A Benefits Assessment of Water Pollution Control Programs Since 1972: Part 1, The Benefits of Point Source Controls for Conventional Pollutants in Rivers and Streams

Final Report

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U.S. Environmental Protection Agency
Office of Water
Office of Policy, Economics, and Innovation

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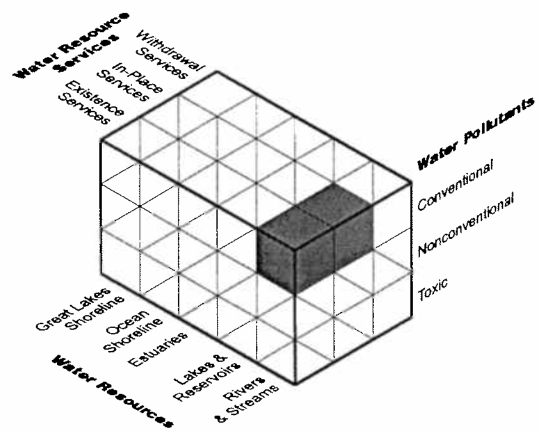
Executive Summary

Since the early 1970s, national water pollution control programs at all levels of government can be largely credited with reversing the centuries-long trend in the degradation of the Nation's waters. Foremost among these programs are those that have been implemented by the U.S. Environmental Protection Agency (EPA) under the Clean Water Act (CWA) of 1972. Prior to these programs, the decline in water quality that accompanied economic industrialization and population growth was epitomized by the day in June 1969 when oil and debris in the Cuyahoga River caught fire. Today, the cumulative impact of the national water pollution programs has been to improve the health of aquatic ecosystems and to expand the share of the Nation's water resources that support various forms of beneficial uses for humans. The purpose of this study has been to develop a preliminary assessment of the national benefits associated with these programs, in particular the CWA.

This analysis represents the first part of an ongoing effort by the Agency to develop a comprehensive assessment of the benefits of the CWA using modern valuation methods. The results of this study must therefore be viewed as partial because they do not yet include all of the facets of water quality benefits. As depicted in Figure ES-1, a comprehensive assessment must fully address the three primary dimensions of water quality improvements. That is, it should address

- all of the **pollutants** addressed by the Agency's programs,
- all of the Nation's surface **water resources**, and

Figure ES-1. Illustration of the Potential Scope of CWA Benefits and Contributions of This Study



- all of the **services** that surface water resources provide to humans.

Our study covers the subset of water quality improvement benefits represented by the shaded area in Figure ES-1. First, it focuses exclusively on the Nation's system of primary rivers and streams. Other important water resources, including the marine coast, estuaries, lakes, and smaller streams, are not included. As a result, the sources that discharge pollutants directly to these other waterbodies are also not included. Second, only conventional pollutants are included in the water quality analysis. Nonconventionals and toxic pollutants are not included. Finally, the monetary estimate of the benefits is confined to a subset of the services provided by water resources. While this coverage is not insignificant, the ultimate goal of future benefits assessments is to cover all the elements in all three dimensions of Figure ES-1.

We estimate that the benefit for the shaded elements in Figure ES-1 is currently about $11 billion annually. This estimate is best interpreted as an approximation of the partial *annual* benefits of current water quality levels relative to what they would have been without the water pollution control programs that have been implemented since the early 1970s, in particular without the CWA.

Although we recognize that it is an oversimplification, for convenience in this report we attribute the benefits of water pollution controls to the CWA. The CWA is the primary Federal law for addressing the Nation's water quality problems. Under the Act the Agency, among other things, establishes industrial and municipal pollution control performance standards for point sources (PS) of conventional, nonconventional, and toxic pollutants. It charges States and tribes with setting specific water quality criteria appropriate for their waters and with developing pollution control programs to meet them. Under the CWA, the Agency also provides funding to States and communities to help them meet their clean water infrastructure needs. These initiatives are likely to be the most significant cause of the water quality improvements achieved since the early 1970s. But they are not solely responsible for the gains.

Other Federal and subfederal legislation and initiatives have contributed to the improvements. For example, the Coastal Zone Management Act addresses NPSs of coastal water pollution. Also, in some cases, pollution controls mandated by State and local agencies can be more stringent than Federal guidelines. Even legislation directed toward other media has contributed to water quality improvements. The Clean Air Act, for example, through its treatment of the pollutants that cause acid deposition, has resulted in lower pH levels in the Nation's waters. In practice it is difficult to fully separate the impacts of various programs; therefore, we assume that the benefits we are measuring are attributable to the CWA.

