. 1986.
[17] SFBRWQCB 2007
[18] Peterson, et.al 2001
[19] Kuenzler et al. 1977.
[20] Leopold 1981.

Research also indicates that healthy aquatic systems can transform animal waste and chemical fertilizers into less harmful substances. Vegetated buffers and protected riparian areas with contiguous riparian corridors have been shown to be effective in reducing pathogens such as coliform and cryptosporidium parvuum.[21]

Comparing Costs: SMURFF vs. Habitat Restoration Projects

If it can be demonstrated that the water quality treatment services of a "brick and mortar" plant can be equated to similar services provided by naturally functioning riparian systems, then a cost comparison between the "brick and mortar" plant is not only illustrative, but may also provide a benefit measure that can be used to evaluate the economic efficiency of proposed habitat protection and/or restoration projects. For this research, we will compare the costs of the SMURFF stormwater treatment plant with a Wildcat Creek multi-objective project in the Bay Area as well as other restoration projects. The critical underlying assumption is that the restoration projects provide similar water quality treatment services as the SMURFF plant. The following assumptions were used to perform the cost comparisons:

- 50 year analysis period and
- 6% discount rate

SMURFF. The SMURFF plant was constructed in year 2000 at a cost of about $12 million (including land costs). The City Engineer's best estimate on the life of this plant is twenty years, based on the technology becoming obsolete by that time, although she cautions that breakdowns and replacements of machinery are inherent in the use of the new technology. The plant construction and land costs converted to 2008 dollars are $14.8 million.[22] Annual maintenance costs are now approximately $216,900 per year. Because the plant's life is shorter than the 50-year analysis period, replacement costs ($5,000,000) were included for each 20 year period to account for significant machinery and equipment replacement. Therefore, the SMURRF construction and operations and maintenance costs annualized over this length of time are about $1.3 million per year for the treatment of 0.5 cfs per day.

Wildcat Creek. Between 1986 and 1989, the Army Corps of Engineers, in partnership with Contra Costa County, constructed a multi-objective flood damage reduction project which included acquisition of the 250-foot-wide-corridor, and creation of a floodplain, vegetated corridor, and stream channel within the 250-foot-wide-corridor over 10,000 lineal feet. Objectives of the project were to provide for a naturally functioning bankfull stream channel and adjacent floodplain, and protection of a riparian corridor. In 2008 dollars, the total construction costs for 10,000 lineal feet was about $26.7 million, and land costs and relocation costs were about $3.7 million for a total project cost of about $30.4 million. The annual maintenance cost expended by the county for this project area and staff support for the watershed council, which oversees the long tem management of

[21] Meyer et al. 2003; Tate, et al. 2004; Tate 1978; Balance Hydrologics 2007.
[22] Higbee 2007.

the project area, is approximately $9,000 per year. Army Corps projects represent the high end of costs for stream and river restoration work; the costs in this case equated to about $2,700 per lineal foot. To make this project comparable to the SMURFF plant, a length of 5,000 should be used, or about half the size of the Army Corps project. Thus, the costs of this project were halved which results in annualized costs over a fifty year period of approximately $967,600 per year.

The Army Corps project should have similar water quality treatment capacities as the SMURRF plant in respect to sediment removal, nutrient absorption, and breakdown of grease and oils, as described above. This riparian area also has the inherent capacity to reduce bacteria and viruses. The ultraviolet light treatment for pathogens is likely a more consistently reliable treatment for the latter; therefore, this may be the one area in which natural riparian system do not have equal treatment capacity. However, the primary objective of this project is flood damage reduction, and water quality benefits would be incidentally related to the creation of a vegetated floodplain corridor. Thus, it is unfair to compare the total cost of the Army Corps project with the SMURFF plant because many of these project costs should be allocated to the flood damage reduction objective, and such a cost allocation was not performed. However, even without a water quality cost allocation, the annualized cost of the Wildcat Creek project ($967,600) is less than the SMURFF plant ($1.3 million per year).

In 2000, the Wildcat-San Pablo Creeks Watershed Council implemented a 5,000-lineal-foot project along a reach in the same corridor to bring the project into conformance with the latest in geomorphic and engineering design knowledge and to provide a stream system with improved environmental values that could better maintain itself in an equilibrium condition. This project restored the stream channel to new dimensions, increased its sinuosity, and increased the average width of the riparian corridor from 30 to 55 feet. The 2000 project represents a major design and construction effort of the county and a non-profit organization; however, the project represents the lower end of the costs spectrum for restoration work at only $23 per lineal foot, for a total cost of $116,600 ($2008). The Army Corps did provide a design document that helped validate the restoration design prepared by the non-profit organization. If the cost of that document is included, the cost of this restoration project is increased to $239,300, with a per lineal foot cost of $48 (2008 dollars). The annualized cost of this restoration project for a fifty-year period is $19,700 per year including maintenance costs (in 2008 dollars). If we add in the original land acquisition costs included in the earlier Corps project, the average annual cost increases to $253,600 and the cost per lineal foot to $785 (in 2008 dollars). Thus, the Wildcat Creek case allows us to compare very high and low range costs associated with stream restoration projects that occurred along the same reach of channel at different times.

