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Subgroup: Practice Resource Stewardship

Chapter [##] Watershed Management

Watershed management is the process of creating and implementing plans, programs, projects and activities to restore, sustain and enhance watershed functions. We rely on these functions to provide the goods, services, and values desired by the community affected by conditions within a watershed boundary. In California, the practice of “community based” watershed management has evolved as an effective approach to natural resource management practiced in hundreds of watersheds throughout the state. These community based efforts are carried out with the active support, assistance, and participation of numerous state agencies and programs.

A primary objective of watershed management is to increase and sustain a watershed’s ability to provide for the diverse needs of the communities that depend on it, from local to regional to state and federal stakeholders. Resource management using watersheds as an organizing unit has proven to be an effective scale for natural resource management. The watershed is an appropriate scale to see, understand, and manage the numerous physical, chemical, and biological processes that make up a particular ecosystem and serves well as a common reference point for the many different activities and actors that affect the system, and promotes greater integration and collaboration among those actions.

Using watersheds as organizing units (Box [Ch#]-1 Watershed defined) for planning and implementation of natural resource management means that:

- large regions can be divided along topographic lines that transcend jurisdictional lines,
- status and trends analysis can be done on the basis of entire natural systems in concert with social conditions,
- communities within and outside a particular watershed can better track and understand the impacts of their management activities on the larger system,
- each watershed can adjust management measures and policies to meet local goals while supporting larger scale goals as well (such as regional and statewide interests), and
- multi-objective planning is facilitated by inclusion in, and reference to, a whole-system context.

Placeholder: Box [Ch#]-1 Watershed Defined

Effective management recognizes the mutually dependent interaction of various basic elements of a watershed system including the hydrologic cycle, nutrient and carbon cycling, energy flows and transfer, soil and geologic characteristics, plant and animal ecology and the role of fire and other large scale disturbance.

Each must be considered in context with the others, because change in one spurs changes in the others, creating a different system outcome.
Watershed Management in California

Significant efforts to better manage natural resources using a watershed approach are occurring in all regions of California. It is estimated that several hundred structured efforts involving organizations, local governments, landowners/users and stewardship groups along with State and federal agencies are currently active.

Many of these efforts are working to blend community goals/interests with the goals of the State of California, carrying out management that helps achieve these goals in a manner consistent with environmental, social, and economic conditions in the watershed. Emphasis at the community level has brought about a broader understanding of shared interests and created innovative management approaches to meet these varied interests. Multiple benefits are being realized through thoughtful watershed based management in such diverse locations as the upper Feather River, the Los Angeles River Basin, and the Napa River to name just a few communities where the watershed approach is being successfully used. The need to address environmental justice and social equity has been recognized and addressed effectively, along with more traditional project management approaches. In many communities, these organized efforts serve as forums for bringing about collaborative management involving the public and private sector, the academic community, and other people working at the local, regional, state and national level, taking advantage of the inherent capabilities of each.

In addition to these local efforts, a number of regional, statewide, and national initiatives have been and continue to be carried out to help improve our overall ability to practice watershed management. Some notable initiatives in California are listed in Box [Ch#]-2 (California Watershed Management Chronology—Key Dates).

Placeholder: Box [Ch#]-2  California Watershed Management Chronology—Key Dates

[See Box [Ch#]-2 California Watershed Management Chronology at the end of this draft

Bond measures have brought significant funding to assist with maintenance and restoration work needed in many of the State’s watersheds. Recent bond measures (Prop 50 and 84) stressed the need for integrated planning that includes multiple objectives at the watershed and regional scales, and provide incentives to carry out work consistent with these plans.
Potential Benefits of Watershed Management

Managing our natural systems using a watershed approach with emphasis on maintaining, restoring or enhancing the many functions associated with these natural systems, can and does result in a number of significant benefits. Many of these benefits are described using typical economic terms such as a product, goods, or service, and are readily valued in the marketplace. Reliable quantities of clean water, agricultural or forest products and biofuel production are good examples. Other values associated with our natural systems are more difficult to quantify monetarily, because these values are not routinely traded in the marketplace. As a result, the term “ecosystem services” is often used to better describe and equate the monetary and non monetary values or benefits provided to society by healthy watersheds.