The benefits of the CWA can be defined (in economic terms) as the increase in human well-being that results from its improvements in water quality. These water quality improvements, in effect, improve the "services" humans receive from surface water resources. To estimate these benefits, it is not enough to examine how water quality has improved since 1972. Rather, it is appropriate to assess current water quality in relation to what it *would have been* today without the CWA initiatives.

This is a complex undertaking since even without the Act other State and local programs may have been expanded or initiated to address the problem of water pollution. Estimating the likelihood and contribution of such efforts is beyond the scope of this study. This study has developed an estimate of what water quality might look like today if current wastewater management practices were similar to 1972's practices, but with today's levels of economic activity. This scenario provides the basis for the without-CWA water quality characterization that is compared to today's water quality levels.

Although the benefit estimates are incomplete, the accomplishments of our study are significant. Only a few prior studies have attempted to value water quality changes, even for a local setting. This study has provided such estimates on a national level, albeit not for all resources. We are continuing the effort to provide the missing elements.

Also included in this report is a case study analysis of the benefits of the water quality improvements in the Willamette River Basin in Oregon. This analysis provides the opportunity to examine the potential benefits of the Act in greater detail and with less abstraction than was possible with the national-level study. The Willamette River Basin was chosen because of the significant improvements in water quality achieved there since the 1960s. The benefits of the water quality improvements for that basin are estimated to be $120 million to $260 million annually.

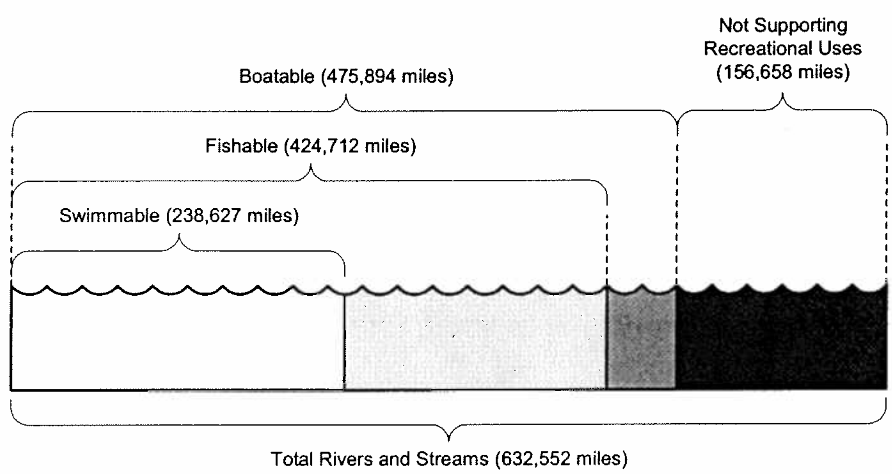
ES.1 WATER QUALITY DIFFERENCES WITH THE CWA

We used the National Water Pollution Control Assessment Model (NWPCAM) developed by EPA and RTI to conduct this assessment of the national benefits of the CWA. The NWPCAM incorporates location-specific estimates of pollutant releases to simulate water quality conditions for 632,552 miles of rivers and streams in the continental United States. Current pollutant PS loadings from industrial and municipal sources and NPS loadings were used in the NWPCAM to characterize today's water quality in terms of oxygen-demanding wastes, sediment, and fecal coliform levels. This characterization was used as the with-CWA water quality reference point.

Without-CWA loadings estimates were also developed, but only for industrial and municipal sources. They were based on estimates of the control efficiency of effluent guidelines and municipal wastewater treatment programs applied to the current industrial base. Because the NPS program is fairly new and data on its effectiveness are not readily available, without-CWA pollutant loadings for these sources were assumed to be the same as current loadings. The without-CWA loadings were used in the NWPCAM to characterize what the current state of water quality would be without the CWA initiatives.

The estimated water quality levels under both with- and without-CWA conditions were mapped into three use support categories—boatable, fishable, or swimmable—based on the minimum levels of water quality needed to support these activities. These three terms, as used here, are essentially shorthand ways to describe water quality based on estimated pollutant levels. The estimated current (with-CWA) national distribution of the river and stream miles across the beneficial use categories is provided in Figure ES-2. Almost 25 percent of the total 632,552 miles of rivers and streams are estimated to be "nonsupport" miles, meaning they

Figure ES-2. Estimated U.S. River and Stream Miles Attaining Recreational Use Criteria With the CWA, Mid-1990s



fail to meet conditions required to support any of the three categories.

