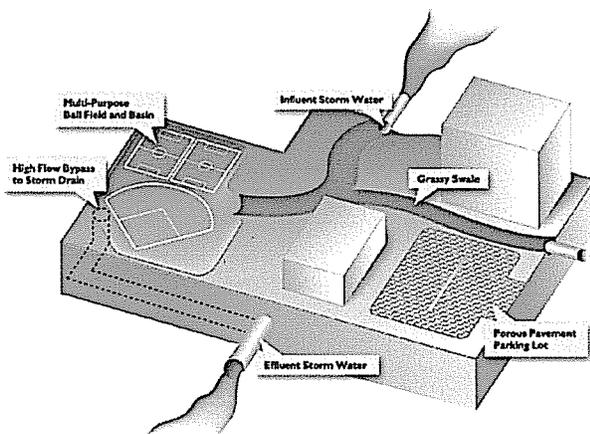


REGIONAL SOLUTIONS FOR TREATING STORMWATER IN LOS ANGELES COUNTY:

A MACROFEASIBILITY STUDY

Prepared by:

BROWN AND
CALDWELL



Prepared for: The Construction Industry Coalition on Water Quality (CICWQ)
April 2003

REGIONAL SOLUTIONS^{FOR} TREATING STORMWATER IN LOS ANGELES COUNTY: A MACROFEASIBILITY STUDY

Date: 12/7/10
Submitted in E&E Committee
Council File No: 09-1554
Item No: 4
Deputy: Adam R. Lid

Prepared by:

**BROWN AND
CALDWELL**

Nancy Gardiner
Cindy Paulson, Ph.D; P.E.
Grant Hoag, P.E.

Prepared for: The Construction Industry Coalition on Water Quality (CICWQ)
April 2003

ACKNOWLEDGMENTS

CICWQ wishes to thank members of the Technical Advisory Committee and others who provided valuable input to this Macrofeasibility Study, including representatives from the following.

- City of Los Angeles
 - Coalition for Practical Regulation
 - Executive Advisory Committee of the Los Angeles County MS4 Permittees
 - Los Angeles and San Gabriel Rivers Watershed Council
 - Los Angeles County Department of Public Works
 - Metropolitan Water District of Los Angeles
 - San Gabriel and Lower Los Angeles Rivers and Mountains Conservancy
 - Sanitation Districts of Los Angeles County
 - Southern California Association of Governments
-

TABLE OF CONTENTS

EXECUTIVE SUMMARY

1. INTRODUCTION	1
On-Site Versus Regional Watershed Approaches	
The Opportunity	
Regulatory Setting: Stormwater Permit Requirements	
Future Regulations: Total Maximum Daily Loads	
2. REGIONAL SOLUTIONS TO STORMWATER MANAGEMENT	4
BENEFITS OF A REGIONAL SOLUTION	
Water Quality Improvements	
Timing	
Long-Term Maintenance	
Cost Effectiveness	
Multiple Uses	
Beneficial Reuse of Stormwater	
WATER QUALITY TRADING	
3. REGIONAL SOLUTION FUNDING ALTERNATIVES	6
FUNDING SOURCES	
Operations	
Projects	
Extractions: Development of Fees and Contributions	
NEW STORMWATER FEE APPROVAL REQUIREMENTS	
Stormwater Fee Struck Down	
Fee Increased Approved	
Fee Increased Not Approved	
Approval Requirements – Majority Versus Supermajority	
City of Los Angeles Tax Bond Initiative	
SUPPORT FOR STORMWATER FUNDING	
4. IMPLEMENTATION OF THE REGIONAL SOLUTION: CASE STUDIES	9
FRESNO	
WASHINGTON, DC AREA	
DENVER AREA	
CINCINNATI AREA	

5. MODEL PROJECT 11

MODEL PROJECT DEVELOPMENT

MEASURES OF EFFECTIVENESS

- Impacts on Water Quality
- Area Treated
- Timing of Improvements
- Cost

MODEL PROJECT QUANTIFICATION OF BENEFITS

- Initial Estimates
- Modeling
- Field Data
- Funding

6. CONCLUSIONS 14

REFERENCES

EXECUTIVE SUMMARY

New regulations in Los Angeles County require on-site treatment of stormwater runoff in areas that are undergoing new development or redevelopment. This smaller-scale on-site approach, however, is less effective in controlling water quality than larger-scale regional, watershed-based approaches.

This Macrofeasibility Study, authored by Brown and Caldwell and sponsored by the Construction Industry Coalition on Water Quality (CICWQ), evaluates the potential for achieving stormwater quality improvements through effective regional approaches. These regional solutions would employ comprehensive best management practices to treat urban runoff from new development sites, as well as surrounding sites that have already been developed. Many groups in the Los Angeles area are interested in applying these regional, watershed-based approaches to achieve comprehensive, long-term water quality solutions.

THE OPPORTUNITY

Municipalities, industry and the general public face new challenges in managing water quality as a result of evolving environmental regulations. Recent amendments to Los Angeles County's municipal stormwater permits require stricter controls on runoff from new land development and significant redevelopment projects. Additional controls on urban runoff could also result from Total Maximum Daily Load (TMDL) limits for pollutants, which are being developed to improve the quality of impaired waters.

Given these pressures, there is a significant window of opportunity for the region to make real improvements in water quality instead of taking a piecemeal, on-site approach. Over the next several years, developers will be required to spend millions of dollars to address stormwater runoff from new development and redevelopment sites. Instead of

spending money on thousands of individual, dispersed facilities—which may or may not be effective over the long term and will treat only small pieces of the overall problem—these funds could support broad, regional solutions and effective, long-term mechanisms that improve water quality cost-efficiency over larger areas.

REGIONAL ADVANTAGES

The amended Los Angeles County stormwater permit relies on Standard Urban Stormwater Mitigation Plans (SUSMPs) to control runoff, on a site-by-site basis, from most new development and redevelopment areas. On-site controls, or SUSMPs, are required regardless of the location of the project, environmental effectiveness, availability of land for treatment, environmental sensitivity or cost.

The SUSMPs must capture, treat or infiltrate runoff from individual sites from a 0.75-inch storm event. SUSMP facilities typically rely on water quality inlet filter devices, oil/water separators or localized hydrodynamic separators. These are often proprietary devices with limited long-term effectiveness in removing pollutants.

Moreover, on-site controls, such as SUSMPs, may work in certain situations, but they are not uniformly effective, especially in treating many toxic pollutants restricted by TMDLs. Much more effective and reliable are regional stormwater facilities, which use infiltration, wetlands or "treatment trains," employing several mechanisms in a series to remove pollutants.

Unfortunately, the amended Los Angeles County stormwater permit does not encourage regional approaches. Regulatory authorities appear to recognize the merits of watershed-based, regional solutions, but in practice they discourage such strategies. Regional solutions require special approval by the Regional Board Executive Officer. In addition, they must meet many additional requirements above and beyond those for SUSMPs. As a result, unless a viable alternative is found, developers will construct on-site controls that may not work well and are not cost-effective to implement.



REGIONAL BEST PRACTICES

This Macrofeasibility Study looks at comprehensive, regional best management practices (BMPs) and systems for treating urban runoff from new development sites, as well as from surrounding areas that have already been developed. The ultimate goal of regional solutions, when fully implemented throughout Los Angeles County, is to substantially reduce pollutants in urban stormwater runoff at a reasonable cost to the region's residents and businesses.

