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DRAFT

THE NATIONAL COSTS TO IMPLEMENT TMDLS

August 1, 2001

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EXECUTIVE SUMMARY

A. INTRODUCTION

This analysis estimates the potential costs for point and nonpoint pollutant sources that are likely to result from implementation of TMDLs nationwide. The States have currently listed nearly 22,000 impaired waters under Section 303(d) of the Clean Water Act (CWA) as waters that will not meet applicable water quality standards even after the application of technology-based effluent limitations. Nearly all of these 303(d) listed waters will need to have TMDLs established.[1] TMDL requirements specify that when a TMDL is developed for an impaired water body, maximum loads must be assigned for the specific point and nonpoint sources that discharge the impairment pollutant(s) affecting the water body. The assigned maximum loads must be sufficient to achieve applicable water quality standards with a margin of safety.

In a TMDL, some point or nonpoint sources will be assigned allowable loads that are less than the loads they currently discharge. These sources will presumably incur some costs to reduce their loads from current levels to the lower levels assigned by the TMDL. It is these costs to reduce pollutant source loads that we attribute to the TMDL program and that we estimate in this report.[2]

More specifically, we estimate the costs that TMDLs will engender for point and nonpoint sources in order to meet water quality standards for the set of impaired waters included in the States' 1998 303(d) lists. For these impaired waters, we attribute to the TMDL program the costs of the additional controls that pollutant sources will need to implement beyond a baseline that includes: 1) Whatever controls were in place at point and nonpoint sources as of when the 1998 303(d) lists were developed; and 2) Assumed compliance with all applicable technology-based requirements. Viewed in another way, the analysis estimates the incremental costs to pollutant sources of achieving water quality standards relative to a baseline of their controls in place in 1998, but excluding the costs of whatever amount of this further progress will be achieved through meeting technology-based requirements that were unmet as of 1998.

B. THREE TMDL PROGRAM SCENARIOS

We estimate the costs for pollutant sources to meet TMDL allocations under each of three broad scenarios: a "Least Flexible TMDL Program" scenario; a "Moderately Cost-effective TMDL Program" scenario; and a "More Cost-Effective TMDL Program" scenario.

1. *The "Least Flexible TMDL Program" scenario.* This scenario explores what costs to pollutant sources would result if the nation chose to restore the currently impaired waters under a TMDL program in

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1 A 303(d) listed water will not require a TMDL to be developed if no pollutant can be identified that is responsible for the impairment. Such waters are said to be impaired by "pollution" but not pollutants. Causes of impairment for such waters might include flow modification, habitat alteration, and the like.

2 Note that some of these same costs could be incurred in the absence of a TMDL, either before the water body is listed or during the period between listing and the development of the TMDL. Section 301(b)(1)(c) of the Clean Water Act requires water quality-based effluent limits (WQBELs) for NPDES permittees if it is determined that these discharges would "cause or contribute to a violation of a water quality standard."

which every source affecting an impaired water would be required to implement further control measures, rather than a more calibrated approach. We assume that States would continue the water quality-based approaches that have commonly been used to date in situations where a TMDL has not been developed. Under CWA section 301(b)(1)(c), NPDES permits for point source dischargers must include limits necessary to meet water quality standards. Similarly, under section 319 of the CWA, States must address the nonpoint sources that contribute to impairment of water bodies (though not necessarily through regulatory mechanisms, as are mandated for point sources through the NPDES program). As States carry out this "Least Flexible TMDL Program" approach for an impaired water body, we assume they would need to address every point and nonpoint source that appears to contribute to impairment of the water body.

2. *The "Moderately Cost-effective TMDL Program" scenario.* The "Moderately Cost-effective TMDL Program" scenario differs from the first scenario in that it presumes (consistent with current implementing regulations) that the TMDL will: 1) Start with a holistic assessment of the impaired water body and all the sources that affect it; and 2) Require carefully chosen load reductions from pollutant sources that together will be just sufficient to achieve water quality standards with a margin of safety. The TMDL determines how much load from all the sources together can be tolerated, and allocates this allowable load in some manner among the responsible sources. Without this more flexible TMDL, every source that discharges the impairment pollutant will presumably need to implement measures to abate its discharge (the previous "Least Flexible TMDL Program" scenario). With a more moderately cost-effective TMDL, a much finer calculation is made, and often not every source will need to abate its discharge. The TMDL determines exactly which sources will need to reduce their loads, and by how much. Depending on the severity of the impairment, with a moderately cost-effective TMDL somewhere between a few and many of the sources discharging the impairment pollutant may not have to reduce their discharge at all. In addressing each source in isolation and requiring further controls from all of them individually, the previous "Least Flexible TMDL Program" scenario is likely to substantially overshoot the load reduction needed to attain water quality standards. Under this second scenario, the number of pollutant sources that have to take any action, should, in most cases, be reduced.

3. *The "More Cost-Effective TMDL Program" scenario.* Neither the Clean Water Act nor EPA's implementing regulations prescribe how a total maximum daily load is to be allocated among the sources that discharge the impairment pollutant. The State may assign responsibilities among sources for load reductions as the state wishes. Different allocations will result in different total costs of achieving the desired total load reduction, as a function of the differing costs per pound for the various pollutant sources to reduce their loads. In general, the total costs of achieving the target load reduction will be lower if the sources with lower per unit control costs are assigned responsibility for achieving the bulk of the desired total load reduction. We use the term "cost-effective wasteload allocation" to denote a situation in which the state attempts to reduce aggregate costs by assigning responsibility for achieving most of the total desired load reduction to sources that have relatively low costs of achieving load reductions. Alternatively, the same economically efficient result (achieving a desired total load reduction in a lower cost manner) can be achieved, in theory, given any initial allocation of control responsibilities, if "trading" is allowed. With trading, any source that is assigned responsibility for a load reduction is free to achieve that load reduction itself, or to buy the equivalent load reduction from another source that might be able to provide it at lesser cost. Whatever the initial allocation, trading will tend ultimately to elicit load reductions from the lowest cost sources.

The "More Cost-Effective TMDL Program" scenario recognizes the possibility of reducing TMDL costs to dischargers through either "cost-effective wasteload allocations" or through trading, or both.

Either of these approaches would reduce the eventual costs to dischargers well below what they would be if TMDLs assigned load reductions on a cost-neutral basis (e.g., if load reductions were determined on a simple proportional rollback basis).

C. COSTS FOR POLLUTANT SOURCES UNDER THE THREE SCENARIOS

For each of the three scenarios, we estimate the costs for controlling the point and nonpoint sources that affect each of the currently listed 303(d) waters. These cost estimates are for the incremental controls – relative to those that existed in 1998 or so when the impaired waters were listed – that will be needed to achieve water quality standards in the listed waters. To the extent that some of the needed progress will be achieved through compliance with as-yet-unmet technology-based standards, we do not count such costs, as they are attributable to sections of the Clean Water Act other than §303. To the extent that some of these costs have already been incurred since the waters were listed, the cost estimates we present here overstate the costs that remain for dischargers.

We estimate the costs to pollutant sources in first quarter 2000 dollars. All costs include capital and operating and maintenance costs, combined into a single annualized cost figure. The cost estimates that we present represent levelized annual amounts beginning in the year 2000 that will continue each year, forever. TMDLs are assumed to be developed at an even pace over the 15 years from now through 2015, consistent with the deadline for TMDL development established by the new regulations. The average source is assumed to begin incurring its costs to implement TMDL allocations five years after the TMDL affecting that source is developed. The timing of compliance investments by sources is assumed to be identical under each of the three TMDL program scenarios. A real discount rate of 7 % is used.[3]

Under a least flexible TMDL program, pollutant sources will incur costs estimated at $1.9 - $4.3 billion per year to implement controls for the nearly 20,000 waters for which TMDLs will be developed (among the nearly 22,000 impaired waters). This is equivalent to approximately $95,000 - $215,000 annually in implementation costs per water body. In addition to these costs, nonpoint sources may realize cost <u>savings</u> of up to perhaps $1 billion per year from the management measures we project that they are likely to adopt.

In contrast, to achieve the same results in the same time frame, but with a moderately cost-effective TMDL program, pollutant sources will need to spend only $1.0 - $3.4 billion per year. This is a cost reduction of 21 - 44 %. A moderately cost-effective TMDL program saves pollutant sources money because TMDLs will involve careful calculations to determine the load reduction that will be sufficient to achieve water quality standards. In the absence of a moderately cost-effective TMDL, though, a State is likely to require further controls from all sources that discharge the impairment pollutant.

Under the "More Cost-Effective TMDL Program" scenario, costs to dischargers may decline by roughly 7 to 13 % ($140 - $235 million annually) from those that would occur under the second scenario if each TMDL were to require equivalent control efforts from all sources needing to implement controls. These savings that we estimate from cost-effective WLAs or trading represent only the savings available from shifting some point source control responsibilities to nonpoint sources (i.e., "point/nonpoint trading").

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3 For the final report, costs will also be estimated assuming a real discount rate of 3% per year.

We have not been able to estimate additional savings that might occur from other sorts of trading (e.g., "point/point" trading, pretreatment trading, trading among nonpoint sources).

Exhibit ES - 1
Estimated Costs for Pollutant Sources to Implement TMDLs

Type of Source	Annual Costs (2000 $ in millions)		
	Least Flexible TMDL Program	**Moderately Cost-effective TMDL Program**	**More Cost-Effective TMDL Program**
Point sources	1,082 - 2,178	812 - 1,634	625 - 1,321
Nonpoint sources	783 - 2,162	234 - 1,791	281 - 1,869
Total implementation costs	**1,865 - 4,340**	**1,046 - 3,425**	**906 - 3,190**
Potential savings for nonpoint sources	undetermined	undetermined	undetermined

1. Costs for point source dischargers

Under the first two scenarios, half or more of the costs will be incurred by point sources. This is despite the fact that point sources affect only about 1/4 of the impaired waters while nonpoint sources affect more than 90 % of them. Under the third scenario, some point source control responsibilities are presumed to be shifted to nonpoint sources because of the expected ability of nonpoint sources to abate loads at lower costs per pound. Even so, point sources may still incur the majority of the implementation costs.

Exhibit ES - 2
Estimated Costs for Point Sources -- Least Flexible TMDLs

Type of Source	Annual Costs (2000 $ in millions)		Number of Affected Facilities	
	Low Est.	**High Est.**	**Low Est.**	**High Est.**
Industrial dischargers	676	1,465	3052	8557
Indirect dischargers (metals)	10	16	at 148 POTWs	at 312 POTWs
POTWs	396	697	1094	3335
Total	**1,082**	**2,178**	**4,146**	**11,893**

Exhibit ES - 3
Estimated Costs for Point Sources for
Moderately Cost-effective and More Cost-Effective TMDL Programs

Type of Source	**Annual Costs (2000 $ in millions)**		**Number of Affected Facilities**	
	Low Est.	**High Est.**	**Low Est.**	**High Est.**
Industrial dischargers	507	1,099	2289	6418
Indirect dischargers (metals)	8	12	at 111 POTWs	at 234 POTWs
POTWs	297	523	821	2502
Total	**812**	**1,634**	**3,110**	**8,919**
Potential savings from cost-effective wasteload allocations	**(187)**	**(313)**	**1,251**	**2,066**

The low and the high estimates shown above reflect differing judgments about how far upstream of an impaired water can there typically be point sources that contribute to the water body's impairment. The lower estimate assumes that only point sources discharging the impairment pollutant directly into the impaired water contribute to impairment. The upper estimate assumes that point sources can contribute to impairment from as far away as 25 miles upstream (if the impairment pollutant is BOD, ammonia or toxic organic chemicals) or 50 miles upstream (if the impairment pollutant is nutrients or metals). We believe these two estimates provide reasonable lower and upper estimates for the geographic extent of point sources that will be judged as relevant in TMDLs.

There are roughly 70,000 individually permitted point source dischargers in the nation. Somewhere between 6 and 17 percent of them appear to contribute to the impairment of a 303(d) water, and would likely be addressed by efforts to restore the nation's impaired waters under a least flexible TMDL program. Based on the experience from a sample of recently developed TMDLs, only about 3/4 of these sources (about 3,000 - 9,000 point source dischargers) will likely incur costs under a moderately cost-effective TMDL program. Of these point sources likely to be affected by the TMDL program, perhaps 20 to 40 percent of them will incur no or reduced costs if the TMDL program proceeds in more a cost-effective manner.