The remaining 475,894 miles are estimated to, at least, support boating activities. A majority of these boatable miles are also estimated to be fishable (424,712 miles), and a smaller subset are estimated to be suitable for swimming as well (238,627 miles). For interpreting Figure ES-2 (and the tables on the following pages) it is important to stress that the mile estimates in the three use support categories are **not** mutually exclusive. They are overlapping. In other words, adding miles across the support categories would result in double-counting because some river and stream miles support more than one use (e.g., swimmable miles are, by definition, also boatable).

Table ES-1 shows what the estimated distribution of water quality would be under the without-CWA scenario. Nonsupport miles increase to 178,514. The number of boatable, fishable, and swimmable miles are all estimated to decline relative to with-CWA conditions.

Using the same use support categorization scheme, we also estimated a third scenario to simulate what conditions would be like if all loadings of conventional pollutants from PSs were eliminated. Because this zero PS discharge scenario represents the maximum achievable control of PSs, it serves as a useful point of reference for evaluating the with-CWA (i.e., current control) scenario. It highlights the fact that, even if all point source loadings were reduced to zero, a sizable portion of U.S. rivers and streams would experience little to no improvement (relative to the without-CWA scenario) in their ability to support specific recreational uses. According to the NWPCAM, going from the without-CWA scenario to the zero PS discharge scenario, only a small percentage (10 percent overall) of the 632,552 miles of rivers and streams would achieve higher recreational uses. This is because the remaining miles are either

- upstream of all PSs of conventional pollutants in the model,
- already achieving maximum use support (i.e., swimmable) under the without-CWA scenario, or

- limited by NPS loadings.

Therefore, Table ES-1 also shows the estimated number of river and stream miles in each recreational use support category for the zero PS discharge scenarios. It shows that, going from the without-CWA scenario to the zero PS discharge scenario, the maximum achievable increase in swimmable miles through PS controls is 33,355 miles. For the fishable and boatable categories, the maximum increases are 42,754 and 36,810, miles, respectively.

Table ES-1. Maximum Achievable Increases in Recreational Use Support Through Point Source Controls

	Number of U.S. River and Stream Miles in Each Use Support Category		
Highest Use Supported	**Without-CWA Conditions**	**Zero PS Discharge Conditions**	**Maximum Achievable Change**
Swimmable	222,120	255,475	33,355
Fishable	399,999	442,753	42,754
Boatable	454,038	490,848	36,810
Nonsupport	178,514	141,704	–36,810

Table ES-2a compares the estimated distribution of river and stream miles across use categories with and without the Act. We estimate that CWA pollution controls have increased the number of miles of rivers and streams attaining swimmable standards by 16,507, which is 50 percent of the maximum increase that would have been achieved by eliminating PS discharges. The additional number of river and stream miles nationally achieving fishable and boatable standards today is estimated to be 24,713 and 21,856, respectively. These increases represent almost 60 percent of the maximum that would have been achieved by complete controls on PS discharges.

Because many of the services received from water resources depend on their proximity to people, in Table ES-2b we also provide estimates of the water quality increases specifically for "populated places" (as defined by the Census). These estimates show that about one-third of the 632,552 river and stream miles modeled in the NWPCAM are in these more populated locations. More importantly, over two-thirds of the *improved* river and stream

Table ES-2a. Rivers and Streams (632,552 miles) Supporting Recreational Uses: Comparison of With-CWA and Without-CWA Conditions in the Mid-1990s

Highest Use Supported	Without-CWA Conditions (miles)	With-CWA Conditions (miles)	Increase in Use Support	
			Miles	Percent of Maximum Increase[a]
Swimmable	222,120	238,627	16,507	49.5%
Fishable	399,999	424,712	24,713	57.8%
Boatable	454,038	475,894	21,856	59.4%
Nonsupport	178,514	156,658	–21,856	59.4%

[a] Maximum defined by difference between without-CWA scenario and zero PS discharge scenario.

Table ES-2b. Rivers and Streams *in Populated Places* (222,789 miles): Comparison of With-CWA and Without-CWA Conditions in the Mid-1990s

Highest Use Supported	Without-CWA Conditions (miles)	With-CWA Conditions (miles)	Increase in Use Support (miles)
Swimmable	109,003	121,530	12,527
Fishable	161,861	178,588	16,727
Boatable	175,666	190,319	14,653
Nonsupport	47,123	32,470	–14,653

miles are also located in these areas. For example, 12,527 (76 percent) of the 16,507 miles that are estimated to achieve swimmable status as a result of the CWA are in populated places.