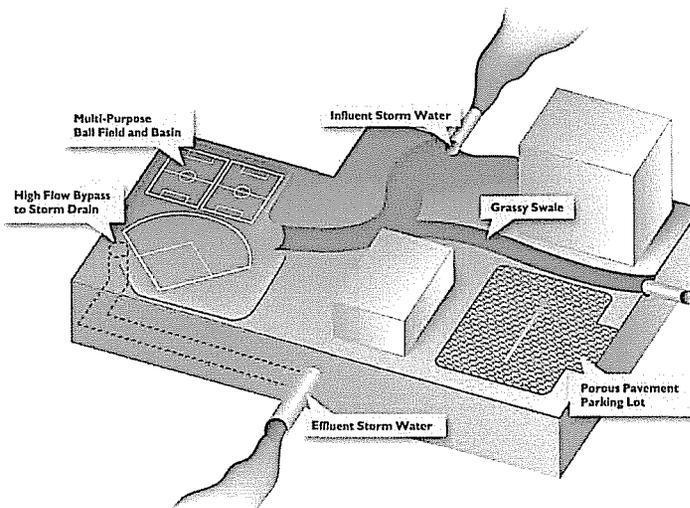
MODEL PROJECT

To illustrate how regional solutions could be applied in Los Angeles, a model project can be constructed at a centralized location to treat runoff from new and existing developed areas. Downtown Los Angeles or nearby redevelopment areas offer potential locations for such a model, given the extent and proximity of ongoing or planned redevelopment.

The project could use regional BMPs to treat runoff from the redevelopment project sites, as well as other urban areas in the county. As an extension of this Macrofeasibility Study, CICWQ is developing details of a model project to be conducted in the next 1 to 2 years in advance of a proposed Los Angeles County ballot initiative in 2004 or 2005.

BENEFITS OF REGIONAL SOLUTIONS

There are many social and environmental benefits of using regional facilities to treat urban runoff. Regional facilities can provide greater benefits for water quality more quickly and cost-effectively than on-site facilities. They can also include multiple-use areas, such as greenspaces and ball fields. In addition, regional facilities can support comprehensive watershed planning efforts to provide holistic solutions and meet multiple basin-specific needs.



In a regional approach, stormwater is routed through a series of control measures to remove pollutants. Some controls may serve multiple functions. Greenspace and ball fields, for example, may double as grassy swales and infiltration basins, respectively, as shown above.



Overall Water Quality Improvement

Municipalities must manage stormwater quality throughout their entire storm drain systems, yet on-site controls such as SUSMPs only address runoff from new development areas, leaving existing developed areas with only limited controls. Regional facilities, however, can treat entire sub-watersheds, including both new and existing development, so overall improvements in water quality are realized much more broadly and quickly.

Regional facilities can also address urban runoff quality during both dry-weather and wet-weather flow conditions. This is particularly important in the greater Los Angeles area, where precipitation occurs about 32 days per year. By treating dry-weather urban runoff during the remaining 333 days per year, regional facilities can provide greater overall water quality improvements than SUSMPs, which are intended only to treat stormwater runoff.

In addition, regional facilities can provide higher levels of treatment than SUSMPs. Finally, more centralized facilities are easier to upgrade and expand as needed to meet water quality objectives, including TMDL requirements.

Improved Long-Term Effectiveness

Without proper maintenance, stormwater treatment facilities can harbor mosquitoes and lose their ability to remove pollutants. Several large, regional stormwater treatment facilities are much more likely to be maintained properly over time than many small, dispersed facilities.

Long-term maintenance of on-site SUSMPs would generally be the responsibility of property owners and homeowners associations. These private individuals and organizations do not often have the capacity to provide effective long-term maintenance, which is necessary to consistently remove pollutants and avoid system failures. Regional solutions, by contrast, are developed through a central agency, such as a municipality, to ensure regular maintenance and effective, long-term operation.

Socioeconomic Improvements

Regional systems can also benefit urban redevelopment areas and enhance public spaces. Most new development in central Los Angeles County is "infill," or redevelopment of vacant or existing properties, providing affordable housing in

economically disadvantaged neighborhoods. There can be special challenges to controlling urban runoff quality in these areas. Many of these communities must balance the competing needs of quality schools, fire protection, crime prevention and other basic services with demands for regulatory compliance. By treating runoff from these areas at centralized downstream locations, such as in dual-use public parks, redevelopment efforts could be maximized and a greater public good achieved at lower cost.

Regional facilities can also provide other advantages, such as improvement of wildlife habitat, the creation or enhancement of public parks and recreation facilities and the preservation of green space.

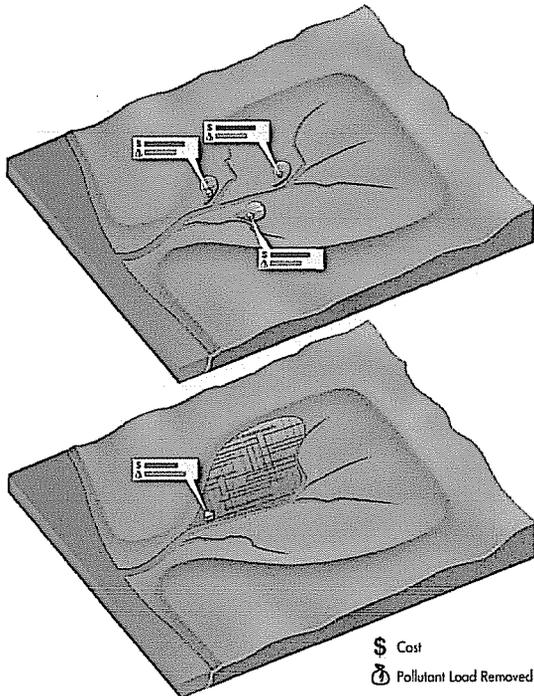
Using Urban Runoff as a Resource

Urban runoff is increasingly being viewed as a potential resource, especially given water supply challenges in Southern California. A number of agencies in the region are considering plans to capture and infiltrate urban runoff to recharge downstream aquifers and enhance water supplies. Regional facilities offer the flexibility to support this integrated resource planning and effective use of limited water supplies.

Lower Cost to Remove Pollutants

Because regional systems treat runoff from large drainage areas, the cost of pollutant removal is lower on a unit basis than multiple facilities (SUSMPs) that are located throughout the same watershed. Taken together, the costs of land acquisition, engineering design, construction and maintenance of a centralized, regional facility can be significantly lower than that for multiple SUSMPs, as shown on the following page.





As seen in the illustration top left, site-specific controls are used at multiple locations to control urban runoff. In the example below, controls are centralized in a more efficient, cost-effective, regional approach.

Support For Regional Solutions

Regional systems for managing stormwater are currently in use elsewhere in the country, and they are gathering momentum in California. Notably, the Santa Clara Valley Water District is strongly advocating the use of regional solutions to control runoff from the new development in the San Francisco Bay Area.

Adopting a Regional Approach

To succeed, regional solutions will require leadership, initiative and cooperation among regulators, municipalities, the development and environmental communities and other stakeholders. In addition to sponsoring this Macrofeasibility Study, CICWQ has been working with other stakeholders to consider a model project to demonstrate that regional solutions can work in the Los Angeles area.

Regulatory Support

To encourage regional approaches, the current Los Angeles County stormwater permit requirements will need to be revised. Local municipalities will also

need to lend support in petitioning regulatory authorities to accept regional alternatives.