Placeholder: Table Ch#-1 Typical list of watershed products, goods, and services

See this table at end of this draft: Table [Ch#]-1 Typical List of Watershed Products, Goods and Services (Adapted from- Rivers of Life- Managing Water for People and Nature- Sandra Postel and Brian Richter- 2003

Potential Costs of Watershed Management

Costs associated with watershed management depend on many factors, such as the size of the watershed, the land and water use activities occurring in the watershed, the state and functional condition of the watershed and the values, goods and services demanded from the watershed.

Much of the cost of watershed management in California is associated with the specific land or water use activities occurring within the watershed on a recurring basis and is coincidental with these uses. Additional or external costs of watershed management discussed in this chapter tend to be associated with interventions designed to influence management or improve the results of management; offer specific protection for certain functions and values, or to restore the functional conditions and associated uses of a watershed. These interventions may come from various levels of government or interests either within or outside the watershed. The potential costs associated with these interventions are estimated here by:

- Applying a “willingness to pay” approach based on existing examples (using CALFED Watershed Program analysis as part of Program Finance Plan development)
- Extrapolating costs based on other program expenditures (CALFED Program example cited in Watershed Management Chapter 25 2005 Water plan update

Although generally thought of as a benefit, it is useful to recognize that thoughtful watershed management can result in significant avoided costs such as flood damage, Health costs, and controlling agricultural pests. An example illustrating this point is shown in Box [Ch#]-3 (Watershed Degradation and Water Treatment Costs)

Placeholder: Box [Ch#]-3 Watershed Degradation and Water Treatment Costs

[See Box [Ch#]-3 Watershed Degradation and Water Treatment Costs at the end of this draft]
Willingness to Pay

To estimate the approximate external costs to fully implement the watershed management strategy, an analysis developed by the CALFED Watershed Program is used. This analysis examined areas where communities have chosen to provide quantifiable financial support for watershed management, thus demonstrating “a willingness to pay” for the services provided by a well managed watershed.

This analysis has been constructed using methods described by the US Department of Energy (Natural Resource Valuation, 1997), and the US Congressional Research Service (RL30242 Report for Congress, 1999). It is an attempt to describe a monetary value to effective watershed management.

The Napa County community was used as a basis for this comparison for several reasons. One is the proximity of demographics to the state as a whole. Another is that the taxes levied are directly tied to implementation of community-generated watershed management plans. The levies also demonstrate strong local support among voters and elected officials for the values inherent in improved management. Finally, the funds are generated and dispersed locally by locally responsive government entities.

Valuations from three different Napa County tax measures were investigated. One is a half-cent sales tax passed by 68 percent of voters in the late 1990s, which generates approximately $10 million in revenue per year specifically for watershed management (the “Living River” program). Another is a parcel tax of $12.70 per parcel supported and levied within the city of Napa for watershed management. This parcel tax is accompanied by an additional parcel tax of $12 per year specifically for storm water runoff management inside the city’s watersheds. The range of value then is from nearly $14,000 per square mile for the sales tax revenue, to just under $1,600 per square mile for the parcel tax.

For the purposes of this value estimate, the lower amount of $1,572 per square mile area is used. That, in turn, is adjusted to account for the slight difference in demographic statistics between Napa and California at large.