2. Costs for nonpoint source pollutant sources

Costs were estimated for four types of nonpoint sources: agricultural land (including crop, pasture and range land), animal feeding operations (AFOs), silviculture, and on-site wastewater treatment systems (septic tanks, etc.). Some of the measures that nonpoint sources are likely to implement to achieve TMDL-mandated load reductions will yield partly offsetting cost savings (e.g., agricultural nutrient management planning implemented pursuant to a TMDL can reduce farmers' costs for chemical fertilizers). Exhibit ES - 4 shows only the costs and not the cost savings from the management measures that may be implemented by the four types of nonpoint sources that we analyze.

Exhibit ES - 4
Estimated Costs for Nonpoint Sources

<table>
<tr><th rowspan="2">Type</th><th colspan="3">Annual Costs (2000 $ in millions)</th></tr>
<tr><th>Least Flexible TMDL Program</th><th>Moderately Cost-effective TMDL Program</th><th>More Cost-Effective TMDL Program</th></tr>
<tr><td>Agricultural land
crop land
pasture land
range land
Potential savings</td><td>
645 - 1,956
5 - 11
2 - 16
(not estimated)</td><td>
183- 1,632
5 - 11
2 - 16
(not estimated)</td><td rowspan="5">Additional costs of 47 - 78 relative to those incurred under moderately cost-effective TMDL program. (Note that in the “more cost-effective” scenario, point sources control less and nonpoint sources control more by an equivalent amount)</td></tr>
<tr><td>AFOs
Potential savings</td><td>76 - 110
(not estimated)</td><td>13 - 73
(not estimated)</td></tr>
<tr><td>Silviculture</td><td>30 - 42</td><td>7 - 31</td></tr>
<tr><td>On-site wastewater treatment systems</td><td>24 - 28</td><td>24 - 28</td></tr>
<tr><td>Total
Potential savings</td><td>783 - 2,162
(not estimated)</td><td>234 - 1,791
(not estimated)</td></tr>
</table>

There is a very wide range of uncertainty regarding the estimates of potential savings. They could range up to perhaps a billion dollars per year. Additional work is being conducted to narrow this range.

In the limited time available for this study, costs were not estimated for the further controls that may be needed for several other potentially important categories of nonpoint sources, including abandoned mines, contaminated sediments, air deposition, and more.

D. ANALYTICAL METHODOLOGY

The task of projecting the costs for pollutant sources to meet the requirements of TMDLs for nearly 22,000 impaired waters is particularly difficult because the background information necessary for developing TMDLs has been generated for only a very few of these waters. We do not know, at this point, how far out of attainment most of the impaired waters will be found to be, what sources will be found to be responsible for each impairment, and what degree of load reduction will be required of each responsible source. In this analysis we must estimate each of these elements now, before the background studies and actual TMDLs have been developed. Our analysis necessarily involves many assumptions that we apply to the relatively limited data that now exists on these impaired waters and the sources that may contribute to their impairment.

The analysis is further complicated by our interest in estimating costs under each of the three scenarios. In addition to a series of technical assumptions involving the likely content of the eventual

TMDLs for the impaired water bodies, we also make assumptions about what will happen differently under each of the three scenarios.

In general, our analysis proceeds by first estimating the costs if all pollutant sources contributing to impairment of an impaired water body were required to implement reasonable measures to reduce their discharge of the impairment pollutant(s). We assume that this reflects the most that might be required under a TMDL -- Scenario 1, the "Least Flexible TMDL Program". We then estimate the costs for Scenario 2 by adjusting downward the costs estimated for Scenario 1, assuming that TMDLs in practice will result in a more precise calculation of how much load reduction is needed from pollutant sources in order to meet water quality standards. The total load reduction required of pollutant sources under Scenario 2 is less than that which would be obtained if all pollutant sources contributing to impairment were to implement abatement measures, as under Scenario 1. The costs of Scenario 3 are then estimated by estimating the savings compared with Scenario 2 that more cost-effective waste load allocations might provide relative to the costs under a cost-neutral TMDL program.

We began by identifying the universe of point and nonpoint sources potentially contributing to impairment(s) of each of the 303(d)-listed water bodies in the nation. For many listed water bodies, States identify whether the sources contributing to impairment are point sources, nonpoint sources, or both. For each water body cited as impaired by point sources (as well as perhaps other source types), we identified the specific point sources that might potentially be contributing to the impairment. Similarly, for each water body cited as impaired by nonpoint sources, we identified the potentially responsible specific nonpoint sources. For 303(d) waters for which States have not provided information on the sources of impairment (e.g., when States cite "unknown" sources of impairment, or simply do not report any source of impairment), we identified all potentially relevant point and nonpoint sources and then extrapolated cost information to them based on relationships we established for waters for which impairment sources were reported.

We assumed that the set of point sources affecting a point-source impaired water is somewhere between two cases:

- *Case 1, "within and upstream"*. We assume that a point source contributes to impairment if it discharges the pollutant of concern within 25 miles upstream of a water body impaired by BOD, ammonia or toxic organic chemicals, and within 50 miles upstream of a water body impaired by nutrients or metals.

- *Case 2, "within only"*. We assume that a point source contributes to impairment if it discharges the pollutant of concern directly into the impaired water body.

The *"within and upstream"* case thus identifies a larger set of point sources as contributing to impairment than does the *"within only"* case. We use these two cases to establish upper and lower estimates for point source costs for each of the three scenarios. For the "Least Flexible TMDL Program" scenario, we assume that States will require further control of all the point sources that contribute to impairment, under the within and upstream case as an upper estimate and under the within-only case as a lower estimate. For the other two scenarios, we use data from a sample of recently completed TMDLs to estimate the fraction of the point sources contributing to impairment that are typically required to reduce their loads in actual TMDLs. In fact, some impaired waters are only moderately impaired, and for these waters TMDLs will require load reductions from only some of all the point sources that discharge the impairment pollutant.

The likelihood that many TMDLs will not require load reductions from all point sources contributing to impairment makes the costs for the "Moderately Cost-effective TMDL Program" scenario less than for the "Least Flexible" scenario. Again, we use the two cases to establish upper and lower estimates for both the "Moderately Cost-effective TMDL Program" scenario and the "More Cost-Effective TMDL Program" scenario.

For nonpoint sources, we assumed that States under the "Least Flexible" scenario would require further controls of all the nonpoint source activity of the relevant variety that occurs within the same county or counties as the impaired water body. For example, if a State identifies a 303(d) water body as impaired by animal feeding operations (AFOs) and silviculture, we assumed that the State would require further controls for all AFOs and all silviculture within the county(s) in which the impaired water body is located. For the "Moderately Cost-effective TMDL Program" and "More Cost-Effective TMDL Program" scenarios, again based on the results from a sample of actual TMDLs, we assumed that the State would make a finer calculation regarding the geographic extent of nonpoint source activity from which load reductions must be obtained. In the great majority of cases, actual TMDLs have required nonpoint source controls from watershed areas much smaller than the entire county(s) surrounding the impaired water body.

As a baseline for cost analysis, we assumed that all these identified affected point and nonpoint sources have control measures in place equal to the greater of: 1) Their current controls in place; and 2) Controls necessary to meet applicable technology-based standards. We assumed that the load allocations established under TMDLs would require all relevant sources to implement the "next treatment step" beyond their assumed baseline controls in place:

- *For industrial point sources:* The next treatment step consisted of a further treatment technology, depending on the specific pollutant, beyond the technologies assumed to be in place to meet effluent guideline requirements.

- *For POTWs:* The next treatment step for most pollutants was assumed to be advanced secondary treatment, the next increment beyond secondary treatment assumed to be in place to meet secondary treatment requirements. When a POTW appeared to need further controls specifically for metals, the next treatment step was assumed to be an enhanced local pretreatment program, requiring further controls of the POTW's indirect dischargers beyond applicable pretreatment standards in effluent guidelines.[4]

- For agricultural, AFO, silvicultural, and on-site wastewater system nonpoint sources: We assumed there were no Federal technology-based requirements applicable in the baseline for these sources. The next treatment step beyond this baseline of no controls was assumed to be implementation of a basic set of best management practices (BMPs) for the particular nonpoint source type as suggested in EPA guidance documents. In estimating

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4 We made two further important assumptions for POTWs. First, we assumed that TMDLs will require no further controls for those POTWs that already provide advanced secondary treatment or better. Second, we assumed that any costs for POTW treatment upgrades that have progressed sufficiently in planning to be included in the 1996 Clean Water Needs Survey (CWNS) should not be viewed as incrementally attributable to the TMDL program. In essence, we consider POTW upgrade projects that were already far along in planning as of 1996 as predating and not deriving from the programs we analyze in this report. Later, we discuss the impact of these two particular assumptions for POTWs on the cost estimates.

the costs of implementing the set of BMPs representing the next treatment step we did, where data were available, reflect the fact that some nonpoint sources have already (in the baseline) adopted some of the BMPs.

- *For urban wet weather sources:* We did not project any further controls to be needed for urban wet weather sources beyond existing technology-based requirements addressing CSOs, SSOs and storm water phase I and II. To the extent that TMDLs do ultimately require further controls for some urban wet weather sources, we have not estimated these costs.

Our estimates for the costs to pollutant sources under the three scenarios consist of the aggregated costs for these "next treatment steps" for all the point and nonpoint sources identified as affecting 303(d) waters. The two sets of key assumptions underlying the analysis include:

1. The assumptions made in identifying the specific point and nonpoint sources that will need further controls beyond current levels and technology-based standards in order to achieve water quality standards; and

2. The assumption that the further control needed from every identified source is the "next treatment step" beyond applicable technology-based requirements.

For many water bodies and many TMDLs, these assumptions may be substantially inaccurate. For any given water body, the sources a State might identify as needing further controls may be more or less than the point sources within the water body and/or 25 or 50 miles upstream and the surrounding county's worth of nonpoint sources. For any given water body, the additional control efforts needed from the affected sources may also be more or less than the assumed next treatment step.

In projecting what future TMDLs are likely to require for the impaired water bodies, we based several key assumptions on our findings from reviewing the content of a sample of fifteen recently completed TMDLs. This review is summarized in Appendix A -- "Ground-Truthing the Implementation Cost Analysis Assumptions". This sample of fifteen is smaller than we would like, and it will be increased for the final version of this report. The major findings from this review of sample TMDLs are:

- TMDLs commonly, but not always, address upstream point sources in addition to those point sources discharging the impairment pollutant directly into the impaired water. The average situation seems somewhere between the "within only" and the "upstream and within" cases;

- The aggregate load reduction needed from point sources is often obtained without requiring further controls from all of the point sources discharging the impairment pollutant;

- The geographic extent of nonpoint sources from which further controls are required is typically much less than the entire county(s) surrounding the impaired water;

- For both point and nonpoint sources, the degree of load reduction that is required is very often less than that which would be achieved if all relevant point and nonpoint sources were to implement "the next treatment step".

More specifically, in estimating the costs of the "Moderately Cost-effective TMDL Program" and "Cost-Effective TMDL Program" scenarios, we drew the following quantitative relationships from the results of the fifteen TMDLs:

- For point sources. In about half the TMDLs, the aggregate load reduction actually required of point sources was roughly equivalent to what would be achieved if all point sources contributing to impairment of the water body were to implement "the next treatment step". In the other half of the TMDLs, "the next treatment step" for all point sources would result in about twice as much aggregate load reduction as was actually needed.

- For nonpoint sources. The size of the watershed from which most TMDLs required nonpoint source load reductions was far smaller than the size of a typical county. The acreage of most nonpoint source TMDL watersheds ranged from about 5% to about 40% as large as the acreage of the county(s) within which the impaired water body was located.

These quantitative relationships should be regarded as tentative pending the evaluation of more completed TMDLs.