Cooperation to Secure Funding

When implemented at full scale, regional solutions throughout Los Angeles County will require funding for facility construction, as well as annual operation and maintenance. If the concepts in this Macrofeasibility Study are embraced and supported by the region's policy-makers, CICWQ is willing to help pursue implementation on a larger scale and develop a coalition to help secure funding.

Only governmental entities have the authority to raise public funds for construction, operation and maintenance of regional stormwater facilities. The funding solution for regional approaches lies in a partnership among stakeholders to achieve a dedicated, sustainable funding source—through a regional ballot measure, for example. CICWQ is ready to work closely with the cities and the County of Los Angeles to promote a ballot initiative or vote of the electorate enabling a regional solution.



Joining Forces

Regional solutions provide an opportunity for all stakeholders to engage in a positive dialogue about what can be done to improve urban runoff quality.

Many other groups in the Los Angeles area—including the Los Angeles and San Gabriel Rivers Watershed Council, the San Gabriel and Lower Los Angeles Rivers and Mountains Conservancy, the Tree People and the City and County of Los Angeles—have indicated strong interest in sustainable, comprehensive watershed approaches to improving water quality. Their ongoing regional efforts could be coordinated to build support for regional solutions.

The model project proposed in this study could help demonstrate the effectiveness of watershed solutions in improving water quality and quality of life in the Los Angeles area. The model could also help provide a roadmap for others to follow in developing more regional projects in the future.



1. INTRODUCTION

Los Angeles's storm drain system, like its sanitary sewage system, collects and moves water, via gravity, from higher elevations to the ocean. The main difference between them is that sewage is centrally treated before it is released into the ocean, while stormwater is not. Regional policy-makers are now requiring on-site treatment for stormwater. Like the septic systems of old, this approach will be relatively less effective in controlling water quality in highly urbanized areas. This Macrofeasibility Study proposes more comprehensive, long-term solutions to address water quality in the Los Angeles area through regional or watershed approaches.

ON-SITE VERSUS REGIONAL WATERSHED APPROACHES

Recently, the region's policy-makers have presented one vision for managing stormwater. It requires capture, treatment or infiltration of the 0.75-inch storm event from most new development and redevelopment sites. This approach relies on Standard Urban Stormwater Management Programs (SUSMPs). SUSMPs are required for most projects regardless of the project's location or potential for pollution. They typically include on-site facilities such as water quality inlet filter devices, oil/water separators or localized hydrodynamic separators. Often, these are proprietary devices with limited long-term effectiveness in removing pollutants.

The regulatory authorities appear to recognize the merits of watershed-based, regional solutions. They require, however, special approval by the Regional Board Executive Officer that such approaches are technically valid and appropriate. As a result of these obstacles, developers will be left to construct on-site controls that may not work well and are not cost-effective to implement.

On-site stormwater controls may work in some places for certain pollutants (e.g., in new developments located on large, flat parcels). They are not uniformly effective, and many are minimally effective in addressing the toxic pollutants of concern in the Los Angeles area. By contrast, regional facilities, such as detention and/or infiltration or wetlands, can provide higher levels of treatment more reliably. A comprehensive regional or watershed approach to stormwater treatment would provide the greatest overall benefit and water quality improvement.

While large-scale residential development is largely located in the region's foothills and urban fringe, most new development in central Los Angeles County is infill or redevelopment. It is often focused on providing affordable housing in economically disadvantaged neighborhoods. The control of stormwater quality in these areas poses challenges beyond the setting aside of land for treatment. Many of these communities must balance the competing needs of quality schools, fire protection, crime prevention and other basic services with regulatory compliance. Runoff from these areas could be treated at centralized downstream locations, such as dual-use public parks, instead of using valuable redevelopment parcels for stormwater treatment. As a result, a greater public good could be achieved at a lower overall cost.

THE OPPORTUNITY

With the recent county stormwater regulations and expected requirements for treating stormwater runoff to meet TMDLs, there is a significant window of opportunity to make real improvements in water quality. Over the next several years, developers will be required to spend millions of dollars to address stormwater runoff from new development and redevelopment areas. These funds could support broader regional solutions and effective, long-term mechanisms to improve water quality over much larger areas instead of thousands of individual, dispersed facilities, which may not be effective over the long term and will treat only small pieces of the overall problem.

Leadership, initiative and cooperation among municipalities and the development community will be needed for regional solutions to succeed. The Construction Industry Coalition on Water Quality (CICWQ) has stepped forward to help provide this leadership and a roadmap for others to follow in the future. CICWQ sponsored this Macrofeasibility Study to outline a regional solution, funding alternatives and a model project to show that regional solutions can work in the Los Angeles area. If the concepts in this study are embraced and supported by the region's policy-makers, CICWQ is willing to pursue implementation on a larger scale and to develop a coalition to help secure funding. Achieving regulatory approval will require strong support from local municipalities, including assistance in petitioning regulatory authorities to accept the regional approach.



Many other groups in the Los Angeles area have also indicated strong interest in sustainable, comprehensive watershed approaches to improve water quality. There are several ongoing regional efforts that could be coordinated, including ones by the Los Angeles and San Gabriel Rivers Watershed Council, the San Gabriel and Lower Los Angeles Rivers and Mountains Conservancy, the Tree People, and the City and County of Los Angeles, among others. The model project proposed in this study could be one demonstration of how regional watershed solutions can improve water quality and provide other important benefits for the area.

REGULATORY SETTING: STORMWATER PERMIT REQUIREMENTS

The current regulation that is driving the need for a regional approach is the Los Angeles County municipal stormwater permit. In December 2001, the Los Angeles Regional Water Quality Control Board (LARWQCB) adopted Order 01-182, which regulates stormwater and urban runoff discharges from municipalities in Los Angeles County. These regulations are enforced through a general NPDES permit that places restrictions on stormwater and urban runoff pollutants flowing through storm drain systems. Eighty-four incorporated cities (except Long Beach) have joined as "permittees" under this regulation.

The permit requires most new development or redevelopment parcels to provide on-site, permanent treatment control BMPs for stormwater runoff. The permit essentially designates SUSMP facilities as the required approach. It does, however, allow regional solutions in Section 4.D.9. Special Provisions - Regional Stormwater Mitigation Program - to substitute for parts or all of the SUSMP requirements.

Unfortunately, the regional program option seems to be offered more as an afterthought than as a viable or encouraged approach. In fact, there are several barriers to the use of regional approaches. The permit requires special application to the Regional Board for approval as well as determination by the Regional Board Executive Officer that the proposed regional approach is "technically valid and appropriate." Any proposed regional solution must demonstrate that its implementation can meet requirements far beyond those required of on-site SUSMP approaches, including:

- Equivalent or improved stormwater quality
- Protection of stream habitat
- Promotion of cooperative problem solving by diverse interests
- Fiscal sustainability with secure funding
- Completion in 5 years, including construction and start-up of treatment facilities.

These same standards are not required for SUSMP implementation. To encourage the application of regional solutions, which can provide greater water quality improvements and other benefits at lower costs, it will be necessary to revise the permit to support regional approaches.

FUTURE REGULATIONS: TOTAL MAXIMUM DAILY LOADS

A new frontier of regulation is imminent, as the region's water quality authorities seek to develop and implement Total Maximum Daily Loads (TMDLs) for numerous rivers, creeks and beaches. TMDLs are developed for "impaired" water bodies that contain an excessive amount of a specific pollutant. They specify a numeric limit (load or concentration) of the pollutant that must be achieved to guarantee that the water body in question will meet water quality objectives. All entities perceived to be discharging these pollutants may be required to install some type of treatment system or device. Municipalities, in particular, face an enormous challenge in meeting future TMDL requirements. The regional approach to stormwater treatment offers more cost-effective strategies for meeting this challenge.