There are other characterizations of current water quality. In particular, the Index of Watershed Indicators (the IWI or Index) organizes and presents aquatic resource information from numerous sources across the country on a watershed basis. The first and foremost of these sources is the information reported under the 305(b) program. Under this program States and jurisdictions designate uses for their water resources and conduct surveys to determine the extent to which each water resource supports each relevant designated use. This is the most comprehensive characterization of the quality of these resources and of the pollutants and pollutant sources that threaten their quality.

A drawback to using the 305(b) information for benefits estimation, however, is that the reported water quality information does not provide an absolute measure of water quality; rather it is an assessment *relative* to the designated use. A further limitation to these data is that they are based on inconsistent sample surveys—the sampling methods vary among the States and, in many cases, are not based on statistical sampling techniques. The resources surveyed are typically those of most importance to the State or under the greatest threat of impairment.

Another drawback to using the 305(b) estimates for benefits estimation is that there is no way to develop alternative (e.g., without-CWA) water quality scenarios within the 305(b) structure. Although data from IWI have supported the development of the NWPCAM, for consistency we used the NWPCAM to estimate water quality conditions both with and without the CWA.

ES.2 WATER QUALITY BENEFITS VALUATION

To assess the value that individuals place on changes in beneficial uses, we relied on estimates (derived in a previous study) of willingness to pay (WTP) for freshwater quality improvements. WTP is usually regarded as the best observable measure of the value that people place on the improvements in the quality of the services provided by the environment. Its use is consistent with most governmental directives for conducting benefits analyses. However, using WTP implies a human-based perspective on the benefits of water quality improvements. For decisionmakers who believe that a more expanded view of the value of ecosystems should be the basis of public policy, WTP would, presumably, represent a lower bound on the value of the water quality improvements under the CWA.

The WTP values used in this study were originally estimated for a 1983 contingent valuation (CV) study conducted for EPA. These CV estimates have been updated, to the extent feasible, to reflect current values. The CV method uses a survey instrument to elicit respondents' valuation of environmental quality improvements. This survey approach provides an effective way to develop some first-order approximations of values that would otherwise be difficult or impossible to obtain.

To estimate values for local water quality improvements, we applied the CV survey results specifically to households living in populated places where rivers and streams improved in quality. To estimate values for more general (i.e., nonlocal) water quality improvements, we applied the CV results to households in the Nation at large. Comparing current conditions with those that would have prevailed in the absence of the CWA, we estimated the *annual* monetary value of the water quality improvements to be $11 billion. Table ES-3 shows the composition of our annual benefits estimate. Most of the estimate is attributable to the estimated improvement in the in-place services of water (especially recreation and aesthetic services) for households that are proximate to the affected resources. In addition, households expressed a value in the CV study for improvements in water quality for resources that they do not expect to use or, at least, that are outside their local area. These existence services are typically assumed to arise from a sense of environmental stewardship. They make up less than 15 percent of the benefits of the Act.

Table ES-3. Estimated Annual Value of Selected In-Place and Existence Benefits of the CWA, Mid-1990s (million 1997$/yr)

Use Attainment	Local/In-Place Benefits	Nonlocal/ Existence Benefits	Total Benefits
Boatable	$4,192	$784	$4,977
Fishable	$3,043	$512	$3,556
Swimmable	$2,356	$216	$2,572
Total	$9,592	$1,513	$11,105

Again, we note that the methodology used to develop our benefits estimate does not address all the sources and loadings, pollutants, water resources, and services affected by the CWA. Thus, the total benefits of the CWA are underestimated by this report. Future Agency efforts are designed to incorporate the omitted sources, pollutants, resources, and services. Once all of these factors are accounted for, the estimated value should increase and provide a more accurate assessment of the total benefits of the CWA.

1 Introduction

The amendment of the 1948 Federal Water Pollution Control Act (FWPCA) in 1972 signaled a major shift in water quality management responsibility from the States to the Federal government. Under the amendments, the U.S. Environmental Protection Agency (EPA) was given the responsibility to, among other things, set technology-driven national effluent limitations for industrial sources, establish water quality standards, and administer a construction grants program for publicly owned treatment works (POTWs) designed to achieve a minimum level of secondary treatment for wastewaters discharged to surface waters by municipal facilities. The industrial standards are administered through the National Pollutant Discharge Elimination System (NPDES). Discharges from POTWs are regulated through national pretreatment standards and local pretreatment programs (Fogarty, 1991). The FWPCA was further amended in 1977 to address the problem of toxic pollutants. Recognition of the impact of pollutants from nonpoint sources (NPSs) on water quality resulted in provisions in the 1987 amendments to address these sources. Today this body of legislation is commonly referred to as the Clean Water Act (CWA).