Fencing/Easement/Restoration Projects.
Protecting With Easements and Fencing
The restoration of degraded riparian corridors is a relatively expensive method of attaining their benefits compared to the more cost effective method of retaining the benefits through the protection of stream and floodplain corridors. Two of the most

effective and commonly used methods to protect and or restore streams are to fence out livestock and/or purchase conservation easements to remove riparian corridors from grazing or other agricultural uses. Only very limited cost information is available for purchase of conservation easements to protect riparian resources in the San Francisco Bay Area. The Napa Valley Regional Natural Resources Conservation Service office located in an agrarian region contiguous with the more urban part of the San Francisco Bay Area, reports that it is exceedingly rare for the federal wetland and floodplain reserve programs to be used to acquire easements in the more urbanized coastal, high value urban and agricultural lands. This rarity of conservation easements is a result of the fact that most of the Bay Area landowners generally want in-fee purchase for the total land values, and land trusts are reticent to accept the maintenance and management costs associated with conservation easements for relatively small linear tracts of property characteristic of riparian corridors as opposed to the advantages of purchasing large parcels of property for open space and wildlife refuges. The U.S. Department of Agriculture reports that its wetland reserve program was used once in the past decade in the Bay Area in partnership with Marin Audubon Society in east Marin County, where the easement price was capped at $5,000 an acre. Most wetland reserve programs are capped at $3,000 per acre federal acquisition costs, but coastal counties in California are allowed a $5,000 cap. In Stanislaus County (inland from the Bay Area) easements purchased in 1999 along the Tuolumne River required a combination of funding sources to cover costs as high as $4,000 an acre.[23] If the per acre cost of $5,000 is applied to a 150-foot-wide riparian corridor it puts the cost of a riparian easement at $86,000 for 5,000 lineal feet of stream. Fencing costs to protect riparian corridors can typically range from $19,000 to $26,000 for a 5,000-foot length of creek (including both banks).[24] A fencing cost of $26,000 results in an annualized cost of about $1,900. The costs estimates in this paper focus on the costs of both in-fee acquisition of land and restoring a 5,000 foot riparian corridor in urban western Contra Costa County and represent low, moderate and high costs associated with an urban environment.

Typical Restoration Costs

The above costs provide actual figures for expensive and low cost projects; therefore, it is also useful to estimate costs that better represent average costs for stream restoration projects. Based on the experience of the author, who is involved in implementing stream restoration projects and comparing costs with other practitioners, a reasonable average lineal foot cost for a project of this scope conducted in 2008 in the San Francisco Bay Area would range between $300 and $700. Using the higher average value of $700 per lineal foot, a reasonable capital cost estimate for a “typical” 5,000-foot riparian restoration project in the median range would be $3.5 million. Adding in average annual maintenance costs of $5,000 per year brings the annualized costs over a fifty-year period to $227,000 per year.

Thus far, we have established that our total project cost comparisons on an annualized basis are $1.3 million per year for the SMURRF plant, and the restoration projects have a wide range of annual costs, from $967,600 for a large multi-objective federal project to

[23] Blake 2008 and Fourkey 2008.
[24] Blake 2008.

$227,000 for “typical” restoration projects and $1,900 for fencing projects. Research indicates that the wide riparian and floodplain corridor and project length of the Wildcat creek case should be more than adequate to insure equivalent water treatment functions and benefits as the plant except possibly virus control. The reason we evaluated a 5,000 foot restoration corridor on Wildcat Creek is that this length of corridor, if it was viewed in isolation from the rest of the watershed, would produce approximately an equivalent average daily flow of about 0 .6 cfs compared to the SMURRF plant average daily discharge of 0.5 cfs. However, we do have to recognize that we are probably not comparing equivalent water treatment functions because the average daily discharge that flows through this restored section of Wildcat Creek—because it is part of a larger watershed—is closer to 7 cfs, as opposed to the 0.5 cfs treated by the plant. Again it is reasonable to assume that the riparian corridor is affecting the quality of the total average daily 7 cfs. We could correct for the equivalent costs for “treatment” of 0.5 cfs by proportionately lowering the costs to approximate the costs per cfs treated. For example the treatment by a riparian system of 7 cfs average annual flow comes at a cost of $877,200 for the large, multi-objective federal project and therefore, theoretically, the costs for treating only 0.5-0.6 cfs would be about $63,000.