Within the greater Los Angeles area, there are already several efforts to restore impaired water bodies through the TMDL process. Section 303(d), listing of impaired waters requiring TMDLs, identifies several specific pollutants in the Los Angeles area. As shown in Table 1, constituents of concern include trash, metals, pathogens, nutrients, ammonia, and tissue and sediment contamination. Future treatment control BMPs for stormwater runoff may be required to focus on these specific constituents to help meet TMDLs. The Los Angeles County stormwater permit also identifies several target pollutants, including trash, indicator bacteria, metals, PAHs, nutrients (nitrogen), sediment and pesticides.



A recent study conducted by the University of Southern California estimated that 65 stormwater treatment plants costing between \$43.7 billion and \$283.9 billion will be required for stormwater compliance in the Los Angeles area over the next 20 years (USC, 2003).

A significant portion of this cost could be reduced through the implementation of regional solutions that treat the water from sub-watersheds throughout the area.

TABLE 1. SUMMARY OF 303(D) LISTING OF IMPAIRED WATERS IN THE LOS ANGELES AREA

Watershed	Trash	Metals ¹	Pathogens ²	Nutrients/ Algae	Ammonia	Tissue or Sediment Contam ³	Other
Ballona Creek	✓	✓	✓			✓	pH, toxicity
Malibu Creek	✓		✓	✓			Foam, sediment
Los Angeles River	✓	✓	✓	✓	✓	✓	pH, foam, odors, oil, PCE, TCE
San Gabriel River	✓	✓	✓	✓			
Santa Clara River			✓		✓		TDS, chloride, nitrite
Dominguez Channel		✓	✓		✓	✓	

¹Metals may include total selenium, total silver, total aluminum, dissolved copper, dissolved zinc, dissolved cadmium, and lead (not generally specified as total or dissolved).

²Pathogens are indicated by high coliform count. Ballona Creek also includes enteric viruses.

³Tissue and sediment contamination may include metals (e.g., cadmium, lead, silver, zinc), DDT, PCBs, PAHs, and other organic compounds (e.g., aldrin, chlordane, dieldrin).



2. REGIONAL SOLUTIONS TO STORMWATER MANAGEMENT

The Watershed Management Initiative Section of the LARWQCB 2001 NPDES permit points out a need to "...integrate various surface and ground water regulatory programs while promoting cooperative, collaborative efforts within a watershed." It adds that "future success in reducing pollutants from non-point sources and achieving additional reductions in pollutants from point sources requires a shift to a more geographically targeted approach." The strategy proposed in this document reflects that philosophy.

The current stormwater regulations are neither the most efficient nor most cost-effective means to achieve improved water quality. In addition, they lack the vision to efficiently address future compliance needs, such as TMDLs. This study explores whether a regional solution that functions on a watershed or local drainage area basis can achieve greater water quality improvement than infiltrating, filtering or treating stormwater on-site using the SUSMP approach.

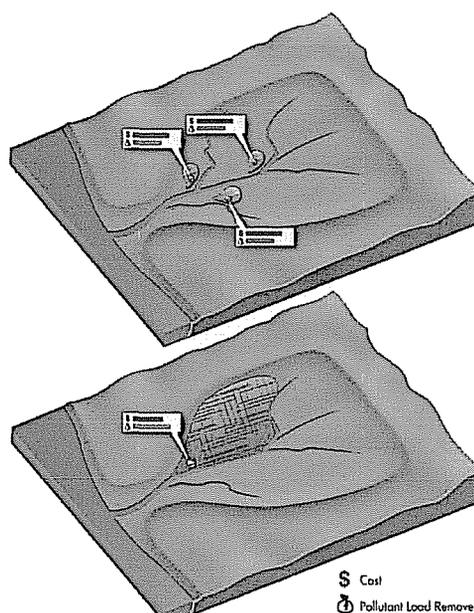
Natural drainage systems work by draining a connected area, or watershed, through branching tributaries, starting at the highest elevations and moving water to a main channel in the basin's lowest points. This same watershed principle applies in urban areas, even though water there is often encased in concrete box-culverts and channels and moves from higher ground to the ocean through an engineered storm drain system of increasingly larger drainpipes and channels.

Watersheds can be subdivided into smaller units, called sub-watersheds, and engineered regional systems can be designed to treat stormwater flows from these smaller sub-watershed areas. Rain vents in a watershed produce too much water and occur much too infrequently to justify the type of management provided by wastewater treatment facilities. In the Los Angeles area for example, storm events occur on an average of about 32 days per year and the remaining 333 days per year are typically dry (USC, 2003). Moreover, most storms that do occur are small, providing frequently less than 0.1 inch of rain.

BENEFITS OF A REGIONAL SOLUTION

There are several significant advantages to using regional approaches to treat stormwater. Regional facilities can support comprehensive watershed planning efforts in which conditions throughout the basin are addressed. They can also support holistic solutions that address multiple basin-specific objectives. Regional facilities can also provide greater benefits for water quality more quickly and cost-effectively than on-site facilities (Figure 1). And they can provide multiple-use areas – such as greenspaces and ball fields - that also treat urban runoff.

FIGURE 1. BENEFITS OF REGIONAL VERSUS ON-SITE SOLUTIONS



In the first illustration (top), site-specific facilities are used at multiple locations to control urban runoff. In the second example, control is centralized using a regional approach, resulting in a lower cost per unit of pollutant removed.

Water Quality Improvements

Now and in the future, municipalities will need to begin meeting TMDL requirements for pollutants in receiving waters throughout the Los Angeles basin. Regional systems can be effective in helping cities meet these limits. First, regional approaches make it possible to manage urban runoff from a larger watershed or sub-watershed area, including existing land uses and new development or redevelopment. Regional facilities can also be optimally located and sized to reduce pollutant loads from all tributary areas within a sub-watershed, not just small discrete portions, resulting in much greater water quality benefits. In addition, regional facilities can address both wet-weather and dry-weather flows. Dry-weather flows, in fact, are suspected of carrying a large portion of urban runoff-related pollutants in the Los Angeles area. SUSMPs, by contrast, are only intended to detain stormwater runoff and could have little or no effect on dry-weather flows. Regional facilities can also enhance water quality to a greater degree by providing larger areas for highly effective, land-intensive treatment methods, such as filtration technologies. Regional facilities, moreover, can be more easily upgraded and expanded to provide higher levels of treatment as needed to meet water quality objectives and TMDL requirements. Finally, regional facilities are more likely to meet water quality standards because design, construction quality and maintenance can be better controlled.

Timing

Regional solutions would generally be constructed in advance of full-scale development and therefore provide immediate water quality benefits. In addition, because regional facilities can be applied to treat entire sub-watersheds, and not just new development or redevelopment, overall improvements in water quality can be realized much more quickly.

For instance, if an area were redeveloping at the rate of 2 percent of the watershed area per year, SUSMPs could require 50 years or more to treat runoff from the entire area. By contrast, a regional solution could address an entire sub-watershed in 5 years or less.

Long-Term Maintenance

Without proper maintenance, stormwater treatment facilities lose their ability to remove pollutants and no longer provide benefits for water quality. Poorly maintained facilities can also contribute to vector problems. A recent survey of on-site facilities on

private land in Spokane, Wash., showed that the majority were failing due to lack of maintenance.