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I. METHODOLOGY

A. THREE TMDL PROGRAM SCENARIOS

We estimate the costs for pollutant sources to achieve the load reductions to be required by TMDLs under each of three broad scenarios: a "Least Flexible TMDL Program" scenario; a "Moderately Cost-effective TMDL Program" scenario; and a "More Cost-Effective TMDL Program" scenario.

1. *The "Least Flexible TMDL Program" scenario*. This scenario explores what costs to pollutant sources would result if the nation chose to to restore the currently impaired waters under a TMDL program in which every source affecting an impaired water would be required to implement further control measures, rather than a more calibrated approach. We see two possibilities for how the nation might meet the Clean Water Act goal of restoring impaired waters under this scenario:

- Progressively tighten the nationally uniform technology-based requirements for relevant classes of dischargers until all water bodies eventually meet standards. Although a theoretical possibility, this approach would be unreasonably inefficient. A relatively small fraction of all point and nonpoint sources affect impaired water bodies. It would be exceedingly costly to require further controls from the entire nation's worth of some category of point or nonpoint sources (e.g., all POTWs in the country, or every silvicultural operation) in order to reduce loads from only the fraction of such sources affecting impaired waters.

- Continue the water quality-based approaches that have commonly been used to date in situations where a TMDL has not been developed. Under CWA § 301(b)(1)(c), all NPDES permits for point source dischargers must include limits necessary to meet water quality standards. Similarly, under § 319 of the CWA, states must address the nonpoint sources that contribute to impairment of water bodies (though not necessarily through regulatory mechanisms, as are mandated for point sources through the NPDES program).[5]

The second approach to the "Least Flexible TMDL Program" scenario is far more realistic, and we assume this is what would occur if more flexible TMDLs were not developed.

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5 Some observers have postulated a different scenario in the absence of TMDLs. These observers emphasize that point sources are subject to regulatory controls under the NPDES program, while nonpoint sources are generally not subject to federal regulatory controls. If achieving water quality standards were to depend solely on federal regulatory authorities available under the Clean Water Act, states or EPA would be able to require further control efforts only from point sources. NPDES permit limits for point sources would be progressively tightened as necessary to make up for uncontrolled nonpoint sources. Under this least flexible scenario for point sources, many point sources would ultimately need to meet exceedingly costly "zero discharge" limits in an attempt to compensate for growing nonpoint source loads.

We regard this scenario as unrealistic and will not analyze it. For many impaired water bodies, the contribution from point sources is minimal or non-existent. Any realistic program to achieve water quality standards in all impaired waters must seriously address nonpoint sources as well as point sources.

Our Methodology for Estimating Costs to Pollutant Sources – the"Worst- Case TMDL Program" Scenario

We follow three steps:

1. Identify all the point and nonpoint sources in the nation that appear to discharge an impairment pollutant to one of the impaired waters on the 1998 303(d) lists.

2. Assume that every such relevant source will be required under the NPDES program or somehow induced under the 319 program to implement additional measures (beyond those assumed to be in place already to meet existing technology-based standards) to abate this discharge.

3. Estimate the costs for each source to implement an appropriate "next treatment step" that will presumably sufficiently reduce the source's discharge.

2. *The "Moderately Cost-effective TMDL Program" scenario*. The "Moderately Cost-effective TMDL Program" scenario differs from the first scenario in that it presumes (consistent with current implementing regulations) that the TMDL will: 1) Start with a holistic assessment of the impaired water body and all the sources that affect it; and 2) Require carefully chosen load reductions from pollutant sources that together will be just sufficient to achieve water quality standards with a margin of safety. The TMDL determines how much load from all the sources together can be tolerated, and allocates this allowable load in some manner among the responsible sources. Without this more flexible TMDL, every source that discharges the impairment pollutant will presumably need to implement measures to abate its discharge (the previous "Least Flexible TMDL Program" scenario). With a more moderately cost-effective TMDL, a much finer calculation is made, and often not every source will need to abate its discharge. The TMDL determines exactly which sources will need to reduce their loads, and by how much. Depending on the severity of the impairment, with a moderately cost-effective TMDL somewhere between a few and many of the sources discharging the impairment pollutant may not have to reduce their discharge at all. In addressing each source in isolation and requiring further controls from all of them individually, the previous "Least Flexible TMDL Program" scenario is likely to substantially overshoot the load reduction needed to attain water quality standards. Under this second scenario, the number of pollutant sources that have to take any action, should, in most cases, be reduced.

Our Methodology for Estimating Costs to Pollutant Sources – the "Moderately Cost-effective TMDL Program" Scenario

We start with the steps for the "Least Flexible TMDL Program" scenario: a) Identify all sources responsible for impairments; 2) Estimate costs for all of them to implement an appropriate "next treatment step". We then:

- Scale these costs down to reflect the average percentage load reduction identified in typical TMDLs relative to the load reduction that would be obtained if all sources were to implement the "next treatment step".

3. *The "More Cost-Effective TMDL Program" scenario*. Neither the Clean Water Act nor EPA's implementing regulations prescribe how a total maximum daily load is to be allocated among the sources that discharge the impairment pollutant. The state may assign responsibilities among sources for load reductions as the state wishes. Different allocations will result in different total costs of achieving the

desired total load reduction, as a function of the differing costs per pound for the various pollutant sources to reduce their loads. In general, the total costs of achieving the target load reduction will be lower if the sources with lower per unit control costs are assigned responsibility for achieving the bulk of the desired total load reduction. We use the term "more cost-effective wasteload allocation" to denote a situation in which the state attempts to reduce aggregate costs by assigning responsibility for achieving most of the total desired load reduction to sources that have relatively low costs of achieving load reductions. Alternatively, the same economically efficient result (achieving a desired total load reduction in a lower cost manner) can be achieved, in theory, given any initial allocation of control responsibilities, if "trading" is allowed. With trading, any source that is assigned responsibility for a load reduction is free to achieve that load reduction itself, or to buy the equivalent load reduction from another source that might be able to provide it at lesser cost. Whatever the initial allocation, trading will tend ultimately to elicit load reductions from the lowest cost sources.

The "More Cost-Effective TMDL Program" scenario recognizes the possibility of reducing TMDL costs to dischargers through either "more cost-effective wasteload allocations" or through trading, or both. Either of these approaches would reduce the eventual costs to dischargers well below what they would be if TMDLs assigned load reductions on a cost-neutral basis (e.g., if load reductions were determined on a simple proportional rollback basis). We expect that pressure to adopt cost-minimizing approaches will build, and more TMDLs will tend toward this "more cost-effective" model. Note, though, that there may be some instances where other concerns (e.g., equity, concern about implementation and enforcement complexities attendant to trading) prevent use of these cost-minimizing approaches.

Our Methodology for Estimating Costs to Pollutant Sources – the "More Cost-Effective TMDL Program" Scenario

We start by estimating the costs for the "Moderately Cost-effective TMDL Program" scenario. We then:

- Scale these costs down to reflect the typical percentage cost savings that might be realized through additional "cost-effective wasteload allocations" or trading.

B. OVERVIEW OF THE ANALYTICAL APPROACH

In this analysis, we estimate the costs as of the spring of 2000 for pollutant sources to reduce their loads as necessary to meet water quality standards for all waters on States' approved 1998 303(d) lists (21,845 listed waters and 41,318 causes of impairment cited for these waters). We estimate these costs under each of the three scenarios we have described. Implementation costs are estimated for each of the listed water bodies and then aggregated nationally. Limited site-specific information was available and could be processed for all these water bodies and the sources that affect them. It was not possible to perform what would in effect be an initial TMDL for each of these water bodies -- determine how far each water body was from attainment, estimate the amount of load reductions necessary to achieve attainment, and estimate the costs for the relevant pollutant sources to accomplish these load reductions. Instead, we made several broad assumptions that limited the amount of site-specific information we needed to obtain and analyze.

In general, our analysis proceeds by first estimating the costs if <u>all</u> pollutant sources contributing to impairment of an impaired water body were required to implement reasonable measures to reduce their discharge of the impairment pollutant(s). We assume that this reflects what would happen under an inefficient or "Least Flexible TMDL Program". This is our Scenario 1. We then estimate the costs for Scenario 2 by adjusting downward the costs estimated for Scenario 1, assuming that moderately cost-effective TMDLs will result in a more precise calculation of how much load reduction is needed from pollutant sources in order to meet water quality standards. The total load reduction required of pollutant sources under Scenario 2 is less than that which would be obtained if all pollutant sources contributing to impairment were to implement abatement measures. The costs of Scenario 3 are then estimated by estimating the savings that cost-effective waste load allocations might provide relative to the costs of a cost-neutral TMDL program.

We began by identifying the universe of point and nonpoint sources potentially contributing to impairment(s) of each of the 303(d) listed water bodies in the nation. For many listed water bodies, states identify whether the sources contributing to impairment are point sources, nonpoint sources, or both. For each water body cited as impaired by point sources (as well as perhaps other source types), we identified the specific point sources that might potentially be contributing to the impairment. Similarly, for each water body cited as impaired by nonpoint sources, we identified the potentially responsible specific nonpoint sources. For 303(d) waters for which States have not provided information on the sources of impairment (e.g., when States cite "unknown" sources of impairment, or simply do not report any source of impairment), we identified all potentially relevant point and nonpoint sources and then extrapolated cost information to them based on relationships we established for waters for which impairment sources were reported.

We assumed that the set of point sources affecting a point-source impaired water is somewhere between two cases:

- *Case 1, "within and upstream".* We assume that a point source contributes to impairment if it discharges the pollutant of concern within 25 miles upstream of a water body impaired by BOD, ammonia or toxic organic chemicals, and within 50 miles upstream of a water body impaired by nutrients or metals.

- *Case 2, "within only".* We assume that a point source contributes to impairment if it discharges the pollutant of concern directly into the impaired water body.

The *"within and upstream"* case thus identifies a larger set of point sources as contributing to impairment than does the *"within only"* case. We use these two cases to establish upper and lower estimates for point source costs for each of the three scenarios. For the "Least Flexible TMDL Program" scenario, we assume that States will require further control of <u>all</u> the point sources that contribute to impairment, under the within and upstream case as an upper estimate and under the within only case as a lower estimate. For the other two scenarios, we use data from a sample of recently completed TMDLs to estimate the fraction of the point sources contributing to impairment that are typically required to reduce their loads in actual TMDLs. In fact, some impaired waters are only moderately impaired, and for these waters TMDLs will require load reductions from only some of all the point sources that discharge the impairment pollutant. The likelihood that many TMDLs will not require load reductions from all point sources contributing to impairment makes the costs for the "Moderately Cost-effective TMDL Program" scenario less than for the"Least Flexible TMDL Program" scenario. Again, we use the two cases to establish upper and lower estimates for both the "Moderately Cost-effective TMDL Program" scenario and the "More Cost-Effective TMDL Program" scenario.

For nonpoint sources, we assumed that States under the ”Least Flexible TMDL Program” scenario would require further controls of all the nonpoint source activity of the relevant variety that occurs within the same county as the impaired water body. For example, if a State identifies a 303(d) water body as impaired by animal feeding operations (AFOs) and silviculture, we assumed that the State would require further controls for all AFOs and all silviculture within the county(s) in which the impaired water body is located. For the “Moderately Cost-effective TMDL Program” and “More Cost-Effective TMDL Program” scenarios, again based on the results from a sample of actual TMDLs, we assumed that the State would make a finer calculation regarding the geographic extent of nonpoint source activity from which load reductions must be obtained. In the great majority of cases, actual TMDLs have required nonpoint source controls from watershed areas that are much smaller than the area of the entire county(s) surrounding the impaired water body.

As a baseline for cost analysis, we assumed that all these identified affected point and nonpoint sources have control measures in place equal to the greater of: 1) Their current controls in place; and 2) Controls necessary to meet applicable technology-based standards. We assumed that the load allocations established under TMDLs would require some or all of these sources to implement a “next treatment step” beyond their assumed baseline controls in place:

- *For industrial point sources:* The next treatment step consisted of a further treatment technology, depending on the specific pollutant, beyond the technologies assumed to be in place to meet effluent guideline requirements.