<table>
<thead>
<tr>
<th>Napa County</th>
<th>Less 10%</th>
<th>Bay-Delta Watershed Area mi²</th>
<th>Southern California Area mi²</th>
<th>Total Value Estimated</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1572 per mi²</td>
<td>$1414 per mi²</td>
<td>48,050</td>
<td></td>
<td>$67,942,700</td>
</tr>
<tr>
<td>30,000</td>
<td></td>
<td></td>
<td>$42,420,000</td>
<td></td>
</tr>
<tr>
<td><strong>Total Valuation:</strong></td>
<td></td>
<td></td>
<td><strong>$110,362,700</strong></td>
<td></td>
</tr>
</tbody>
</table>

These amounts represent an estimated, annual, external cost to fully implement the watershed management strategy over approximately half the surface area of the state, including all or part of the following regions: Sacramento, San Joaquin, Tulare, Bay, South Coast, and South Lahontan. A simple extrapolation of these costs to the entire land area of the state would result in an estimated annual cost of $221,000,000 to fully implement the strategy. It should be noted here that an undetermined, but likely significant portion of that cost is not added cost, but existing expenditures applied differently. For instance, permits and stream alteration agreements issued by watershed boundary instead of jurisdictional boundary could result in considerable added benefit and positive effect without adding to the real cost of implementation. Also, land use planning done on the basis of watershed impact may yield higher beneficial results without increasing costs.
Table Ch#- Preliminary estimates of watershed management costs, time periods from 2004 through 2030

<table>
<thead>
<tr>
<th>Period (years)</th>
<th>Assessment planning¹ ($ million)</th>
<th>Public process² ($ million)</th>
<th>Projects³ ($ million)</th>
<th>Total for period ($ million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004-2009</td>
<td>$10-37.5</td>
<td>$8-16</td>
<td>$14-$80</td>
<td>$160-667</td>
</tr>
<tr>
<td>2010-2015</td>
<td>$10-30</td>
<td>$8-16</td>
<td>$14-88</td>
<td>$160-804</td>
</tr>
<tr>
<td>2016-2030</td>
<td>$10-25</td>
<td>$8-16</td>
<td>$14-100</td>
<td>$160-2,115</td>
</tr>
<tr>
<td>Total</td>
<td>$480-3,586</td>
<td></td>
<td></td>
<td>$480-3,586</td>
</tr>
</tbody>
</table>

Source: California Water Plan Update 2005: Vol2, Ch25, Table 25-1

¹ CALFED service area estimated as 40% of Statewide need. Therefore, statewide Assessment and Planning=2.5 x CALFED values from draft CALFED Finance Plan (2004)

² The service area for Public Process estimated as 25% of the statewide need. Therefore, statewide Public Process = 4x CALFED values

³ For Projects, CALFED service area is estimated to be 25% of the Statewide need. Therefore, statewide Projects = 4x CALFED values

Major Issues Facing Watershed Management

Development of land and water resources for selected products, services and values have altered the conditions and functions of many watersheds in California.

Land Uses Alter Hydrologic Cycles

The hydrologic cycle includes snow or rain, the flow of water over and beneath the land, and the evaporation of water into the atmosphere. How the land is managed can reduce rainwater infiltration and the timing, and in some case, the volume of stormwater runoff. Storms, especially in urban areas, but also in some rural areas are now marked by high intensity runoff over short periods. This creates greater flood risk and reduces the ability to capture water for needs during dry times. From an ecological perspective, this compression of runoff events robs the streams and landscape of groundwater. This leads to dry land, a shift in vegetation types, lower and warmer streams, deterioration of stream channels, all of which lead to shifts in the plants and animals that can be supported. In some cases the diversion of water from streams in the watershed to other regions outside the watershed, or the application of water imported from outside the watershed, has changed ecological functions or altered the flow of water through the watershed.