Large numbers of small dispersed SUSMP facilities present major maintenance challenges, often requiring several visits during a storm season to ensure effective operation. Maintenance responsibilities for SUSMPs associated with new development and redevelopment projects generally fall to home-owners associations or management companies. These private organizations are not traditionally set up to provide effective long-term maintenance of stormwater facilities. The municipality, however, would still be required to meet stormwater requirements even if these facilities fail.

Fewer facilities combined with municipal responsibility for maintenance could result in greater assurance of consistent operation in perpetuity.

Cost Effectiveness

Regional facilities are inherently more cost-effective to construct and maintain when compared on a cost-per-acre basis (Urbonaz, 1990). Economies of scale provide greater pollutant reductions for the capital and ongoing operation and maintenance costs expended.

For example, a facility for storing runoff might have an embankment height of 10 feet or less. Small increments in height for a regional detention facility would have minor expense but substantially more volume for storage than on-site facilities, providing greater water quality benefits.

Multiple Uses

A guiding principle of urban stormwater management is that "an urban drainage strategy should be a multipurpose, multimeans effort (WEF and ASCE, 1992). Because of their larger size and jurisdiction, regional facilities present more opportunities to serve multiple purposes. Regional facilities can often provide other advantages, especially in economically disadvantaged areas, such as habitat improvements, green space preservation and public park and recreation facility creation or enhancement.

Beneficial Reuse of Stormwater

Urban runoff is increasingly being viewed as a potential resource, especially given the water supply challenges in Southern California. The City of Los Angeles, for example, is currently working on an



Integrated Resources Plan that would capture a portion of existing dry- and/or wet-weather urban runoff and infiltrate it to recharge downstream aquifers, enhancing existing water supplies (City of Los Angeles, November 2001). The Los Angeles and San Gabriel Rivers Watershed Council is also performing a Water Augmentation Study to explore the potential for increasing water supplies and reducing urban runoff pollution through infiltration of stormwater runoff (Los Angeles and San Gabriel Rivers Watershed Council, 2002). Regional facilities offer the flexibility for future enhancements that would support integrated resource planning and better use of limited water supplies.

WATER QUALITY TRADING

With the projected addition of another 15 million or more people to California by 2025 (U.S. Census, 2002), increasing urbanization will further complicate the task of managing stormwater runoff. Given the unique challenges of highly urbanized watersheds, there are advantages to using innovative approaches such as Water Quality Trading. This strategy allows for cost-effective pollutant reductions within a watershed, where feasible, in exchange for credits that can be applied in other, more challenging areas.

The concept of Water Quality Trading, initiated by the EPA in 1996, was based on principles similar to those of air emissions trading programs that helped solve air quality problems over the last decade. The new EPA trading policy "encourages States and Tribes to implement trading programs" where possible to achieve water quality improvements with "greater efficiency and more flexible approaches" (U.S. EPA, 2002). The EPA recognizes that trading programs are not only cost-effective, but can also provide ancillary environmental benefits beyond reductions in specific pollutant loads, including creation and restoration of wetlands, floodplains and wildlife habitat. In addition, trading programs can help achieve early reductions in pollutants and progress toward water quality standards in impaired waters.

A Water Quality Trading program could provide more comprehensive, watershed-wide solutions to urban stormwater runoff challenges within Los Angeles County. Some of the highly urbanized areas, like downtown Los Angeles, provide very limited opportunities to capture and treat stormwater runoff effectively. By applying a watershed-based

trading program, cost-effective stormwater BMPs could be applied in optimal locations to achieve the greatest reductions in pollutants and the most environmental benefits at the lowest cost. A bank of credits could then be created to provide for pollutant reduction needs throughout a watershed or sub-watershed. These credits could be purchased to achieve the overall reductions required, especially in watersheds with limited opportunities for efficient controls. The credits could then be applied to fund centralized investments in larger facilities to achieve more effective stormwater management and control.

3. REGIONAL SOLUTION FUNDING ALTERNATIVES

When implemented at full-scale, regional solutions throughout Los Angeles County will require significant funding for facilities construction and annual operation and maintenance (O&M). Since regional systems provide multiple benefits, municipal governments would have responsibility for implementing these systems. Unlike private organizations or developers, governmental entities also have the authority to raise public funds for construction, operation and maintenance of regional stormwater facilities.

Stormwater program costs may be funded under a variety of mechanisms. However, state laws governing creation of new tax- and rate-based revenue sources for ongoing program costs are very restrictive.

The program costs are affected by economies of scale. Larger, regionally managed stormwater programs are generally more efficient and less costly than localized projects, especially when these costs include the management, administration and operation of stormwater facilities. Since costs of a stormwater utility are ultimately borne by the region, an area-wide approach results in the lowest cost per household.

FUNDING SOURCES

Public stormwater programs may be funded through periodic local fees, charges and taxes; agency general funding, including utility taxes; one-time impact fees to developers; land conservancies; state and federal grants; congressional appropriations; state low-interest loans; and commercially available bonds. The key issues associated with various funding mechanisms are described on the following pages.



Operations

Operating costs are for salaries, utilities, facility maintenance, administration, contractual services, regional service agreement charges and debt. Operation and maintenance costs cannot be funded with grant or loan proceeds (i.e., assessment district or municipal revenue bond proceeds). All operating costs must come from local fees and charges, interfund transfers from other sources or tax proceeds. In addition, a Mello-Roos Community Facilities District may be formed to fund operations (as well as facilities) by levying special taxes against the real property within the service area. This funding approach is most advantageous for growing communities.

Grants and loans can only be used to fund one-time planning studies or the capital costs of facilities and equipment. Because stormwater treatment programs have a high proportion of operating to capital costs, operations typically have the greatest funding requirements. For example, 75 percent of the stormwater program budget for the City of Santa Ana in Orange County is for operation and maintenance. For this reason, a sustainable funding source for any stormwater program must be local.

State laws regarding creation of new tax- and rate-based revenue sources for stormwater operating costs are very restrictive. Los Angeles County and its cities are unlikely to transfer any maintenance burden to themselves without some form of comparable support. As such, there is a need for a partnership between municipalities and the development community supported by a dedicated, sustainable funding source.

Because regional solutions can address TMDL compliance needs more efficiently and cost-effectively than SUSMPs, municipalities may benefit significantly by supporting regional solutions.

Projects

Municipalities usually fund utility projects from fee revenues and built-up reserves. To the extent that a facility serves increased loads from new development, cities rely on developer impact fees and contributions in lieu of construction. The most common funding sources for larger projects are bond proceeds from the commercial markets. This is also the most costly source because of the relatively high interest payments on the debt. Government-supported debt, most commonly the State Revolving Fund (SRF), provides relief from high interest rates, but it requires more documentation and is less available than

commercial bonds. Low-cost stormwater project funding is available primarily in the form of SRF loans. The Costa-Machado Water Act of 2000, approved by the California voters as Proposition 13, provided much of the state matching funds needed to secure federal funding for the SRF program. The 2002 passages of Propositions 40 and 50 will maintain the availability of this funding for many, but not all, communities. Funding is restricted to specific types of projects. The difference between SRF loans and municipal revenue bonds is currently about 2 percent.

Grant funds, while rare, require no repayment. Stormwater grant programs for local government and non-profit organizations are administered by the State Water Resources Control Board under the Clean Water Act (CWA). The two most significant grant programs are the CWA Section 205(j) grants for watershed planning, and Section 319(h) grants for non-point source pollution control. Funds are exhausted in both grant programs, but they may be restored and available in the future. Statewide competition for these monies, however, will be strong.