- *For POTWs:* The next treatment step for most pollutants was assumed to be advanced secondary treatment, the next increment beyond secondary treatment assumed to be in place to meet secondary treatment requirements. When a POTW appeared to need further controls specifically for metals, the next treatment step was assumed to be an enhanced local pretreatment program, requiring further controls of the POTW’s indirect dischargers beyond applicable pretreatment standards in effluent guidelines.[6]

- For agricultural, AFO, silvicultural, and on-site wastewater system nonpoint sources: We assumed there were no Federal technology-based requirements applicable in the baseline for these sources. The next treatment step beyond this baseline of no controls was assumed to be implementation of a basic set of best management practices (BMPs) for the particular nonpoint source type as suggested in relevant EPA guidance documents. In estimating the costs of implementing the set of BMPs representing the next treatment step we did, where data were available, reflect the fact that some nonpoint sources have already (in the baseline) adopted some of the BMPs.

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6 We made two further important assumptions for POTWs. First, we assumed that TMDLs will require no further controls for those POTWs that already provide advanced secondary treatment or better. Second, we assumed that any costs for POTW treatment upgrades that have progressed sufficiently in planning to be included in the 1996 Clean Water Needs Survey (CWNS) should not be viewed as incrementally attributable to the TMDL program . In essence, we consider POTW upgrade projects that were already far along in planning as of 1996 as predating and not deriving from the TMDL program. Later, we discuss the impact of these two particular assumptions for POTWs on the cost estimates.

- *For urban wet weather sources:* We did not project any further controls to be needed for urban wet weather sources beyond existing technology-based requirements addressing CSOs, SSOs and storm water phase I and II. To the extent that TMDLs do ultimately require further controls for some urban wet weather sources, we have not estimated these costs.

Our estimates for the costs to pollutant sources under the three scenarios consist of the aggregated costs for these "next treatment steps" for all the point and nonpoint sources identified as affecting 303(d) waters. The two sets of key assumptions underlying the analysis include:

1. The assumptions made in identifying the specific point and nonpoint sources that will need further controls beyond current levels and technology-based standards in order to achieve water quality standards; and

2. The assumption that the further control needed from every identified source is the "next treatment step" beyond applicable technology-based requirements.

For many water bodies and many TMDLs, these assumptions may be substantially inaccurate. For any given water body, the sources a State might identify as needing further controls may be more or less than the point sources within the water body and/or 25 or 50 miles upstream and the surrounding county's worth of nonpoint sources. For any given water body, the additional control efforts needed from the affected sources may also be more or less than the next treatment step we have assumed.

In projecting what future TMDLs are likely to require for the impaired water bodies, we based several key assumptions on our findings from reviewing the content of a sample of fifteen recently completed TMDLs. This review is summarized in Appendix A -- "Ground-Truthing the Implementation Cost Analysis Assumptions". This sample of fifteen is smaller than we would like, and it will be increased for the final version of this report. The major findings from this review are:

- TMDLs commonly, but not always, address upstream point sources in addition to those point sources discharging the impairment pollutant directly into the impaired water. The average situation seems somewhere between the "within only" and the "upstream and within" cases;

- The aggregate load reduction needed from point sources is often obtained without requiring further controls from all of the point sources discharging the impairment pollutant;

- The geographic extent of nonpoint sources from which further controls are required is typically much less than the entire county(s) surrounding the impaired water;

- For both point and nonpoint sources, the degree of load reduction that is required is very often less than that which would be achieved if all relevant point and nonpoint sources were to implement "the next treatment step".

More specifically, in estimating the costs of the "Moderately Cost-effective TMDL Program" and "More Cost-Effective TMDL Program" scenarios, we drew the following quantitative relationships from the results of the fifteen TMDLs:

- For point sources. In about half the TMDLs, the aggregate load reduction actually required of point sources was roughly equivalent to what would be achieved if all point sources contributing to impairment of the water body were to implement "the next treatment step". In the other half of the TMDLs, "the next treatment step" for all point sources would result in about twice as much aggregate load reduction as was actually needed.

- For nonpoint sources. The size of the watershed from which most TMDLs required nonpoint source load reductions was far smaller than the size of a typical county. The acreage of most nonpoint source TMDL watersheds ranged from about 5 % to about 40 % as large as the acreage of the county(s) within which the impaired water body was located.

These quantitative relationships should be regarded as tentative pending the evaluation of more completed TMDLs.[7]

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7 Note that we are not presuming to use this small sample of 15 cases as a basis for projecting the national costs of TMDLs. We have not estimated implementation costs for sources in each of the 15 cases and then extrapolated or scaled up from these cases to the nation as a whole. In fact, early in the history of this project to estimate TMDL implementation costs, we considered such an approach. We decided quickly, though, that it would not be possible to select a set of 15, or 50, or 100, or perhaps even 200 TMDLs that could serve as a representative sample from which to extrapolate to the nation. There is so much diversity across TMDLs -- in the size and type of impaired waterbodies, the degree to which they are impaired, in the pollutants and source types involved, in the geographic settings, etc. -- that we believed any sample of less than several hundred TMDLs would likely misrepresent in some important ways the universe of all of them. We decided then that a "sample and extrapolate" approach for estimating national implementation costs was infeasible. A substantial effort would be required to perform a mini-TMDL in advance for a single sample impaired water body and then estimate the costs for sources to implement this TMDL: determining how far the water body is from attainment, modeling the load reduction needed, identifying relevant sources, developing a load allocation, and estimating how much if would cost each source to achieve its load reduction. We could not afford to do such analysis for several hundred sample impaired water bodies.

Instead, we adopted the approach described here of estimating the implementation costs for all of the impaired water bodies in the nation by employing a series of simplifying assumptions about what typical TMDLs will require of relevant sources. Under this approach, we use the 15 case studies not as the fundamental basis from which to extrapolate, but instead in a more limited way to shed light on the reasonableness of our assumptions. The case studies suggest that actual TMDLs only very rarely require load reductions as large as those presumed under our Scenario 1 (all relevant point sources implement the next treatment step, and all relevant nonpoint sources in the entire county implement the next treatment step). The case studies thus suggest that Scenario 1 really is something like a worst case. The case studies also suggest what some assumptions more typical of most TMDLs might be. We use some rough averages drawn from the case studies in defining our more cost-effective Scenarios 2 and 3.

This rather lengthy discussion is intended as a reply to potential reviewers of this draft to the effect that the 15 case studies are unrepresentative in one or another way. EPA recognizes that 15 case studies cannot be representative of all conditions that may be found in potential TMDLs. For instance, none of the 15 is a water body impaired by agricultural chemicals or sediment in a major crop producing area. We believe this is acceptable because we use the case studies in a manner such that this sort of representativeness is not critical. We use the case studies primarily to elucidate several much broader

C. COSTS THAT ARE NOT ESTIMATED

This study attempts comprehensively to estimate the costs that pollutant sources will incur to achieve the load reductions that will likely be required by the eventual TMDLs for waters listed on the States' 1998 303(d) lists. Given this objective, we want to be clear that the study explicitly does not estimate several sorts of costs:

- *Costs for activities other than abating loads from pollutant sources.* We do not estimate the costs to develop TMDLs. These costs, which will be borne by States and EPA (and perhaps also by local governments and other Federal agencies) are estimated in the companion report titled "The National Costs to Develop TMDLs".[8] Nor do we estimate the costs that States, EPA, and other government agencies will incur to implement TMDLs. Thus we do not estimate the costs that State permit authorities will incur in reissuing NPDES permits for point sources to incorporate the load reductions required by TMDLs, nor the costs that USDA and other agencies might incur in providing information and technical assistance to farmers who need to reduce their loads.[9] However, to the extent that Federal, State or other agencies themselves are the owners of facilities or lands that are pollutant sources (e.g., military bases, Federal forest and range lands), we do estimate these costs.

- *Broader social consequences that might occur as pollutant sources meet TMDL requirements.* We estimate the costs for sources to reduce their loads to meet TMDL requirements, but these costs may have further consequences for society. We have not attempted to describe the social consequences of these actions or to assigne monetary values to these changes. For example, higher water and sewer rates as a result of increased costs for POTW treatment may increase the number of households facing high rates and place greater economic stress on these households. In addition, increased production costs for farmers implementing agricultural BMPs will likely result in reduced

questions: Is Scenario 1 really something like a worst case? For a moderately cost-effective Scenario 2, how much less should we assume than "the next treatment step will be implemented by all relevant point sources within a relevant distance and all relevant nonpoint sources in the entire county"? For questions at this greater level of generality, we believe that our sample of 15 is reasonably representative. Nevertheless, we agree that the sample to be used for "groundtruthing" our assumptions should be expanded, and we will do so for the final version of this report.

8 Environomics and Tetra Tech, Inc., *National Costs to Develop TMDLs*, prepared for the U.S. EPA, Office of Wetlands, Oceans and Watersheds, draft, July 2001.

9 We attempt to estimate the costs of the measures and practices that sources will need to implement to meet TMDL load reduction requirements, whoever pays these costs. In some cases, Federal and State governments contribute substantially in paying the costs for sources to implement these measures. For example, USDA and other agencies provide: 1) Cost-share funds to assist farmers in implementing BMPs; and 2) Technical assistance contributing to the planning and design tasks involved in implementing the BMPs. With respect to agricultural nonpoint source load reductions, then, we attempt to estimate the total costs of planning, designing and implementing the needed farm BMPs, whether the costs are paid for by the farmers, by USDA, or by others.

agricultural output and/or higher agricultural commodity prices. We also do not estimate the distributional impacts of the costs to pollutant sources. If pollutant sources are particularly concentrated geographically, there may be economic dislocations in the local or regional areas surrounding the concentrations. On the other hand, farming economies in other areas not affected by TMDLs will likely see increased activity triggered by reduced production in the areas affected by TMDLs and resulting higher commodity prices. These sorts of secondary and ultimate impacts cannot be assessed without broad economic modeling of the sectors within which the TMDL-affected pollutant sources operate. This sort of modeling is beyond the scope of this analysis. However, we expect that these broader consequences of TMDL costs will not be large, as TMDL costs represent only a small fractional increase in the current costs of the activities the pollutant sources conduct.

- *Costs for pollutant sources affecting waters that will be found in the future to need TMDLs developed for them.* This analysis addresses costs relating to currently impaired waters on States' 1998 303(d) lists. More waters may be listed in the future as needing TMDLs. This might be because monitoring at some time in the future finds a currently unassessed water to be impaired, or because economic growth or something else causes a currently unimpaired water to become impaired. In either case, though, we have no basis for projecting where these as-yet-unlisted waters will be found and which pollutant sources might need to be addressed because of them.[10]

Other sorts of costs are omitted from this analysis not because we define them as outside of our analytical scope, but because we have been unsuccessful in finding a way to estimate them within the time and data constraints for this study. The major sorts of costs that we have omitted because of analytical resource limitations include:

- *Costs for achieving load reductions from several difficult-to-analyze nonpoint source types.* We estimate the costs for TMDL-prompted load reductions from agriculture, confined livestock, silviculture and on-site wastewater treatment systems (septic tanks, etc.). Likely important but omitted nonpoint source types include resource extraction (mines and oil and gas development), atmospheric deposition, contaminated in-stream sediments, natural sources (e.g., salt springs, natural mineral deposits) and land disposal (both formal and informal sites). We estimate that these omitted source types account for about 14 % of all 303(d) river miles and 22% of all 303(d) lake acres. Some of these omitted source types can entail high costs for mitigation (e.g., some instances involving dredging and disposing of contaminated in-stream sediments). On the other hand, if impairment from one of these source types cannot be remedied or will involve "widespread social and economic impacts", then the water quality standard giving rise to the TMDL

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10 On the other side of the coin, some of the currently listed 303(d) waters will eventually achieve standards without a TMDL having been established for them. The 1998 303(d) lists represent water quality as of perhaps 1997 or so when the lists were compiled. Since then there has been substantial progress in water pollution control (e.g., POTW upgrades, new effluent guidelines, wet weather requirements, voluntary and cost-shared nonpoint source programs) as well as shifts in population and economic activity also. These processes will continue, and many of the 1998 303(d) waters will be found to have attained standards before their TMDLs are developed. Some of the currently listed waters may also be removed from the list for various reasons without a TMDL having been established for them.

may be revised through a use attainability analysis. In general, we have not estimated costs for these source types because one or the other of the following sorts of information is not available: 1) Information at a relatively fine geographic level on the extent of the source activity that is occurring and that might need to be controlled in order to resolve local water quality problems; and 2) Information on the unit costs of broadly applicable measures to abate pollutant loads from the source.