Human Activities Alter Nutrient Cycles

Another important natural cycle is the nutrient cycle. As watersheds are developed, we tend to increase the ambient amount of water soluble nutrients, often from concentrations in fertilizers or biosolids. These concentrated forms of nutrients can trigger dramatic changes in water bodies, vegetation, and animal communities. Many native plants evolved under fairly low nutrient conditions. Increasing the available nutrients often allows invasive plants to overrun the native vegetation. This can reduce the infiltration capacity of the land and diminish the habitat quality. We often export nutrients from the location that they are generated, frequently from inappropriate use or application rates. In some cases this is through the pollution of water that carries the nutrients to a point where they can support algae or other plant growth that impairs the usability of water. In other cases this is through the transport of waste materials, or the application of fertilizers. In any event, the result is an increase in nutrient loads that often diminish the ecological quality in water bodies.
Disrupting habitats and migration corridors is a frequent result of development within a watershed. Elimination of large amounts of dendritic drainage through culverts and other diversions, increased impervious surfaces, disruption of corridors by transportation and development, and reduction of riparian forest areas are examples of changes that have far reaching impacts on watershed hydrological and ecological conditions.

Life cycles and migration patterns of animals is another set of important cycles to consider. Many projects built in the past prior to environmental laws such as CEQA and NEPA have disrupted migration corridors or destroyed or impoverished habitat that is critical for certain life stages of animals. Coastal wetlands that support breeding, nursery and rearing habitat for many ocean species have been particularly hard hit. Dams have blocked access to spawning and rearing habitats for anadromous fish. Riparian forests that support migration of South American birds, and inland wetlands that support the Pacific Flyway species have all been severely impacted.

An example is when steepening of river banks through down-cutting or construction, such as creating levees, has changed the gradient of shorelines, and diminished the gradual gradients necessary for many aquatic semi-aquatic species (especially plants and insects) to complete their life cycles. This, in turn affects larger life forms that rely on those specific species, and diminishes the buffering impacts of near-shore vegetation.

Fire and Water
The management of our forest and brush lands over the past few generations has created a risk of very large, very hot fires that do much more damage to watersheds than fires of historical intensities. The result is that watersheds are not capable of rapidly repairing the damage from these fires. These fires create long periods of erosion and diminish the plant communities that cover the land. They displace animals and limit the subsequent human use of the lands. This results in more water quality problems, more runoff and less infiltration, increased operations and maintenance costs for our reservoirs and canal systems, unstable lands, and large economic losses, including significant alterations of natural biological cycles.

Recommendations to Better Manage Watersheds in California

Policy Level recommendations:

1. Establish a scientifically valid means of tracking change in the State’s major watersheds that will provide reliable, current information to local communities, State agencies and others regarding the net effects of past management in the context of external change.
2. Establish adaptive management programs that regularly assess the performance and condition of projects and programs to determine if they are satisfying ecological and community needs compatibly. Adjust the operations or re-design existing projects or programs as needed.
3. Clearly define expected products, goods and services from the State’s level, to stand as a basis from which to apply local variations and additions.
4. As appropriate, coordinate State funding and support within watersheds and between programs to generate more focused, measurable results.
5 More effectively align agency goals and methods to reflect coordinated approaches to resource management using watersheds as the context for implementation and effectiveness measurement.

6 Provide a means of easy access to technical information such as geographic information system (GIS) layers, monitoring data, planning models and templates, assessment techniques, etc., from multiple sources that is useful at multiple levels of decision-making.

7 Conduct present business activities in a manner, and within a context, that is consistent with watershed dynamics and characteristics.

8 Provide local land use decision-makers with watershed education and information access to better inform local decision making to maintain and improve watershed functions.

Strategic practices recommendations:

1 Design and select projects with ecological processes in mind and with a goal of making the projects as representative of the local ecology as possible

2 Increase the ability for precipitation to infiltrate into the ground; reduce surface runoff to a point where it better reflects a natural pattern of runoff retention (such as Low Impact Development, or LID)

3 Retain floodplain and other wetlands intact to the extent possible, in order to maintain or increase residence time of water in the watershed.

4 Decrease the amount of irrigated landscape in the watershed, and increase the use of native vegetation in landscaping and agricultural buffer lands.

5 Design appropriate wildlife migration corridors and biological diversity support patches by watershed when planning fire-safe vegetation alteration.

6 Support the installation and maintenance of stream flow gauges in major drainages.

7 Maintain and create habitat around stream and river corridors that is compatible with stream and river functions. Provide as much upslope compatibility with these corridors as possible.