Extractions: Development Fees and Contributions

Cities and counties have authority to control growth. With this authority, they may also specify development-related funding methods — known as extractions — for growth-related facilities. The SUSMP requirements, in effect, limit the cities' and county's legal authority to define the nature of the extraction. They dictate that all development-related extractions include specific on-site stormwater load remediation. These SUSMP developer extraction requirements are known as subdivision reservations and project design and improvements, as defined in Chapter 4, Article 4, Sections 66411, 66476 et al of the Map Act. The SUSMP requirements also specify stormwater-related O&M requirements for new development that would otherwise fall to the cities and county.

This study's goal is to support the agencies' authority to use all forms of extractions. Regional solutions would restore the cities' and county's authority to select development extractions providing the same level of stormwater load remediation that the permit requires at lower regional cost and with greater regional benefits. Specifically, the regional solution approach seeks to expand the cities' choices of extractions to include fees in lieu of contributions, as well as mitigation and impact fees. Each fee is slightly different in



definition and use, but all generate agency proceeds for use in acquiring land and constructing facilities to achieve regional permit compliance.

NEW STORMWATER FEE APPROVAL REQUIREMENTS

Proposition 218, approved by the state's voters in November 1996, added Articles XIII C and D to the California Constitution. The key feature of Prop. 218 affecting stormwater fees is Article XIII D, Section 6 (c). It states that some fees need to be submitted for voter approval. Specifically, it provides that "Except for fees or charges for sewer, water, and refuse collection services, no property related fee or charge shall be imposed or increased unless and until such fee or charge is submitted and approved by a majority vote of the property owners of the property subject to the fee or charge..."

Stormwater Fee Struck Down

In July 1999, the City of Salinas adopted a new storm drainage ordinance. The Howard Jarvis Taxpayers Association, et al, initiated a "Reverse Validation Action" to challenge the fee. The County of Monterey Superior Court ruled in favor of the City by finding that the fee was not property-related. In June 2002, however, the California Sixth Appellate District Court (with statewide jurisdiction) reversed the judgment, and the State Supreme Court refused a petition to review the case.

Consequently, some cities have resisted implementing new stormwater fees due to the burden of the ballot approval process. However, some cities have implemented variations of a stormwater fee without the ballot process, as well as water, sewer or trash utility taxes, to support stormwater program costs. While the Jarvis Association will resist circumvention of the voter approval process or attempts to charge for services historically provided without fees, it has expressed support for ballot measures that seek approval for fees needed to fund the incremental new costs of a stormwater utility.

Fee Increase Approved

Since the approval of Prop. 218, only two California cities have attempted a ballot approval of increased stormwater fees. In November 2002, the City of San Clemente conducted the first successful Prop. 218-compliant ballot to increase household fees from \$2.96 to \$7.98 per month. With a 49 percent return on the approximately 17,000 ballots, the measure passed by 57 percent. The ballot effort is believed to have succeeded because the measure provided a sunset on the fee after five years and the moderately wealthy beach community is sensitive to water pollution issues.

Fee Increase Not Approved

In 2000, the City of Palo Alto unsuccessfully sought approval for an increase in stormwater fees. The approval rate of 37 percent failed to reach the simple majority required for passage. The ballot effort is believed to have failed because the City did not adequately inform property owners of funding needs, the fees were permanent and indexed to inflation, and stakeholder opposition was organized and significant.

Approval Requirements—Majority versus Supermajority

Under Prop. 218, a new fee can be approved by a simple majority approval of parcel owners, based on one vote per parcel, regardless of size. By contrast, assessment act bond votes require weighting of votes based on size of the assessment. However, while an assessment act bond can be used solely for facility funding, a fee can be used for any dedicated purpose, including O&M.

Prop. 218 also provides that a new fee may be approved with a two-thirds (supermajority) vote of the electorate in a community. An evaluation of the likelihood of a successful vote, therefore, should include a comparison of property owner voting behavior versus the combined voting behavior of property owners and apartment renters. In urban areas, where a large proportion of voters reside in apartments, the success of a stormwater fee measure may hinge on the difference between the two voting groups.



City of Los Angeles Tax Bond Initiative

In the near future, the City Council of Los Angeles may consider authorizing a citywide ballot for a new ad valorem tax bond of \$250 million. The ballot measure is currently being defined. Its intent is to develop funds, to be spent over 10 years, for complying with the Regional Board permit for trash removal from stormwater flows. It will also fund acquisition of parklands with dual-use capability for stormwater hydraulic and pollutant-load remediation. The bond proceeds are likely to be divided equally between the two activities.

A tax bond requires two-thirds approval for passage, and the City has yet to define the measure as a Prop. 218-related tax. It is possible that staff will restructure the measure from an ad valorem tax to a utility fee before it is presented to the city council.

Under the initiative, the city will receive an estimated \$16 million in annual tax revenues. The impact per typical household is estimated at \$22 per year. This funding will not fully support the city's stormwater program, but the measure will generate new revenues for compliance with elements of the permit.

SUPPORT FOR STORMWATER FUNDING

Most stormwater program costs are for routine operations that are ineligible for either loan or grant funding. As a result, no stormwater utility, regional or otherwise, will succeed without local community funding sources. Nevertheless, while a city may prepare a ballot on fees, law precludes it from actively supporting its approval. City funds may only be used for public information and outreach programs. Nevertheless, in California, successful propositions often require expensive voter campaigns to succeed.

In order to implement new stormwater fees under Prop. 218, a ballot measure must first be approved by at least 50 percent of the parcel owners in the community. Without an extensive campaign, as demonstrated in Palo Alto, opposing stakeholders will easily block the approval of a fee. Private groups such as CICWQ, however, are in a position to persuade the public to support approval of the ballot measure. A collaboration of CICWQ, organizations supportive of environmental causes, neighborhood advocacy groups for increased dual-use parklands and even the Jarvis Association could create a voting block strong enough to develop momentum for a successful ballot measure.

Such a constituency can initiate and promote the outreach needed for a successful ballot for new fees. In exchange, the cities would petition the LARWQCB to accept the regional alternative to the SUSMP and restore their historical authority to define development extractions. Public agencies would also accept the responsibility for O&M of all facilities. Under this scenario, facility costs of on-site stormwater treatment facilities would be replaced by a regionally based stormwater extraction or impact fee. Existing developed areas and new development would enjoy water quality improvement and ancillary benefits under the regional approach. As a result, the costs of improvements and their operation would be supported by all property owners countywide. The level of the extraction fee could be based on the lower costs under a regional stormwater mitigation plan, and fee proceeds could promote acquisition of dual-use open space facilities where feasible. All parties would share in the benefits of this alternative.

This collaborative funding strategy provides synergistic benefits to all participants. The cities would implement new stormwater fee measures with the support of stakeholder funding needed for successful campaigns. Neighborhoods would benefit as redeveloped land is transformed into new open space and dual-use parks and developers would be free from the requirement of building inefficient, development-specific facilities.

4. IMPLEMENTATION OF THE REGIONAL SOLUTION: CASE STUDIES

Regional approaches to managing stormwater are currently being applied elsewhere in the country and are gathering momentum in California. To a limited extent, regional solutions have even been tried in Los Angeles, at Pan Pacific Park, where a multi-purpose recreation area with soccer fields, baseball fields and a picnic site doubles as a detention and infiltration basin. In response to permit conditions requiring on-site controls for new developments, several other cities and counties are exploring regional approaches. Notably, the Santa Clara Valley Water District is strongly advocating the use of regional solutions to control runoff from new developments in the San Francisco Bay Area. Similarly, San Diego's Model SUSMP includes a provision for using "Local Equivalent Area Drainages"—drainages from larger sub-watersheds—as an alternative to the SUSMP.