Multiple Benefits

This analysis so far restricts itself to only the comparable water treatment functions of the riparian system and the SMURRF plant. However, there are additional benefits of both the SMURRF Plant and the riparian systems that should be recognized and these can be described in either qualitative or quantitative terms.

The SMURRF plant also serves as a public education facility in which visitors can tour the plant and read interpretive displays about the plant and stormwater management. City records indicate that the plant averages about 230 visitors a year.[25] Some of the water treated by the SMURRF plant is sold to customers, including the City of Santa Monica, for landscape irrigation and use in dual plumbing systems. Currently the water supplied by the plant is used in the new dual- plumbed Santa Monica Public Safety Building housing the police and fire departments, and the water is used to irrigate the grounds of the civic center parking structure, city parks, and cemetery, and Caltrans applies it to Santa Monica freeway landscaping. The income receipts for this water use currently total $32,000 a year based on 2003-2004 records.[26] New water customers just now hooking up include a state-of-the art Rand Corporation Building and a commercial building known as The Water Gardens, which will be dual plumbed. It is estimated that this may increase the use of the water from the plant by 20 percent; therefore, receipts in the next few years could reasonably expect to increase to almost $40,000 annually. Unused flows return to the regional sewage treatment plant. It is very hard to predict future demand for the water cleaned by the plant because high volume estimates would be based on demand for newly constructed dual plumbing systems. The city water resources engineer’s best estimate of a potential full use annual income if there is a demand for the full 230,000

[25] Higbee 2005.
[26] Lowell 2005.

gallons a day (based on a three tier pricing rate structure) is about $390,000 per year by 2016.[27] If we apply some optimistic assumptions about increasing demand over time for the water supply created by the plant, which includes a demand for the full amount treated by 2016, the plant will bring in an average annual income, based on a plant life of twenty years, of about $150,000 per year. (The plant may reasonably bring in total revenue of about $3,000,000 during its life span.) This benefit helps offset the annual maintenance costs of $216,900 ($2008) which lowers the total annualized costs of the plant to about $1.1 million a year.

The Wildcat Creek restoration project has enabled an adjacent regional trail to be developed, and the project serves as a part of the educational opportunities for a very disadvantaged elementary school serving an impoverished community located next to the creek. The creek restoration area is also the focus for a Richmond High School environmental education program that serves about 25 students a year. The elementary school located next to the restored creek banks serves about 307 students a year. The project also serves as an anadromous steelhead (a threatened species) fisheries habitat restoration project and supports habitat and protection for the endangered California clapper rail and salt marsh harvest mouse. It is known that the restored riparian system offers habitat for mammals, raptors and other birds, and a range of aquatic organisms. One of the important objectives of the restoration project is to protect 200 acres of high quality brackish marsh from degradation by sedimentation. Environmental organizations hold regularly scheduled birding and wildlife hikes along the creek. The restored creek serves as the location for an on-going inner city youth environmental stewardship, training, and employment program that has involved an average of another 15 students on an annual basis for the past ten years, and there are varying numbers of community based water quality monitoring volunteers. This particular program has attracted over $200,000 in grants and donations to the community's desperately needed youth programs in a ten-year period.

Water Quality Program Policy Implications

Water quality programs have followed a logical progression from the first emphasis on the treatment of "point pollution" discharges from sewage treatment plants and industrial facilities. The second generation of water quality programs has focused on the avoidance and treatment of polluted runoff from "non-point" sources. The U.S. Environmental Protection Agency has identified six categories of non-point sources of polluted runoff including: urban properties and streets; farm fields, pastures and operations; forestry activities; marinas and recreational boating; hydromodifications of streams such as channelization, bank stabilization projects and stormwater discharge increases; and alteration of wetland and riparian areas. The three strategies applied to managing non-point sources pollution are prevention of pollution at the source, control and reduction of unavoidable runoff, and cleanup and remediation of pollutants that remain. Best management practices including environmentally sensitive land use and development site plans, and stormwater catchment and detention and filtering systems are common

[27] Lowell 2005.

examples of source control and remediation. Protecting riparian areas, of course, directly addresses the avoidance of pollution from environmentally damaging hyrdomodifications and alterations of wetland areas. The evaluation most often missing from this non-point source management model is the recognition of the role of natural riparian areas to serve as part of the remediation system for runoff that escapes catchment and or detention near its source. This gives added value to riparian areas of not only addressing a part of the strategy to avoid degradation but also pro-actively remediating the impacts of various causes of non-point source pollution. A possible practical application of this information could be to assign water quality credits for meeting TMDL requirements in a watershed through the implementation of stream protection and restoration projects.