8 Design drainage and storm water runoff controls to maximize infiltration into local aquifers, and minimize immediate downstream discharges during periods of runoff.

9 Provide regionally appropriate, regular and dependable educational materials to encourage water conservation, water re-use, and water pollution prevention.

10 Restore and preserve stream channel morphology to allow access of flood waters to the floodplain and to provide for stable banks and channel form.

Selected References


To be completed at a later date
<table>
<thead>
<tr>
<th>Typical watershed products, goods and services (also described as ecosystem services)</th>
<th>Benefit of Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provision of water supplies</td>
<td>Sustainable production of agricultural and forest products that are dependent on healthy productive soils, favorable climate and water conditions, and the availability of pollinators.</td>
</tr>
<tr>
<td>Provision of Food, fiber, fuel</td>
<td>Well managed watersheds produce clean, cool water generally useful for a broad range of beneficial uses. Virtually all freshwater used in California originates as precipitation that is intercepted, captured, routed and released from our watersheds.</td>
</tr>
<tr>
<td>Water purification/ waste treatment</td>
<td>Healthy watersheds with adequate distributed wetlands and functional floodplains moderate the volume and timing of surface runoff, reducing flood damage.</td>
</tr>
<tr>
<td>Flood Mitigation</td>
<td>A healthy watershed works like a sponge to store and release water to both streams and groundwater. In California, healthy watersheds increase the residence time of water, and tend to store and release water longer into the dry season.</td>
</tr>
<tr>
<td>Drought mitigation/ flow attenuation</td>
<td>Uplands, rivers, streams, floodplains and wetlands provide necessary habitats for fish, birds, mammals, and countless other species, and generally sustain a strong level of biological diversity that provides wide benefits to society.</td>
</tr>
<tr>
<td>Provision of aquatic and terrestrial habitat</td>
<td>Soil health and fertility is an essential component of primary ecosystem production, and critical for maintenance of important terrestrial, floodplain, riparian and wetland components and processes.</td>
</tr>
<tr>
<td>Soil fertility, health, productivity</td>
<td>Cycling of nutrients is necessary to maintain healthy, diverse biological systems, to sustain biological diversity that mediates disease, and sustains populations of native species.</td>
</tr>
<tr>
<td>Nutrient, mineral cycling and delivery, carbon sequestration</td>
<td>Diverse assemblages of species work to provide the services (including all those listed in this table) upon which societies depend. Conserving genetic diversity preserves options for the future, and increases the resilience of ecosystems in the face of the impacts of a changing climate.</td>
</tr>
<tr>
<td>Biodiversity maintenance</td>
<td>Swimming, fishing, hunting, boating, wildlife viewing, hiking, and skiing are all delivered or enhanced in healthy watersheds, often resulting in concurrent economic improvements in local communities reliant on recreation as a source of economic sustenance or growth.</td>
</tr>
<tr>
<td>Recreational opportunities</td>
<td>Adequate diversification of a watershed ecological system will allow a more robust adaptation to rapid climate changes. That adaptation will better ensure that watershed ecosystem functions will continue to provide the goods, services and values of the systems we experience today.</td>
</tr>
<tr>
<td>Climate moderation/ buffering</td>
<td>Quality of life is a major, but difficult to quantify benefit of watershed conditions. Pleasant surroundings, with clean air, clean water and adequate recreational opportunities have been shown to be beneficial across a broad spectrum of social structures.</td>
</tr>
<tr>
<td>Managing salinity gradients</td>
<td>Freshwater flow regimes can determine salinity gradients in Deltas, coastal estuaries and near shore marine environments, a key to biological richness and complexity.</td>
</tr>
</tbody>
</table>
Box [Ch#]-1 Watershed Defined

What is a watershed?