The overall goal of the CWA is to "... restore and maintain the chemical, physical, and biological integrity of the Nation's waters." One of the more specific provisions of the Act required eliminating "... the discharge of pollutants into navigable waters" by 1985. The

Act is generally credited with reversing the trend in the degradation in water quality that began with the industrialization of the economy in the 1800s and was epitomized by the incident in June 1969 when the Cuyahoga River near Cleveland caught fire. Today, that location is lined with restaurants and pleasure boat slips (Schneider, 1997).

Complementing the CWA are other governmental initiatives at the Federal and subfederal levels that address the problem of water quality. Notably, the Coastal Zone Management Act is directed toward coastal water pollution problems at a national level. Actions taken under this and other legislation have contributed to the improvements in the Nation's water quality. Because the CWA has been in place longest with the greatest coverage, however, programs administered under this Act are primarily responsible for the water quality improvements. For this reason, as well as for the convenience of having a single inclusive term, we attribute the water quality improvements described in this report to the CWA.

It is natural and appropriate to ask "what have we achieved since 1972?" Such a question is motivated by the desire to know how we are doing in achieving the Act's goals and by the recognition that resources needed to protect and restore the Nation's waters are scarce (costly) while the benefits of water quality improvements are not infinite. Thus, society may seek to learn if the benefits of this public policy, as of others, are worth its costs. Students of public policy counsel that part of effective public policymaking is learning how these polices have performed; and then changing them to improve their performance (e.g., see Stokey and Zeckhauser [1978]). The Government Performance and Results Act (GPRA) codifies these expectations into law; it requires that agencies report on their performance goals and actual achievements. Also, under the provisions of Executive Order (EO) 12893, EPA must evaluate the benefits and costs of municipal infrastructure projects designed to protect water quality. Thus, there are many reasons for evaluating progress under the CWA.

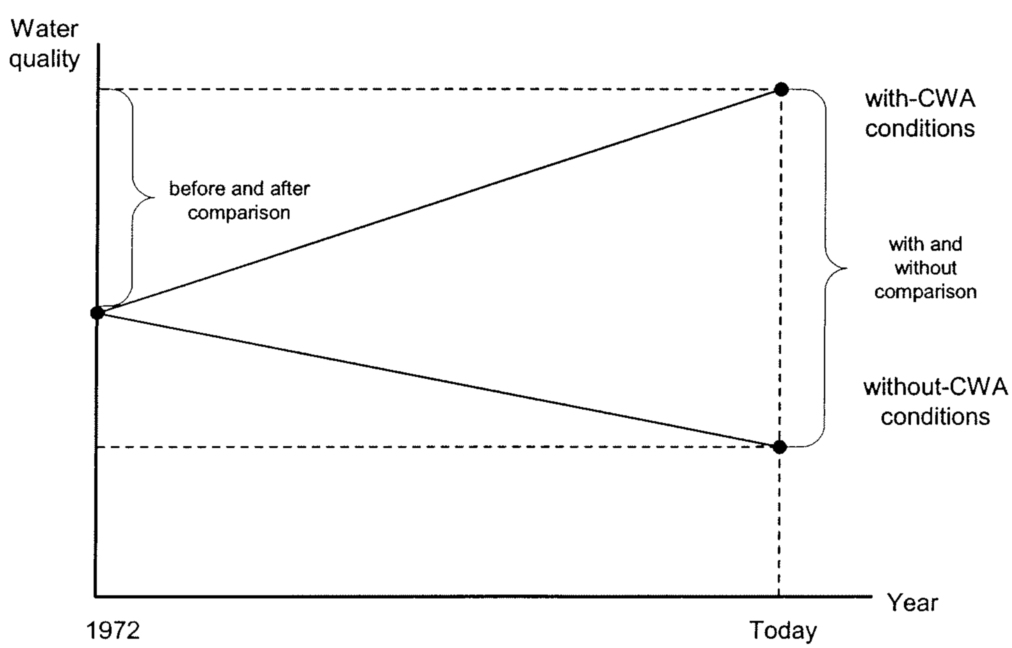
Analysts can address the question of the benefits of the CWA from two perspectives:

1) Before-after perspective: How has the Nation's water quality changed since 1972, and what is the benefit of the change to society?