- *Costs for achieving any needed load reductions from point sources covered by general permits.* Our analysis of TMDL-related costs for point source dischargers covers all point sources for which individual NPDES permits have been issued. However, in addition to the roughly 60,000 active NPDES point source dischargers with individual permits, however, there are potentially 385,000 sources to be covered by stormwater general permits and approximately 52,000 point sources that are covered by non-stormwater NPDES general permits.[11] To the extent that TMDLs will require load reductions below currently allowed levels for these general permittees, we do not estimate these costs. We assume broadly that TMDLs are unlikely to require stormwater abatement beyond what is required under recent stormwater and construction regulations. We also believe that non-stormwater NPDES general permittees[12] are typically much less environmentally significant than individual NPDES permittees, and that TMDLs will rarely require further controls of them beyond what is already in their permits. Issuance of general permits has been discouraged for any sources that discharge to impaired waters and may need water quality-based effluent limits;[13] such sources have preferentially been addressed by individual permits even if they otherwise meet criteria for general permits. In sum, we believe that TMDLs will rarely require further load reductions from point sources that are currently covered by general permits, and that our omission of these sources from the cost analysis results in only modestly underestimating costs.

D. CROSS-CUTTING ANALYTICAL ISSUES

A subsequent chapter describes in detail the methodology we use to estimate costs for point sources, and another chapter addresses nonpoint sources. This section discusses several general analytical issues that pertain to the methodologies for both point and nonpoint sources.

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11 Figures as of 10/2000. See: http://cfpub1.epa.gov/npdes/permitissuance/statistics.cfm?program_id=1

12 Some sorts of discharges that are often covered by non-stormwater general permits include: non-contact cooling water, oil and gas production facilities, pipelines, drinking water treatment facilities, aquaculture, mines, and lagoons. Most of these discharges are expected to be infrequent, and/or low volume and/or low impact.

13 See U.S. EPA, Office of Water. "General Permit Program Guidance". February, 1988. Www.epa.gov/npdes/pubs/owm0465.pdf. Also, "Water Permitting 101", at www.epa.gov/npdes/pubs/101pcpe.htm.

1. The baseline for the analysis

We estimate the costs that TMDLs will engender for point and nonpoint sources in order to meet water quality standards for the set of impaired waters included in the States' 1998 303(d) lists. For these impaired waters, we attribute to the TMDL program the costs of the additional controls that pollutant sources will need to implement beyond a baseline that includes: 1) Whatever controls were in place at point and nonpoint sources as of when the 1998 303(d) lists were developed; and 2) Assumed compliance with all applicable technology-based requirements. Viewed in another way, the analysis estimates the incremental costs to pollutant sources of achieving water quality standards relative to a baseline of their controls in place in 1998, but excluding the costs of whatever amount of this further progress will be achieved through meeting technology-based requirements that were unmet as of 1998. Several aspects of how we define the baseline and costs for pollutant sources deserve more explanation:

- As of when the 1998 lists were developed, many pollutant sources had implemented control measures or BMPs beyond those required by technology-based standards. Many point sources had implemented advanced treatment measures as required by water quality-based effluent limits (WQBELs) in their NPDES permits. Many nonpoint sources had implemented BMPs voluntarily or because of incentive programs or State requirements. Because of this progress beyond technology-based standards, our analysis thus does not estimate the costs of achieving water quality standards over and above the costs of meeting technology-based standards. A substantial amount of the progress beyond meeting technology-based standards that will be needed in order to attain water quality standards had already occurred by the time the 1998 lists were developed.

- By the same token, some of the progress needed to meet water quality standards for the 1998 303(d)-listed waters has already occurred since they were listed. Since 1998 or so, many more point sources have installed advanced treatment measures as required by WQBELs,[14] and many more nonpoint sources have implemented desirable BMPs. Some of the costs that we estimate in this report will need to be spent to meet water quality standards have already been spent. We estimate costs to meet water quality standards relative to a circa 1998 baseline. These costs that we estimate are therefore greater than would be necessary if we were to measure them relative to a current 2001 baseline.

- We do not count as costs of the TMDL program those costs to dischargers that have yet to be incurred to meet existing technology-based standards. Some of progress needed to meet water quality standards will come as sources meet as-yet-unmet technology-based requirements, most notably the requirements pertaining to storm water, CSOs and SSOs. The costs of meeting these technology-based standards will be substantial, and for many waters these additional control efforts will be critical to attaining water quality standards.

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14 EPA does not have full information on the fraction of all NPDES permittees who have permit limits reflecting only the minimum technology-based requirements and the fraction that have more stringent water quality-based limits. A recent analysis for POTWs specifically suggests that perhaps 68 % of major POTWs and 59 % of minor POTWs currently appear to have WQBELs. No data is available on industrial point sources. It is clear, though, that extensive water quality-based permitting has already occurred, and the nation has a substantial head start on the task of achieving water quality standards in impaired waters.

However, technology-based requirements and their associated costs are pursuant to sections of the CWA other than §303 (TMDLs). Dischargers are and will be required to meet these technology-based standards regardless of whether a TMDL is established or not. Consequently, we do not include these baseline costs in our study.

2. Important data bases

For this analysis, we use data that is available at the national level on impaired waters and on the point and nonpoint sources that may affect them.

The set of 303(d) waters for which TMDLs must be developed is revised frequently as States submit their new lists, EPA reviews them, and changes are made. Extensive information on the listed waters (e.g., causes, pollutants, lengths, use impairments) is compiled and entered into a 303(d) data base that is updated as the lists and associated information change. For this analysis, we used information in the 303(d) data base as of the spring of 2000.[15] At that time, the 303(d) data base included some version of the 1998 303(d) list for every State; for most States the data base included their fully approved 1998 303(d) lists. As of then, the 303(d) data base included 21,845 waters and 41,318 listed causes of impairment for these waters.

For point source dischargers, the key data base that we used is the Permit Compliance System (PCS). PCS includes information on every point source holding a NPDES permit, including data that we used on each discharger's location, SIC code, flow, and monitoring results. Similarly as for the 303(d) data base, we "froze" the information from PCS as of mid-summer, 2000. At that time, there were approximately 63,000 point source dischargers listed in PCS for the U.S. and territories, of which 58,977 were active. For POTWs, we also used the 1996 Clean Water Needs Survey to obtain more detailed information on flow, industrial flow, and treatment equipment in place.

The key nonpoint source data bases we used for this analysis included:

- For agricultural land (crop, pasture and range), the 1997 National Resources Inventory (NRI) (USDA) as it existed prior to very recently released corrections;
- For silviculture, the 1996 Timber Product Output Data File (U.S. Forest Service);
- For AFOs, the 1997 Census of Agriculture (USDA); and
- For on-site wastewater treatment systems, the 1992 Census of Housing (USDOC).

Each of these nonpoint source data bases are the most recent versions available.

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15 Since the spring of 2000, the 303(d) data base has been updated several times to reflect new changes to States' lists, revised procedures for estimating the length of some impaired water bodies, and other developments. Because we "froze" the data base as of the spring of 2000 for this analysis, information on impaired waters that is now available at the Agency reflects newer numbers and is slightly different from what is portrayed in this analysis. As of XXXX, 2001, the 303(d) data base includes XXXX waters and XXXX causes, a small change since last year.

3. Scaling to adjust for limited geographic coverage

The data used to estimate the implementation costs for point sources and for nonpoint sources do not completely cover the United States. Various sorts of desired data are unavailable for some States and for some sources. In general, we estimate implementation costs for the subset of States and sources for which we have data, and then extrapolate the results to the remainder of the nation using a scaling factor reflecting the portion of the nation for which we do have data. We assume that the portion of the nation for which we do not have data has impairments and will incur compliance costs at the same rate as the portion of the nation for which we do have data. The scaling procedures we employ are different for point sources and for nonpoint sources.

a. Scaling in the point source analysis

The point source analysis in effect depends on comparing the locations of georeferenced 303(d) waters with the locations of georeferenced point sources. We begin with an impaired water that we have located geographically. We then search within that water body and upstream an appropriate distance along a comprehensive network of linked water reaches to identify any point source dischargers that are discharging the relevant impairment pollutant. We then simulate controls for these identified point sources as necessary to address the point source contribution to impairment of the water body. We repeat this process for all impaired waters. There are three reasons why, as we implement this analysis, we ultimately do not cover all impaired waters and all potentially contributing point sources:

- Some 303(d) waters have not been georeferenced by locating them with respect to Reach File 3 (RF3) reaches. An impaired water that has not been georeferenced in this manner is not covered in our analysis because we cannot trace upstream from it to find the point sources that may be affecting it;

- Some point sources have not been georeferenced. A point source that has not been georeferenced is not covered in our analysis because it cannot be "found" via this process and cannot have any costs estimated for it;

- The procedure for matching water bodies against point sources is not operable for a variety of reasons in several States. These entire States are not covered by the analysis.

We develop scaling factors to account for these shortfalls in analytical coverage. We estimate point source costs for the portion of the universe that we do cover, assume that this portion is a sample representative of the entire country, and then extrapolate the costs estimated for our sample to the entire country by using an appropriate scaling factor.

The matching procedure is not currently operable for the Pacific Northwest States (AK, ID, OR, WA), Massachusetts, Hawaii and the Territories. The matching procedure thus covers 44 States plus the District of Columbia. In these 44 States plus DC, there are 41,316 active point sources that have been georeferenced. In the nation as a whole plus territories, there are 58,977 active point sources. The scaling factor to account for incomplete coverage involving point source georeferencing and the matching procedure is thus 58,977/41,316, or 1.427.

In the 44 States plus DC, there are 18,162 303(d)-listed waters, of which 16,143 have been georeferenced. The scaling factor to account for incomplete georeferencing of impaired waters is thus 18,162/16,143, or 1.125. Although we do apply this scaling factor, it is very likely an overestimate. Adding more georeferenced waters to the analysis would likely lead to a less than proportional increase in compliance costs, since many of the point sources implicated by the added waters would have already been included in the analysis and would have already incurred compliance costs as a result of previously georeferenced waters. (We assume that a point source that already must incur a compliance cost because it affects an impaired water will not incur increased costs if it is found also to affect additional waters.)

Combining the two point source scaling factors (1.427 x 1.125) yields a combined scaling factor of 1.605. The aggregate point source costs we estimate in our analysis are multiplied by 1.605 in order to estimate the total national costs for point sources. Again, we believe this is likely an overestimate.

b. Scaling in the nonpoint source analysis

Scaling issues are different for the nonpoint source cost analysis than for the point source analysis. For the nonpoint source analysis, georeferencing of impaired waters is essentially complete, using procedures that do not depend on RF3. All impaired waters have been located and the counties through which they pass have been identified. The coverage of our analysis is incomplete, though, because identification of the nonpoint sources associated with these impaired waters is incomplete.

States vary in the degree to which they provide information on the source types responsible for impairment of impaired waters. Some States do not report source information at all, some report in modest detail (e.g., using only broad identifiers of source types such as “point sources”, “nonpoint sources”, “unknown sources”, etc.), and some report in great detail (e.g., using specific identifiers of source types such as “municipal point sources”, “CSOs”, “silviculture”, “irrigated crop land”, etc.). Our procedure for identifying water bodies impaired by various nonpoint source categories relies on detailed source reporting by those States that provide such information, either in their 303(d) submissions or in their 305(b) submissions. For example, in analyzing silviculture, we:

- Identify the 303(d) water bodies that States report as impaired by silviculture as a source.
- Identify the 305(b) water bodies that States report as impaired by silviculture as a source. We then crosswalk from each of these silviculture-impaired 305(b) waters and determine whether there is a corresponding 303(d) water body. (Some States report 305(b) source information but not 303(d). This second step effectively increases the set of States within which we can find silviculture-impaired 303(d) waters.)
- Add the results of the first and second steps, thus obtaining a list of silviculture-impaired 303(d) waters. We note the States in which these waters are located. We then assume this set of States to be the sample covered by our analysis, and we assume that this sample is representative of the nation as a whole.
- States for which we can identify no silviculture-impaired water bodies may either: a) Actually have no silviculture-impaired water bodies; or b) Actually have them, but report source information in a manner that does not allow for identifying them. Conservatively, we assume the latter -- we assume that a State that reports no silviculture-impaired water

bodies is effectively "non-reporting". We extrapolate the costs we estimate for controlling silviculture in the sample States (those that report silviculture impairments) to the assumed non-reporting States by scaling up based on the volume of silviculture occurring in the sample States relative to that occurring in the non-reporting States.