Pan Pacific Park in Los Angeles serves as both a recreational area and a stormwater treatment basin.



Detention and infiltration basins are used extensively in Fresno, Calif., for regional treatment of stormwater runoff.

FRESNO

While the efforts in Santa Clara and San Diego are recent, some areas of the state have long employed regional stormwater approaches to flood protection and water quality improvement. For example, the Fresno Metropolitan Flood Control District attempts to stay ahead of development by purchasing land in the developing urban fringe for regional infiltration facilities. Each drains an area of approximately one square mile and is funded by a combination of monies from tax revenues and developers' fees.

Developers are required to provide construction-phase water quality controls and design source controls into their developments. The regional facilities provide post-construction water quality treatment, except in areas that discharge directly to

the San Joaquin River. There, developers are required to construct swales on site. The District emphatically pursues multi-objective facilities and has built many parks. Funding for new regional facilities is obtained through "prepaid drainage assessments."

WASHINGTON, D.C., AREA

In other parts of the country, particularly the East Coast, regional stormwater treatment facilities are common practice. Since the mid-1970s, the State of Virginia has been required to control peak stormwater flows. Local governments typically resorted to on-site detention, believing that on-site facilities required less planning and were relatively easy to administer. Many of the local governments in Virginia, however, are now using the regional approach for a number of reasons, including:

- ▣ Lower costs
- ▣ Increased development opportunities, since less land is required
- ▣ Increased recreational opportunities
- ▣ Ability to manage urban runoff from existing and new development
- ▣ Ability to locate regional facilities strategically and achieve improved watershed performance

DENVER AREA

Water quality trading programs have also been effectively applied elsewhere in the country to reduce stormwater pollutant loadings. In the Cherry Creek Basin just south of Denver, Colo., for example, watershed-based trading helped to reduce phosphorus loadings to Cherry Creek Reservoir, one of the state's largest recreation areas, while permitting population growth to occur upstream (WERF, 2000). The trading program relied on credits derived from the construction of several centralized Pollutant Reduction Facilities (i.e., detention ponds, retention ponds and wetlands) that were effective in removing pollutants from stormwater runoff.





Regional stormwater detention facilities were used effectively to control runoff from new development in the Cherry Creek area.

CINCINNATI AREA

More recently, a study of Cincinnati's Shepherd Creek demonstrated that trading could cost-effectively help control excess stormwater associated with development in a watershed area (Thurston, et al., 2002).

5. MODEL PROJECT

This study proposes the development of a local model project, based on credible engineering and scientific bases, to illustrate the applicability of regional solutions in the Los Angeles area. This model project, sponsored by CICWQ, will provide a real-world example of how a regional watershed-based solution compares to alternative on-site (SUSMP) approaches.

The concept of the regional solution is to implement centralized BMPs, treating stormwater runoff not only from development projects but also from existing developed areas of the drainage area. The purpose of the model project is to show that a regional solution to treating stormwater from new development/redevelopment is more cost-effective than an on-site approach and provides greater water quality and multi-use benefits.

MODEL PROJECT DEVELOPMENT

Each potential model project site must:

- ▣ Be located in an area undergoing significant new development or redevelopment

- ▣ Have a drainage area of approximately 1 to 2 square miles (600 to 1,200 acres)
- ▣ Have an existing drainage system offering opportunities for stormwater treatment improvements without sacrificing flood control
- ▣ Be located downstream in order to site regional stormwater controls between developments and the receiving water
- ▣ Have a cross-section of developed land uses within the drainage
- ▣ Offer opportunities for multiple uses such as recreation, aesthetic improvement and improved groundwater recharge opportunities
- ▣ Offer opportunities for partnering and cooperation with development, redevelopment and community groups

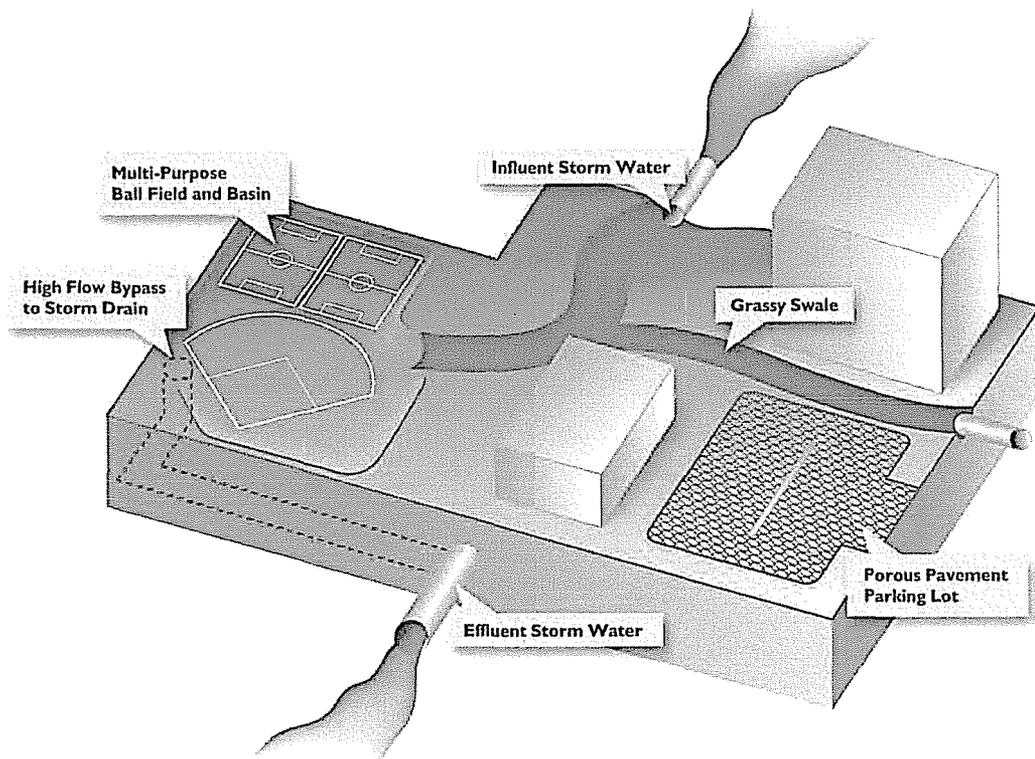
The area of greatest interest for the model project is urbanized Los Angeles County. Given the extent of significant redevelopment and the close proximity of redevelopment projects in this area, it appears that this area could be targeted for a project using regional BMPs that treat runoff from the redevelopment sites and other developed areas.

Flow from the upstream redevelopment site (along with runoff from adjacent developed areas) would be routed through the City of Los Angeles storm drain system into the regional treatment facility. The treatment process would most likely be a "treatment train," or series of treatment systems within the selected location. For example, runoff could be routed from the existing storm drain system through a grassed swale into a sand filter, with overflows directed into a depressed area built to maximize infiltration (Figure 2). The remaining treated effluent could then be discharged back into the storm drain. The regional treatment facilities would be sited in parks, vacant lots or other open spaces at one or more locations located downstream of the redevelopment projects. Potential Los Angeles locations include:

- ▣ Staples Center campus redevelopment project sites
- ▣ Redevelopment projects along Main Street in downtown Los Angeles



Figure 2. Conceptual Schematic of BMP Treatment Train for a Regional Solution



In a regional approach, stormwater is routed through a series of control measures designed to remove pollutants. Some controls may serve multiple functions, such as greenspace and ball fields which double as grassed swales and infiltration basins, respectively, as shown above.