2) With-without perspective: How does the current quality of the Nation's water resources compare with what it would have been like without the CWA, and what is the benefit to society of the difference?

Figure 1-1 illustrates the differences between these two perspectives. In the figure the actual level of water quality is shown as improving because of pollutant reductions due to the CWA. The first perspective identified above takes a "before and after" view of the contributions of the CWA to water quality improvements—it compares conditions in 1972 to current conditions. However, other things may have changed between 1972 and today that would have affected the quality of the Nation's water resources and the services provided by them.

Figure 1-1. Illustration of Alternative Analytical Perspectives for Evaluating CWA Benefits



The second perspective—"with-without"—considers that without changes in pollutant management practices, economic growth would have resulted in the deterioration of water quality over the period. Providing a plausible characterization of current conditions without the CWA requires developing a without-CWA scenario. This scenario is shown in Figure 1-1 as the declining water quality curve. Although it is more analytically demanding, the "with-without" perspective should be adopted because it is the conceptually correct basis for valuing the benefits. The challenge in such analyses is to develop a consistent, accurate characterization of the without-CWA conditions. That characterization must link estimates of pollutant discharges (i.e., loadings) without the CWA to their impacts on surface water quality, on the services provided by water resources, and on the social value of these services. Those metrics are then compared to the ones developed similarly under with-CWA conditions.

The Nation's water resources, broadly described, include rivers and streams, lakes and reservoirs, estuaries, wetlands, the ocean shoreline, and the Great Lakes. This study focuses only on rivers and streams and, within this category, only the 633,000 miles of larger waterbodies (out of 3.5 million in the Nation) that are catalogued in EPA's Reach File 1 (RF1) database. In terms of their size, the rivers and streams captured in this analysis are the key resources in this category. The Agency has plans to extend the analysis to include additional water resources in the future, especially coastal, estuarine waters, and lakes.

Water pollutants are typically divided into conventional, nonconventional, and toxic pollutants. Source types include points sources (PSs) such as drains, ditches, sewer outfalls; nonpoint sources (NPSs) such as runoff; and atmospheric deposition of air pollutants such as rain or snow contaminated with air pollutants. This analysis includes three pollutants: fecal coliform (FC), an infectious agent; biological oxygen demand (BOD), an oxygen-demanding waste; and total suspended solids (TSS), a sediment. While these pollutants are important contributors to water quality, they are not the only contributors. In particular, many EPA programs are currently aimed at controlling toxic pollutants. The Agency has plans to expand the pollutants covered in future analyses of the benefits of the CWA to include toxic and nonconventional pollutants.

The benefits of water quality improvements achieved under the CWA are evaluated here from an exclusively human-based perspective. From this perspective, the value of a resource is based on individuals' preferences, and the valuation effort focuses on how the services provided by water resources affect individuals' welfare. Water resources provide a variety of services both when withdrawn and when left in place. The focus here is primarily on the effect of water quality on the recreation services of water. This human-based perspective of value is the cornerstone of applied benefit-cost analysis and is codified into governmental and agency practices (e.g., EO 12866, Agency guidelines for performing regulatory impact analyses). However, alternative views do exist on why society should seek to preserve or improve the functioning of ecosystems. Such alternative views may provide a more expansive view of CWA benefits than the human-based approach used in this analysis.

To summarize, our study uses a national water resources network model based on RF1. That model is designed to link PS and NPS loadings, river and stream flows, and the beneficial use goals of the CWA. We used the results of this modeling effort, together with results from existing empirical literature, to estimate the economic significance of current beneficial use attainment relative to the expected state of the Nation's water quality in the absence of the CWA.

This analysis builds on previous work undertaken by Clark et al. (1995) and Research Triangle Institute (1997b) and represents an ongoing effort to develop a comprehensive assessment of the benefits of the CWA as discussed above. Thus, although this study does expand the range of pollutants and sources considered in the analysis over earlier versions of the study, it is important to note that it represents only another increment in an on-going process of evaluating all of the water resources, pollutants, and associated service flows affected by the provisions of the Act. A more comprehensive evaluation will require expanding the water resources and pollutants covered, as well as addressing a number of analytical issues.

A case study of the Willamette river basin in northwest Oregon is also included to complement and contrast with the national evaluation. It provides a more comprehensive analysis of the water quality changes and of the services provided by water resources within a specific region. By working on a smaller geographic scale, the analysis has the benefit of being less abstract than is required when conducting a national analysis. Thus, it provides an informal type of validation test for our national modeling approach.