We employ this approach for each of the different nonpoint source types we analyze. Different sets of States are considered to be "non-reporting" for the different nonpoint source types. For each nonpoint source type, we use a different volume-based scaling factor to extrapolate our cost estimates from the "reporting" to the "non-reporting" States. The volume measures that we use in scaling are as follows:

- *For silviculture.* The annual volume of timber harvested.
- *For agriculture.* Crop land-related costs are extrapolated based on the acreage of crop land. Similarly, pasture-related costs and range-related costs are extrapolated based on the acreage of pasture and range lands.
- *For AFOs.* The number of confined animal units (AUs).
- *For on-site wastewater treatment systems.* The number of dwelling units served by septic systems.

The specific scaling factors we develop (e.g., the ratio between the total national annual timber harvest and the harvest volume in our "reporting" States) are described in the report sections providing cost estimates for each of the nonpoint source categories.

We also apply another sort of scaling factor in the nonpoint source cost analysis. In our nonpoint source analysis, we attempt to cover those States that report source information and scale to those that do not. Among the States that report source information, though, we count a water body as impaired by a specific nonpoint source type only if the State affirmatively cites that specific nonpoint source type as a source. A State that reports source information sometimes reports the source as "nonpoint source (not classified)" or as "unknown source". In some fraction of these cases, we would guess that silviculture or AFOs or agricultural land or some other specific nonpoint source type we are interested in will eventually be found to be one of the responsible sources. Perhaps we should regard as a sample the instances in which a specific source type is reported, and we should extrapolate from that sample to the instances in which a non-specific source type is reported (i.e., NPS not classified, or unknown source). The following exhibit provides information that can be used in developing a scaling factor reflecting this approach:

Exhibit I-1
Information Used for Nonpoint Source Scaling Factors

	303(d) information				305(b) information	
	# rivers listed	# lakes listed	River miles	Lake acres	River miles	Lake acres
Unknown source	8.1 %	5.4 %	5.7 %	6.8 %	1.9 %	N.A.
NPS (not classified)	12.5 %	8.6 %	14.7 %	8.8 %		N.A.
All other sources	79.4 %	86.0 %	79.6 %	84.4 %	98.1 %	N.A.

The nonpoint source categories we are interested in can be cited by a State only when the State cites a specific source. Specific sources are cited in 79.4 - 98.1 % of the instances. The scale factor to reflect extrapolation to instances where a State does not cite a specific source can range from 1.02 (100/98.1) to 1.26 (100/79.4). About half of the waters identified in our analysis as impaired by specific nonpoint source types derive from 303(d) and about half derive from 305(b) listings. We thus adopt a scale factor of 1.13, averaging between a typical scale factor of approximately 1.25 for 303(d) listings and 1.02 for 305(b) listings.

4. Cost estimating conventions

We estimate costs for pollutant sources in first quarter 2000 dollars. All costs include capital and operating and maintenance costs, combined into a single annualized cost figure that is assumed to continue forever. We estimate the time at which each pollutant source will begin to incur this annualized cost stream, sum the costs across pollutant sources, and then discount the costs incurred in future years back to a present value cost in 2000. We then annualize this present value cost. The cost estimates that we present thus represent levelized annual amounts that will continue each year, forever.[16] A real discount rate of 7 % per year is used. The assumed useful life of capital investments varies with the nature of the investment, ranging from 3 years for some nonpoint source management measures (e.g., a nutrient management plan) to 20 years for capital equipment at POTWs.

5. Assumptions regarding the time when costs will be incurred

A pollutant source will presumably not incur costs resulting from a TMDL until sometime after the TMDL affecting the pollutant source has been developed. Given that the July 2000 TMDL regulations do not require all TMDLs for the 1998 listed waters be developed until 2015, there may be many years until a pollutant source needs to incur the costs of achieving any reduced load assigned by a TMDL. To the extent

16 The cost estimates are expressed in this manner so that they can be compared with cost estimates for other regulations, policies, programs or initiatives that are also expressed as levelized, continuing annual amounts. The actual costs of any program typically fluctuate over time, with varying amounts of capital and operating/maintenance costs incurred in various future years. These costs may continue forever into the future, or they may end at some point. In summarizing the costs of any such program, analysts typically convert the fluctuating stream of actual cost payments into a single levelized annual amount by: 1) Discounting all the actual costs in different future years back to a discounted present value in the base year; and 2) Annualizing this discounted present value, converting it into an equivalent stream of equal annual payments that continue forever.

that costs are incurred far in the future, the present value of these costs is reduced. The costs that pollutant sources will incur as a result of the TMDL program (or alternatives to it) depend on when these costs will be incurred.

The pace at which TMDLs will be developed for the waters on the 1998 303(d) list is unknown. A companion report to this one -- the TMDL Development Cost Report[17] -- discusses various possibilities regarding the pace of TMDL development. For this analysis, we have chosen an "even pace" projection from among those considered in the Development Cost Report.

Exhibit I-2
Projected Pace of TMDL Development Used for This Analysis

Year of Completion	# TMDLs Completed
2000 and before	2,000
2001	2,282
2002	2,282
2003	2,282
2004	2,282
2005 - 2014	2,282 each year
2015	2,282
Total	36,225

The "even pace" projection reflects the number of TMDLs for 1998 303(d) waters that have already been developed (an estimated 2,000 developed before 2001) and then assumes that the remaining TMDLs are developed at an even pace through the deadline at the end of 2015. Note that the estimated total number of TMDLs to be developed is only 36,225, relative to a projected number of causes for the currently listed 303(d) waters totaling 41,318. Roughly 5,000 of the causes (about 12 % of the total) associated with currently listed waters involve "pollution" rather than pollutants (e.g., flow alteration, habitat alteration) and TMDLs are not expected to be prepared for such causes. The costs we estimate for pollutant sources will increase somewhat to the extent that further research ultimately identifies pollutants requiring TMDLs for some of these "pollution"-impaired waters.

For this cost analysis, we assume that a point or nonpoint source that will need to implement further control measures as a result of a TMDL will begin to incur the costs of doing so an average of five years after the TMDL is developed. The capital costs for the necessary control measures will be incurred five years after the relevant TMDL is developed, and annual O&M costs will also begin at that point. Thus, the schedule upon which sources will begin to incur TMDL compliance costs will be lagged five years relative to the TMDL development schedule shown above.

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17 Environomics and Tetra Tech, Inc., *National Costs to Develop TMDLs*, prepared for the U.S. EPA, Office of Wetlands, Oceans and Watersheds, draft, May 2001.

The cost models we use to estimate compliance costs for sources generate estimates of annualized costs as of the year when compliance costs begin. In effect, the numbers generated by the cost models are estimates as if all the sources would need to begin incurring all their TMDL compliance costs immediately, in the year 2000. To reflect the pace of TMDL development as shown above and the assumed 5-year time lag between TMDL development and when compliance costs will begin, we must scale down the estimates from the cost models. A spreadsheet in Appendix B shows the derivation of a scaling factor that reflects the particular pace of TMDL development and compliance time lag that we have assumed. At a discount rate of 7 %, the scale factor to convert the annualized cost once all sources are incurring their costs to an equivalent annualized cost beginning in the year 2000s is 0.4484.

This pace/lag scale factor is applied to the outputs of the point source and nonpoint source cost models. The raw outputs of the cost models show total annualized costs for sources after the point in time when all sources have begun incurring their TMDL compliance costs. This will not be until 2020 (assuming the last TMDLs for the 1998 listed waters are developed in 2015 and compliance costs lag TMDL development by another five years). Between now and 2020, annual costs to sources will slowly rise until they reach the maximum in 2020, and they will then continue at this maximum level forever. Many pollutant sources will not need to implement their projected control and management measures until many years in the future. This gradual development and implementation of TMDLs for currently listed waters will reduce the present value of the management and control costs for the TMDL program well below what it would be if all TMDLs were completed immediately and sources needed to comply immediately. The impact of stretching out the compliance expenditures is captured in the "pace/lag" scale factor. If TMDL development were accelerated relative to the pace shown in the exhibit above, or if the compliance time lag were assumed to be less than five years, the scale factor would increase and the estimated present value TMDL implementation costs would increase.

We assume that the timing of compliance investments by sources will be the same under Scenario 1 and Scenario 3 as what we have projected here for the Moderately Cost-effective TMDL Program (Scenario 2). This is so that the estimated cost differences between the scenarios result only from substantive differences between them rather than differences involving timing.

6. Assumptions regarding changing conditions over time

We estimate the costs for sources to achieve water quality standards based on current conditions. For example, for a POTW that will need to upgrade its treatment to meet the requirements of a TMDL, we estimate its costs based on the POTW's current level of flow or population served and current treatment in place. For a county in which silvicultural activities will need to adopt improved management practices to meet TMDL requirements, we estimate costs based on the current volume of silvicultural activity in the county. In reality, though, if the TMDL affecting these two example sources will not be developed for another decade or more, when it comes time to comply with the TMDL's allocations, the POTW may have a larger or smaller flow, and the volume of silvicultural activity taking place in the county and needing control may have changed also. Or, conditions regarding other sources may have changed in a manner affecting what these sources need to do -- perhaps, for example, by the time the TMDL is eventually developed, a large, poorly controlled industrial discharger affecting the same water body will have gone out of business, and the POTW and the silvicultural operations will not need to implement further controls. We do not attempt to predict these changes in source activities over time that may affect what the sources need to do in order to meet the requirements of the eventual TMDLs. We estimate costs for sources to meet the likely requirements of TMDLs given current conditions.

We also do not evaluate the potential impact of another set of changing conditions over time -- changes in the list of waters for which TMDLs will be necessary. As States assess more of their waters and as source activities increase with a growing population and economy, additional water bodies will likely be listed for which TMDLs will need to be developed. Also, though, as a wide variety of incentive programs (e.g., agricultural cost share programs) and new regulations (e.g., State requirements for nutrient management planning, new Federal effluent guidelines, and new rules for SSOs) continue to be developed and implemented and sources respond, some currently impaired waters that need TMDLs will attain standards and ultimately not need TMDLs. Again, in this analysis we estimate costs for the current set of listed waters, assuming current conditions. This approach differs somewhat from the accompanying TMDL development cost analysis, which estimates costs also for future waters that might be added to the present 303(d) lists.[18]

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18 This analysis diverges in several additional respects from the TMDL Development Cost Analysis. Most notably, costs are presented in this report as levelized annual amounts beginning now and continuing each year, forever. Whereas compliance costs continue indefinitely (we assume that a source's compliance obligation is a continuing one), the cost of developing a TMDL is a one-time cost – once a TMDL is developed, there is no further development cost. Consistent with the fact that TMDL development will end at some point, the Development Cost Analysis thus shows costs in several ways that are different from how costs are shown here: showing them as undiscounted costs in the years in which they will occur, and also as total undiscounted costs over this time period.

The Development Cost Analysis also does not count the costs of developing the TMDLs for water bodies on the 1998 303(d) lists that have already been developed. In this analysis, though, we include the costs for pollutant sources to meet the requirements of these TMDLs because the bulk of these costs have presumably not yet been incurred.

II. IMPLEMENTATION COSTS FOR POINT SOURCES

A. OVERVIEW

We identified the specific point source facilities that might discharge the pollutants responsible for impairments in 303(d) listed waters. For Scenario 1 ("Least Flexible TMDL Program"), we assumed that all of the facilities that might reasonably be expected to control these discharges further will be required to install the "next treatment step", and estimated the costs associated with those controls. For Scenario 2 ("Moderately Cost-effective TMDL Program") we scaled down the costs estimated for Scenario 1 to reflect the degree to which actual TMDLs have required aggregate load reductions from point sources less than that which would be achieved if all point sources implemented the next treatment step. For Scenario 3 ("Cost-Effective TMDL Program"), we adjusted the costs estimated for Scenario 2 to reflect the potential savings to point sources from more cost-effective waste load allocations or trading. We will describe this analysis in detail as consisting of eight steps:

1. Select the pollutants that point sources are most likely to be required to control further -- these included BOD, nutrients, toxic organics, ammonia and metals.