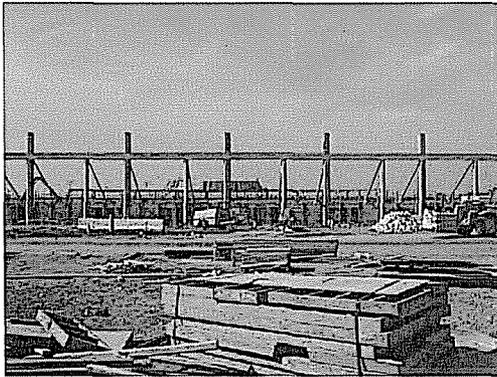
Alternatively, an urbanized watershed site in another Los Angeles community could be selected for the project. For example, in the City of Carson, the California State University—Dominguez Hills area is currently undergoing significant residential and commercial new development and redevelopment, including construction of a soccer stadium for the Los Angeles Galaxy. New development is adjacent to established developed areas, and downstream is the Victoria County Park, which could be a model project site. This location is particularly attractive. Portions of the park land are depressed relative to the adjacent streets, and the park is located between the areas undergoing development and the local receiving water (Dominguez Channel).



Runoff from the L.A. Galaxy Stadium and other developed areas could be treated at a regional facility, such as at Victoria County Park (lower photo).

MEASURES OF EFFECTIVENESS

The regional solution should result in two overall benefits: decreased discharge volume and improved effluent water quality. Together, reduction of volume and effluent concentration would result in reduction of the total "load" or mass of pollutants removed from runoff. The model project will evaluate the effectiveness of regional versus SUSMP approaches by looking at several measures.



Development activities at the new Los Angeles Galaxy stadium on the campus of CSUS – Dominguez Hills.

Impacts on Water Quality

Improvements in water quality associated with urban runoff can occur from reducing both flows and pollutant concentrations. The model project will estimate total reductions in pollutant loading for regional versus on-site approaches.

Area Treated

One of the major advantages of a regional solution is that urban runoff from existing development can be captured and treated along with runoff from new development areas. In contrast, a SUSMP approach would capture and treat runoff only from smaller, dispersed areas associated with new development or redevelopment. The model project will estimate the area to be treated by a regional facility and compare it to the area treated by on-site facilities associated with new development in a selected watershed.

Timing of Improvements

Because much of the Los Angeles area is already highly developed, regional solutions that would capture existing development areas could greatly speed the collection and treatment of urban runoff. The rate of recent and planned development and redevelopment of the selected watershed will be evaluated to estimate the time required to treat the entire watershed using SUSMPs versus regional facilities.



Cost

The costs of implementing SUSMPs or a regional solution will be estimated and compared. Capital, as well as annual operation and maintenance costs, will be considered. The study will also compare the costs per unit of pollutant removed per acre throughout the selected watershed study area under both scenarios.

MODEL PROJECT QUANTIFICATION OF BENEFITS

Given the high degree of variability in stormwater quality, it is challenging and costly to collect enough field data to demonstrate the effectiveness of Best Management Practices for stormwater treatment (ASCE and U.S. EPA, 2002). Therefore, the model project will apply a three-tiered approach to quantify the benefits of a regional system versus on-site facilities. The project will start with desktop evaluations, and potentially lead to field data collection and evaluation. The objective will be to provide cost-benefit comparisons for regional versus on-site facilities.

Initial Estimates

Site-specific data will be collected for the selected sub-watershed to support simple estimates of several effectiveness measures. These include reductions in pollutant loading, area treated, time required for implementation of watershed controls and planning level cost estimates. Site-specific data may include basin characteristics such as existing storm drain system, precipitation, land use, runoff coefficients and development plans.

Modeling

Hydrologic modeling can be applied to provide more detailed estimates of volume reduction and water quality improvements through the regional system. Using hydrologic models such as SWMM or HSPF, simulations can be developed to compare the flow into and out of the regional system. The model can be based on actual data (e.g., historical rainfall record) from the Los Angeles area.

Field Data

Some limited field monitoring of treated effluent could be performed to compare its quality to typical influent runoff concentration ranges for various constituents, measured by the Los Angeles County stormwater monitoring program (more than seven years of data are available).

Funding

Given the nature of this innovative model project, joint public/private funding with the support of grant programs is very likely.

6. CONCLUSIONS

In conclusion, a regional, watershed-based approach is a sensible, cost-effective and scientifically valid approach to water quality management. Regional approaches provide an opportunity for stakeholders to come together and talk about what can be done to improve urban water quality.

There are significant benefits to be gained from a larger-scale regional solution. Although smaller-scale on-site controls, such as SUSMPs, may work in certain situations, they are not uniformly effective. The proposed alternative employs comprehensive regional BMPs to treat the runoff not only from new development sites, but also from surrounding areas that have already been developed. For Los Angeles County, the benefit would be to substantially reduce pollutant loads in urban runoff more efficiently and at a more reasonable cost to area residents and businesses.

A model project can serve as a case study for observing the regional approach in operation in the Los Angeles area. It is hoped that other groups and agencies will pursue regional solutions aggressively and gain approval from local regulatory authorities. Cooperation between regulators, municipalities, the development and environmental communities and other stakeholders will be needed to identify a sustainable funding source to support full-scale regional solutions throughout the Los Angeles basin.



REFERENCES

American Society of Civil Engineers Urban Water Resources Research Council and U.S. EPA, 2002. Urban Stormwater BMP Performance Monitoring – A Guidance Manual for Meeting the National Stormwater BMP Database Requirements. EPA-821-B-02-001.

Los Angeles and San Gabriel Rivers Watershed Council, 2002. Water Augmentation Study.

Los Angeles, City of, 2001. Integrated Resources Plan.

Los Angeles Regional Water Quality Control Board, 2001. Order No. 01-182 NPDES Permit No. CAS004001 Waste Discharge Requirements for Municipal Stormwater and Urban Runoff Discharges within the County of Los Angeles, December 13, 2001.

Los Angeles Regional Water Quality Control Board, 1996. Order No. 96-054.

Thurston, H.W., H.C. Goddard, D. Szlag, and B. Lemberg. 2002. Trading Stormwater Abatement Credits. Stormwater. July/August, 2002.

University of Southern California, 2003. An Economic Impact Evaluation of Proposed Storm Water Treatment for Los Angeles County.

Urbonas, Ben, 1990. On-Site Detention vs. Regional Detention: A Summary of Issues.

U.S. Census Bureau, 2002. Internet web site.

U.S. EPA, 2002. Proposed Water Quality Trading Policy.

U.S. EPA, 2002. Memorandum – Establishing Total Maximum Daily Load (TMDL) Wasteload Allocations (WLAs) for Stormwater Sources and NPDES Permit Requirements Based on Those WLAs, Office of Wetlands, Oceans and Watersheds. November 22, 2002.

Water Environment Federation and American Society of Civil Engineers, 1992. Design and Construction of Urban Stormwater Management System, p. 47

Water Environment Federation and American Society of Civil Engineers, 1992. Design and Construction of Urban Stormwater Management Systems.

Water Environment Research Foundation (WERF), 2000. Phosphorus Credit Trading in the Cherry Creek Basin: An Innovative Approach to Achieving Water Quality Benefits. Project 97-IRM-5A. Alexandria, Virginia.