In its historical definition, a watershed is the divide between two drainage streams or rivers separating rainfall runoff into one or the other of the basins. In recent years, the term has been applied to mean the entirety of each of the basins, instead of just the divide between them. The Continental Divide is a watershed according to the earlier definition, where rainfall runoff is directed toward the Gulf of Mexico or toward the Pacific Ocean. The Mississippi River basin and the Colorado River basin are watersheds under the new definition. Other parts of the world use the terms catchment, or river basin, to describe the drainage area between (historical) watersheds. It is from the earlier definition of watershed that we derive the phrase “watershed event”—an occurrence that changes the pattern of all that follows, moving the flow of events toward a different outcome.

A watershed embraces all its natural and artificial (manmade) features, including its surface and subsurface features: climate and weather patterns, geologic and topographic history, soils and vegetation characteristics, and land use. A watershed may be as small as a house roof’s, gutters and downspout, and as large as the Sacramento, San Joaquin or Klamath river basins.
Box [Ch#]-2 California Watershed Management Chronology—Key Dates

1997 – “Ten Lessons Learned” – A summary of key experiences implementing the watershed management efforts from the US EPA Office of Wetlands, Oceans and Watersheds (OWOW). It was EPA’s initiative that prompted the State to begin addressing resource management from a watershed perspective.

1998 – Draft CALFED Watershed Strategy – assembled by State and Federal agency representatives to respond to public comment regarding early expenditures by CALFED that largely left out projects above major dams or below Carquinez Strait. This evolved to the development of the CALFED Watershed Program as part of the overall CALFED Bay-Delta Program.

1997-99 – Watershed Protection and Restoration Council (WPRC) – established by Executive Order to develop Statewide watershed management policies focused on fostering and supporting community-based watershed management activities along with coordination among State agencies- largely on salmonid species recovery in California.

1999 – Watershed Management Council (WMC) Forums – A series of public meetings to generate recommendations for improving coordination among state agencies and between the State and Federal governments and local management programs. Created the “12 Steps to Watershed Recovery” document.

1999 – California Biodiversity Council Watershed Work Group (CBC-WWG) – formed to carry on the work begun by the WPRC and to develop principles and guidelines for coordinating state agency activities related to watershed management. Developed a set of Management Principles for watershed management activities and programs.

1998-2000 – Development of the CALFED Watershed Program – established to aid in achieving the overarching goals of the CALFED Bay Delta Program by working with the community at watershed level. The Program Plan was published in 2000. The Plan was developed in close partnership with the Bay-Delta Advisory Committee’s (BDAC) Watershed Work Group, the Inter-Agency Advisory Team (IWAT), and the CBC-WWG.

2000 - California Coastal Salmon and Watersheds program - established to “recover harvestable salmon and steelhead populations, restore watersheds, and so contribute to building healthy communities.”

2000- Formation of California Watershed Network (CWN) a non-profit organization with the mission to help people protect and restore the natural environments of California watershed while ensuring healthy and sustainable communities. CWN worked to develop a coordinated network of community based watershed management in California.

2000- AB 2117 (Wayne) – to evaluate a sample of locally-led watershed management partnerships and produce a report back to the Legislature.

2001 – Joint Task Force on California Watershed Management (Joint Task Force) – established to oversee the report required by AB2117. The report, “Addressing the need to protect California’s watersheds ” was published in 2002. It listed the results of the investigation, and produced some recommendations to the State. Among the recommendations was to develop a watershed management Strategic Plan for the State.
2001 – Memorandum of Understanding – established between State and Federal government agencies to provide a framework for implementing the CALFED Watershed Program. The MOU identified implementing and coordinating agencies, outlined their roles, and established a formal means to conduct the business of the CALFED Watershed Program element. The MOU expired in 2003.

2002- Watershed, Clean Beaches and Water Quality Act (Pavley) – authorizes the establishment of an Integrated Watershed Management Program (IWMP) to develop coordinated and complementary strategies and solutions for watershed management across land ownership and agency jurisdictional boundaries.