2. Identify the facilities that are within a relevant distance upstream of an impairment for any of these pollutants.

3. Determine which of these upstream facilities will likely be required to implement further controls for each impairment pollutant under a water quality-based permitting approach (Scenario 1).

4. Develop cost functions for the "next treatment step" for each relevant pollutant

5. Apply the cost functions for every pollutant source needing further control for an impairment pollutant.

6. Adjust the estimates to exclude costs for point sources affecting waters that States identify as impaired by nonpoint sources only. At this point, costs for point sources under Scenario 1 are estimated.

7. Adjust the Scenario 1 cost estimates to reflect the results of a sample of actual TMDLs and estimate the costs for Scenario 2.

8. Adjust the Scenario 2 cost estimates to reflect opportunities for additional cost-effective waste load allocations or trading in which lower-cost control of nonpoint sources might substitute for some further point source controls.

This chapter summarizes each of these steps and their results. Appendices C through H provide further details.

B. POLLUTANTS FOR ANALYSIS

In order to limit the analytical workload (e.g., developing and applying cost functions for the next treatment step for each pollutant), we chose to analyze only those particular pollutants for which TMDLs or water quality-based permits are most likely to require further controls (beyond technology-based standards) for point sources. We obtained data on the frequency with which different causes of impairment are cited for waters impaired by point sources. We considered the most frequent causes of impairment, and asked whether each of these causes would commonly trigger the need for further controls of point sources that are already meeting technology-based standards. We concluded that the following pollutant classes are the most likely to prompt requirements for further point source controls: BOD, nutrients, toxic organic chemicals, metals, and ammonia. Some of our judgments in settling on this list of pollutants to trigger point source controls were:

- We chose not to analyze causes of impairment when no pollutant was identified. Examples included flow or habitat alteration or fish consumption advisory when no pollutant was listed also.

- We chose not to analyze pollutants that are extremely unlikely to be discharged in sufficient quantity to be problematic by a point source meeting technology-based standards. Examples included temperature or pH.

- We chose not to analyze pollutants for which only a very small fraction of point sources might require additional beyond-technology-based controls for process water discharges. Examples include sediment or pathogens. We believe that the great majority of instances where waters are impaired for these causes and point sources are cited as a source involve wet weather discharges from point sources. We believe these problems will largely be remedied when existing technology-based standards for wet weather discharges -- storm water, construction, CSO and SSO requirements -- are complied with.

- We chose not to analyze in this study pollutants representing a very small fraction of causes that would require specialized treatment technologies as the"next step". Examples include chlorine and cyanide. We could consider such infrequent causes of impairment in a future study.

Appendix C provides supporting data and further information on our judgments in arriving at the list of five pollutants that we will consider as triggering point source controls under TMDLs or water quality-based permits.

The next step in the point source cost analysis is to identify the facilities that discharge any of these five pollutant classes -- BOD, nutrients, toxic organics, metals, or ammonia -- in a manner so as to affect a 303(d) water that is impaired for one of these pollutants.

C. NEARBY FACILITIES

These are the point sources that we consider potentially to contribute to impairment and perhaps to be affected by TMDLs or water quality-based permits. We adopted two alternative scenarios for identifying point sources and considering them for further controls:

- *Case 1, "within and upstream".* We assume that a point source contributes to impairment if it discharges the pollutant of concern: a) Directly into the waterbody; or b) Within 25 miles upstream of a water body impaired by BOD, ammonia or toxic organic chemicals, or within 50 miles upstream of a water body impaired by nutrients or metals.

- *Case 2, "within only".* We assume that a point source contributes to impairment if it discharges the pollutant of concern directly into the impaired water body.

For each water body impaired by one of the five causes we selected as potentially triggering point source controls (BOD, ammonia, toxic organic chemicals, nutrients, metals), we identified all point sources with outfalls discharging into the impaired segment or within the 25 or 50 mile distance upstream of the upstream end of the impaired segment. This step involved a complex procedure to interlink three very large electronic data bases: 1) Information on the location and causes of impairment for most of the more than 21,000 currently listed 303(d) water bodies; 2) Information on the location of the receiving water and other data for the nearly 60,000 active point source dischargers; 3) A nationwide network model that links water reaches to each other, allowing one to trace upstream any specified distance from a water body to upstream reaches, tributaries, headwaters, etc.. This analysis was performed by Tetra Tech, Inc.

The two cases for analysis reflect different possible judgments about how far downstream the pollutants discharged by point sources will typically have an impact. Metals and nutrients -- conservative pollutants that do not degrade over time or distance -- have the longest range downstream effect. Ammonia, BOD, and many toxic organics have a much shorter range downstream effect, strongly affecting receiving waters shortly below the point of discharge and weakly affecting waters farther downstream. Tetra Tech's engineers judged that 50 and 25 miles were reasonable upper limits to the upstream distance within which point sources discharging these pollutants would likely have a substantial impact warranting attention in TMDLs or water quality-based permitting.

In the TMDL "groundtruthing" analysis reported in Appendix A, we have attempted to determine whether actual TMDLs have typically focused only on point sources discharging to the impaired water body or whether they have typically addressed upstream point sources also. And, if upstream dischargers were considered, how far upstream? The results from our sample of 15 TMDLs are not conclusive. Sometimes only point sources discharging directly into the impaired water are considered, sometimes the TMDL addresses upstream point sources also.

In the absence of more extensive information, we believe the "within and upstream" case (and the 25 and 50 mile assumed distances) is generally conservative. For most impaired water bodies, these upstream distances will pull in more point sources than would likely be considered as contributing importantly to impairment. However, for some large and significantly impaired water bodies, basin-wide load reductions from point sources may be necessary that will extend well beyond these distances. On the whole, though, we expect the total national costs for point sources that actually result from TMDLs and water quality-based permitting will be somewhere between the *"within and upstream"* case and the *"within only"* case.

It should be noted that the number of point sources potentially affected by TMDLs or water quality-based permitting increases much less than linearly with an increase in these assumed distances. Many impaired waters are in headwaters, and 25 or 50 miles already reaches a stream's origin. Also, many impaired waters are near other impaired waters and looking further upstream simply identifies point sources already identified as affecting other impaired waters.

D. FACILITIES THAT NEED TO REDUCE LOADS

The next step involved making a judgment about whether each point source discharging into or within a 25/50 mile distance upstream of a water body that is impaired for one of these pollutants might be required by the eventual TMDL or water quality-based permit to implement further controls. We sought to determine whether an identified point source meeting applicable technology-based standards was likely to discharge the impairment pollutant in sufficient quantity to warrant consideration for further controls. This judgment was particularly difficult to make because there is little data available at the national level on the pollutants that individual facilities discharge and their amounts. For the majority of dischargers, the Permit Compliance System (PCS) – EPA's major data base on point source dischargers that we used to identify potentially relevant facilities -- provides information only on which pollutants a facility is required to monitor for. For only a very few facilities does PCS provide reliable information on the amount of the monitored pollutants that are discharged. PCS provides no information on whether a facility discharges unmonitored pollutants or their amounts.

We tested three alternative approaches for determining whether or not a specific point source (after meeting applicable technology-based requirements) discharges the impairment pollutant in an amount making the source likely to be addressed in the TMDL or water quality-based permit:

- The first approach was to use the information in PCS on whether monitoring is required for a pollutant as an indicator of whether or not a facility discharges the pollutant in a meaningful amount. We applied this approach for each 4-digit SIC code -- if at least 15 % of all the facilities in PCS in a particular 4-digit SIC code were required to monitor for a pollutant, then all the facilities in that SIC code were deemed to discharge the pollutant in a meaningful amount. If the facility was thus judged to discharge the impairment pollutant, we then assumed conservatively that the facility would be identified as contributing to impairment and would be addressed in the TMDL or water quality-based permitting process.

- The other approaches relied instead on an engineering judgment as to whether each 4-digit SIC is likely, after meeting BPT/BAT/secondary treatment requirements, to discharge each pollutant at levels that could warrant potential further control. Two EPA engineers experienced in industrial water pollution control made these judgments for each of more than 500 different SIC codes. We then implemented the engineering judgments in two alternative ways, resulting in high and low estimates for the number of point sources likely to be deemed as discharging the impairment pollutant in sufficient quantity as to be contributing to impairment. The high estimate adopts more liberal rules for matching sources and impairments than does the low estimate. For the high estimate, when a water body is impaired by a specific metal (except mercury) or a specific toxic organic (except PCBs or dioxin) and the facility (based on engineering judgment for its SIC) is expected generally to discharge metals or toxic organics, then the facility is assumed to be a candidate for mandated further controls. For the low estimate, the match must be exact in order for further controls to be considered for the facility: if a water body is impaired for metals generally then facilities that discharge metals generally are assumed to warrant consideration, but if a water body is impaired for a specific metal or toxic organic (e.g., zinc, phenol), only those facilities discharging that specific metal or toxic organic are assumed to warrant consideration.

We ultimately selected the engineering judgment approach using liberal matching rules. The three approaches yielded broadly similar results (within + or - 20 %) in terms of: a) the numbers of point sources presumed likely to discharge an impairment pollutant in a quantity potentially warranting further control under a TMDL or water quality-based permit; and b) the costs of these controls. The engineering judgment approach, however, often yielded more sensible results regarding individual SIC codes than did the approach based on monitoring requirements. The monitoring requirement-based approach, for example, projected that metal finishers contribute to impairments for nutrients, and "fabricated metal products" dischargers do not contribute to impairments for metals. The engineers, on the other hand, judged that metal finishers meeting BPT/BAT requirements would typically not discharge significant quantities of nutrients and that TMDLs or water quality-based permits would be unlikely to address them when nutrients were at issue. The engineers believed the reverse was likely true for "fabricated metal products" facilities. We chose the approach using liberal matching rules in order to reduce the likelihood that we exclude from our cost analysis some point sources that ultimately will end up being addressed by TMDLs or water quality-based permits.

A fuller description of the three alternate approaches and the results obtained under each is provided in Appendix D.

We made two further decisions that limited the set of point sources presumed likely to incur additional costs as a result of TMDLs or water quality-based permits:

1. We assumed that POTWs that currently provide better-than-secondary treatment would not be required by TMDLs or water quality-based permits to further improve their treatment for BOD, nutrients, toxic organics and/or ammonia.

2. As a definitional matter, we decided to attribute any POTW treatment upgrade projects that were listed in the 1996 Clean Water Needs Survey to Clean Water Act requirements other than TMDLs. In effect, we believe that POTW upgrades that were far enough along to be included in the 1996 CWNS should not be attributed to the TMDL program and should instead be counted as part of the pre-TMDL baseline.

These limitations on the set of POTWs that we consider likely to incur incremental costs attributable to the TMDL program have an important influence on the TMDL implementation costs that we estimate. The following exhibit shows how the estimated implementation costs for POTWs would change if one or both of the limitations were not adopted. Costs are shown for the "within and upstream" case.