Current water quality budgets and priorities should evaluate the expenditures that have gone into treatment plants in the past and the expenditures that could occur in the future with mechanical stormwater treatment facilities, and use this evaluation as a budgeting framework for addressing the next generation of treatment systems. The comparisons described here indicate that projects designed to restore degraded stream environments as fully functioning water treatment systems (which provide a significant range of other environmental benefits) can have a wide range of annual costs, from $967,600 for a large multi-objective federal project to $227,000 for “typical” restoration projects but involve discharge amounts much greater than those addressed by a treatment plant. More attention could be given to the purchase of riparian easements for unprotected riparian corridors in suburban and urban areas to provide cost-effective long term benefits as part of a protection program which supplements regulatory programs. The costs of these alternatives can be compared to the annual cost of the stormwater treatment plant of around $1.3 million for a system that treats a fraction of the amount of water and that has inherent limitations on additional environmental benefits. This represents a substantial magnitude in cost differences while the benefits of riparian environmental protection or restoration should be viewed as a more sustainable approach for attaining many more benefits through time.

Comparison of Project Costs (2008 Dollars)

US Army Corps of Engineers Wildcat Creek Project	**Wildcat-San Pablo Creeks Watershed Council Wildcat Creek Project**	**SMURRF Plant**
1986 U.S. Army Corps of Engineers multi-objective flood damage reduction project of 10,000 foot length Estimated construction costs: $26,673,400 Estimated permanent rights of way and relocation costs for $3,687,700 Total project costs: $30,361,100 Design and construction per lineal foot: $2,700 Average Annual Maintenance costs: $9,000 These costs were reduced by 50% to be comparable with a stream length (5,000 feet) that would provide similar water quality benefits.	2000 Watershed Council Restoration Project (executed by Contra Costa County and a non-profit). Channel excavation and partial revegetation for 5,021 feet of project channel Costs: $116,600 for design and construction by the watershed council $127,700 Army Corps planning Total Cost: $239,300 Design and construction per lineal foot including Army Corps planning; $48 Average Annual Maintenance including management of the watershed council: $4,500.	Constructed in 2000. Values provided by City of Santa Monica Construction costs: $14,761,900 Land Costs: The land used for construction of the SMURRF plant was in city ownership and is an odd shaped parcel, which made it infeasible to develop. The Los Angeles Assessors' office values the parcel of land, 2,783 sq. ft at $33,300. . Average Annual Management costs: $216,900
Total Annual Average Cost for 5,000 length project $967,600	**Total Average Annual Costs $19,700** **With Corps land purchase & relocation costs: $253,600**	**Total Average Annual Cost $1,283,800**

Data from:

- Contra Costa County Wildcat and San Pablo Creeks Project Cost Summary
- 1985 U.S. Army Corps of Engineers Design Memorandum for the Wildcat- San Pablo Creeks Flood Control Project, Richmond, Contra Costa County, Calif.
- City of Santa Monica
- Cost annualization computed over a fifty year analysis period with a 6% discount rate (Capital Recovery Factor = 0.06344)

Comparison of Projects Benefits

Summary of Benefits of the Wildcat Creek Project	Summary of Benefits of the SMURRF Project
• 6.9 acres of high quality riparian corridor with a diversity of species and forest tiers to support wildlife habitat • 5,000 lineal feet of fish habitat and habitat for other aquatic species • Water quality functions: sediment collection and storage; nutrient uptake and conversion; bacteria reduction • Watershed Council conducts biannual community sponsored program of trash clean up • Water quality functions for average annual flows and greater magnitude flows • Flood storage and conveyance sufficient to protect the surrounding community from the damages associated with the one in one hundred year flood. Estimated average annual savings from avoided flood control damages calculated by the Army Corps of Engineers in 1986 for the period 1988-2088 is $1,498,000 ($2008). • Active, hands-on environmental education experiences including water quality monitoring, and cleanup and revegetation projects for 340 plus elementary school students and other local public schools and community members • Youth training and employment projects (ten year program attracted more than $200,000 to community youth programs) • Riparian corridor bird habitat and bird watching for hikers who use the creekside trail. (The Sierra Club, schools and other organizations sponsor hikes.) • Riparian corridor and floodplain protect 250 acres of downstream brackish and saltwater wetlands and San Francisco Bay water quality. • Endangered species habitat	• 1,200 sq.ft. educational facility for the public. Visitors recorded averaged 230 annually • Partial trash collection • Treatment of low-flow dry weather runoff • Water Quality functions: sediment removal; nutrient removal to a water treatment plant for further treatment; bacterial treatment, and virus control • Protection of the Santa Monica beach and the surfers and other public who frequent the ocean in the area • Income from the sale of recycled water averages $153,000 a year. • Water conservation for avoidance of use of equivalent potable supplies.

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