2003 – Memorandum of Understanding – between the Resources Agency and CalEPA to implement the IWMP from the Pavley bill. Established the California Watershed Council as an advisory group.

2003 – California Watershed Council – designed to provide advice and recommendations to the Secretaries regarding watershed management policy and programs. The group generated several work products that included a set of basic principles, and a series of recommendations for funding processes, technical assistance, communications, information sharing, and coordination processes.

2003- AB 1405 (Wolk) California Watershed Protection and Restoration Act - enacted the California Watershed Protection and Restoration Act to encourage CalEPA and the Resources Agency to provide assistance and grants to those who choose to participate in watershed restoration and enhancements, and declared that local collaborative watershed partnerships are in the State’s interest in terms of effectiveness, citizen involvement and community responsibility. This bill authorizes certain State agencies to provide technical assistance to local watershed partnerships, and requires that State guidelines adopted for use by local watershed partnerships provide flexible mechanisms to achieve quantifiable watershed objectives.

2003 - California Agency Watershed Program Strategic Plan – developed by a consultant group after interactions with members the Joint Task Force.

2004 - Memorandum of Understanding between Cal EPA and the Resources Agency (revised) – rewrote the 2003 MOU. It was designed to emphasize and implement the Governor’s Environmental Action Plan and the Ocean Action Plan, using stakeholder advisory processes and inter-agency collaboration

2005 – California State Agency Watershed Management 18 month Action Plan – designed to replace the Strategic Plan with a more action-oriented approach for agencies to pursue watershed management.

2007 (Nov) - Establishing a Statewide Watershed Program- The Resources Secretary calls for the transition of the CALFED Watershed Program to a “Statewide” Watershed program and assigns the Department of Conservation to administer this effort.
Box [Ch#]-3 Watershed Degradation and Water Treatment Costs

The development of watershed and aquifer recharge lands results in increased contamination of drinking water. With increased contamination come increased treatment costs. The costs can be prevented with a greater emphasis on source protection. A study of 27 water suppliers conducted by the Trust for Public Land and the American Water Works Association in 2002 found that the more forest cover in a watershed, the lower the treatment costs. According to the study:

- Approximately 50 to 55 percent of the variation in treatment costs can be explained by the percent of forest cover in the source area.
- For every 10 percent increase in forest cover in the source area, treatment and chemical costs decreased approximately 20 percent, up to about 60 percent forest cover.

The study did not gather enough data on suppliers with over 65 percent forest cover to draw conclusions; however, it is suspected that treatment costs level out when forest cover is between 70 and 100 percent. The 50 percent variation in treatment costs that cannot be explained by the percent forest cover in the watershed is likely explained by varying treatment practices, the size of the facility (larger facilities realize economies of scale), the location and intensity of development and row crops in the watershed, and agricultural, urban, and forestry management practices. The table below shows the change in treatment costs predicted by this analysis, and the average daily and yearly cost of treatment if a supplier treats 22 million gallons per day.

<table>
<thead>
<tr>
<th>% of Watershed Forested</th>
<th>Treatment and chemical costs per MG</th>
<th>Change in costs</th>
<th>Average treatment costs daily per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>10%</td>
<td>$115</td>
<td>19%</td>
<td>$2,530</td>
</tr>
<tr>
<td>20%</td>
<td>93</td>
<td>20%</td>
<td>$2046</td>
</tr>
<tr>
<td>30%</td>
<td>$73</td>
<td>21%</td>
<td>$1,606</td>
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<tr>
<td>40%</td>
<td>$58</td>
<td>21%</td>
<td>$1,276</td>
</tr>
<tr>
<td>50%</td>
<td>$46</td>
<td>21%</td>
<td>$1,012</td>
</tr>
<tr>
<td>60%</td>
<td>$37</td>
<td>19%</td>
<td>$814</td>
</tr>
</tbody>
</table>

SOURCE: Extracted from Land Conservation and the Future of America's Drinking Water- Protecting the Source- 2004- Published by the Trust for Public Lands and the American water Works Association