Exhibit II-1

Incremental Implementation Costs for POTWs – Scenario 1 (Least Flexible TMDL Program) ("within+upstream" case)

Basis for Estimate	# of POTWs Incurring Costs	Annualized Costs for POTWs (2000 $ in millions/yr)
Preferred estimate: 1) assume POTWs that are already beyond 2° will incur no costs, and 2) attribute no TMDL costs to projects approved in 1996 CWNS	3335	697
Drop the 1st limitation: assume TMDLs will require "next treatment step" of all POTWs, whether or not they already provide advanced treatment	5262	1,869
Drop the 2nd limitation: attribute costs of "next treatment step" for POTWs not already beyond 2° to the TMDL program, whether or not the upgrade was planned long ago	3694	836
Drop both limitations	5622	2,009

Incremental Implementation Costs for POTWs – Scenario 2 (Moderately Cost-effective TMDL Program) ("within+upstream" case)

Basis for Estimate	# of POTWs Incurring Costs	Annualized Costs for POTWs (2000 $ in millions/yr)
Preferred estimate: 1) assume POTWs that are already beyond 2° will incur no costs, and 2) attribute no TMDL costs to projects approved in 1996 CWNS	2502	523
Drop the 1st limitation: assume TMDLs will require "next treatment step" of all POTWs, whether or not they already provide advanced treatment	3947	1,402
Drop the 2nd limitation: attribute costs of "next treatment step" for POTWs not already beyond 2° to the TMDL program, whether or not the upgrade was planned long ago	2770	627
Drop both limitations	4216	1,506

Abandoning these two limitations would increase our implementation cost estimates for POTWs sharply, by a factor of nearly three (from $697 million annually to $2,009 million annually for Scenario 1, and from $523 million annually to $1,506 million annually for Scenario 2). The assumption that TMDLs will not require further controls of POTWs that already provide better-than-secondary treatment is particularly important, resulting in nearly $1.2 billion in estimated cost reductions for Scenario 1 and nearly $900 million for Scenario 2. In essence, we project that there are many large POTWs that already employ advanced treatment that nevertheless still appear to discharge meaningful amounts of an impairment pollutant into or somewhat upstream of impaired waters.[19] Are the eventual TMDLs likely to require further controls of these already well-controlled POTWs?

The sample of 15 TMDLs that we reviewed for "ground-truthing" purposes provide some information relevant to this question. Across the 15 TMDLs, in some cases POTWs discharging the impairment pollutant that now provide better than secondary treatment are being required to reduce their loads further, and in some cases they are not. When they are not required to reduce loads further, sometimes a rationale is offered that they have already reached their practical limits of treatment, and sometimes no rationale is offered. In no case does the TMDL submission explicitly cite an "equity" rationale to the effect that responsibility for further load reductions should not focus on sources that have already gone beyond minimum technology-based requirements. On balance, we believe the sample size for the groundtruthing case studies is small, and we cannot conclude anything more than some TMDLs in practice will adopt limitation #1 and some will not.

The TMDL groundtruthing case studies do not shed any useful light on the second limitation. It is really a policy question rather than an empirical one – what do we count as being in the baseline, and what do we count as being incrementally attributable to the TMDL program? In our view, projects listed in the 1996 CWNS have been planned so far in advance of virtually all TMDLs that they should be defined as not attributable to the TMDL program.

The rationales for these two potential limitations involving POTWs would seemingly apply to industrial dischargers as well as to POTWs.

- Both industrial dischargers and POTWs that already provide better treatment than technology-based standards require may receive some special consideration from control authorities for their extra treatment efforts when wasteload allocations are developed under TMDLs. Control authorities may look for additional controls first to sources that have not yet gone beyond the required minimums. In many cases, POTWs or industrial dischargers that already provide advanced treatment will not be required to do more in future TMDLs. In some cases, there may be no reasonably available treatment technologies that they could implement beyond the advanced treatment they have already adopted.

- Similarly, the cost of treatment upgrades that were planned and approved five or more years ago, whether for POTWs or for industrial dischargers, should not be counted as prompted by the TMDL program.

However, we have implemented these two limitations for POTWs alone because we have data on implementation of advanced treatment and long-planned projects only for POTWs, from the CWNS. There is no parallel source of data for industrial dischargers. There is no ready source of information for industrial dischargers on treatment-in-place (from which we could identify the facilities with treatment beyond BPT/BAT) or on already-planned treatment upgrade projects.

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19 This finding is quite consistent with the previous observation that most (68 %) major POTWs appear currently to have WQBELs that require better-than-secondary treatment. As noted previously, the nation has already made important progress beyond technology-based standards in addressing impaired water bodies.

E. COST FUNCTIONS FOR THE "NEXT TREATMENT STEP"

We developed relationships predicting cost as a function of flow for all pollutant sources potentially needing additional controls for BOD, nutrients, toxic organics, ammonia or metals. These cost functions are as follows.

1. Treatment for metals from direct dischargers except POTWs

Polishing multi-media filtration was assumed as the "next treatment step", assumed to be incremental over the technologies assumed to be in place to meet BAT (flow reduction, chemical precipitation, clarification). The capital and O&M cost functions for polishing filtration are drawn from EPA's development document for the centralized waste treatment industry.[20] The equations are described more fully in Appendix E.

2. Treatment for metals from POTWs

An enhanced pretreatment program with tighter local limits (tighter than PSES) for significant metals indirect dischargers was assumed as the "next treatment step" when POTWs need to provide enhanced control of metals. The enhanced pretreatment program was assumed to be incremental over a baseline pretreatment program in which local limits match effluent guideline requirements for indirect dischargers.

Our procedure for estimating the costs for such an enhanced pretreatment program at a POTW involves calculating the number of the POTW's indirect dischargers that will need to improve their treatment for metals, and then applying the cost functions for polishing filtration to the flows for these indirect dischargers. There are several steps in this procedure:

- We assumed that any major POTW within the relevant distance upstream of a metal-impaired water will need to implement an enhanced pretreatment program for metals. We assumed that no minor POTWs will need to implement such a program.. These assumptions likely result in some overestimate of the number of POTWs that will ultimately need to enhance their pretreatment programs as a result of TMDLs.

- For a major POTW that is presumed to need an enhanced pretreatment program for metals, we obtained information from the CWNS on the POTW's industrial flow. We then made assumptions and applied information from EPA's RIA for the Great Lakes Water Quality Guidance to estimate that significant industrial users totaling about 10 % of the POTW's industrial flow would need to improve their metals treatment. These significant industrial users were estimated to have an average flow of 0.1 mgd each.

- We then applied the cost functions for polishing filtration to the number of indirect dischargers that was calculated to need to implement this next treatment step.

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20 U.S. EPA, Office of Water. *Development Document for Proposed Effluent Limitations Guidelines and Standards for the Centralized Waste Treatment Industry*. December, 1998.

3. Treatment for BOD, nutrients, ammonia and toxic organics

Some form of advanced secondary treatment was assumed as the "next treatment step" for both industrial dischargers and for POTWs. Advanced secondary treatment is the next treatment increment over secondary biological treatment, which is assumed to be in place for industrial dischargers to meet BPT/BAT and for POTWs to meet secondary treatment requirements. The capital cost functions for this increment of control were drawn from the equations underlying EPA's 1996 Clean Water Needs Survey.[21] The CWNS includes an extensive set of cost functions that are used as checks on State-submitted cost estimates for POTW treatment upgrade projects, and as defaults for generating treatment cost estimates when States have not developed them. While the CWNS functions have been used previously by EPA specifically to estimate costs for POTWs, we use them also to estimate costs for treatment upgrades at industrial point sources. The CWNS cost functions are based on underlying cost models for basic wastewater treatment unit processes (e.g., screening, flow equalization, primary clarification, etc.) that were developed to apply to both domestic and industrial wastewater.

Capital cost functions were drawn from the CWNS for upgrades to the "next treatment step" beyond secondary treatment, as follows:

- All dischargers presumed to need additional treatment for nutrients and/or ammonia are assumed to incur the costs to upgrade to "secondary treatment with nutrient removal";

- All dischargers presumed to need additional treatment for BOD and/or toxic organics are assumed to incur the costs to upgrade to "advanced treatment I"; and

- All dischargers presumed to need additional treatment for nutrients and/or ammonia <u>and</u> BOD and/or toxic organics are assumed to incur the costs to upgrade to "advanced treatment I with nutrient removal".

The specific cost functions that we used are shown and described further in Appendix E. This Appendix also provides further detail on all the other point source cost functions discussed in this section.

It should be noted that the capital costs for upgrades estimated using the CWNS cost functions are substantially higher than the costs that would be projected using equations derived from POTW cost data for advanced secondary treatment that underlie EPA's final Best Conventional Technology (BCT) rule.[22] The BCT data had been suggested to us as an alternate source for cost information on treatment upgrades. Upon examination, we concluded that the CWNS equations were more appropriate for our purposes because:

- The treatment upgrades considered in the BCT analysis focused exclusively on increased chemical addition and included virtually no capital equipment.

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21 Tetra Tech, Inc. *Software Requirements Document for the 1996 Clean Water Needs Survey Treatment Plant Cost Curves*, Revision 2. March 20, 1998.

22 51 F.R. 24974, July 9, 1986. Also: Science Applications International Corp. *BCT Benchmarks: Methodology, Analysis and Results*. May, 1986.

- The BCT treatment upgrades were intended specifically to provide additional removals of BOD and suspended solids. They likely would not have accomplished the additional removals of nutrients, ammonia and toxic organics that can be addressed with the CWNS cost functions.

- The BCT costs were estimated specifically and only for POTWs, and there is no reason to believe they would be appropriate for industrial dischargers also. We believe the CWNS cost functions are reasonably applicable to both POTWs and industrial dischargers.

- The CWNS cost functions have been developed and used more recently and more widely than the BCT costs.

However, the CWNS cost functions have one major disadvantage. They are designed in a manner such that the cost of upgrading an existing treatment plant is estimated as the cost of a new plant providing the desired level of treatment less the salvage value of the existing plant. In reality, upgrades can generally be accomplished for less than is projected by this “new plant less salvage value” approach. We believe the CWNS cost equations thus probably overestimate the costs of treatment upgrades. Unfortunately, we are aware of no alternative, broadly applicable, equations for estimating upgrade costs.

The CWNS – since it is concerned with capital costs only -- does not provide functions for estimating the increased operating and maintenance (O&M) costs associated with upgrading wastewater treatment facilities. We developed an O&M cost function for upgrades from survey data assembled by the Association of Metropolitan Sewerage Authorities (AMSA) on O&M costs for POTWs operated by member institutions.[23] AMSA’s survey provides annual O&M costs for each of 119 agencies serving nearly half of the nation’s sewered population. The data on O&M costs and flow for these agencies are broken down by level of treatment provided (primary, secondary, and tertiary). We segregated the data by level of treatment, and developed two regression equations, one explaining annual O&M costs as a function of flow for secondary treatment POTWs and another explaining O&M costs as a function of flow for tertiary POTWs. We then assumed that the increase in O&M cost for an upgrade from secondary to advanced treatment was given by the difference between the estimated secondary and tertiary O&M cost equations.

We have two reservations about this approach to estimating O&M costs associated with the “next treatment step” beyond secondary treatment/BPT/BAT:

- The AMSA data is drawn specifically from POTWs, and there may be some reasons why O&M costs for industrial facilities would differ systematically from those for POTWs. Labor costs for wastewater treatment plant operators, for example, might differ between the private and public sectors.

- The AMSA data distinguished only between primary, secondary and tertiary levels of treatment. AMSA’s data did not distinguish between plants that provided “secondary with nutrient removal”, “advanced treatment I”, “advanced treatment I with nutrient removal”, “advanced treatment II”, and “advanced treatment II with nutrient removal”. Based on

23 Association of Metropolitan Sewerage Authorities. *AMSA Financial Survey*. 1999.

discussions with officials responsible for the AMSA survey, respondents would likely include plants at all of these levels within AMSA's "tertiary" category. The likely result is that the O&M cost differential we estimate between AMSA's secondary and tertiary categories somewhat overstates the real O&M cost differentials that we are interested in resulting from the smaller increments from secondary to "secondary with nutrient removal", to "advanced treatment I", and to "advanced treatment I with nutrient removal".

We have used the equation derived from the AMSA data despite these reservations. We are not aware of any better alternative.

A further issue in costing the "next treatment step" for point sources is that all of our cost equations presume that the "next treatment step" begins from the point at which the source just meets applicable technology-based requirements. For POTWs, the "next treatment step" is assumed to be an increment beyond secondary treatment, while for industrial point sources the increment is beyond BPT and BAT. In fact, though, as noted previously, many POTWs and industrial dischargers currently have treatment in place that exceeds technology-based requirements. For dischargers with advanced treatment in place, the "next treatment step" should be different from the "next treatment step" for dischargers without advanced treatment in place. Assuming increasing marginal costs of control, one might surmise that the "next treatment step" for a discharger already having advanced treatment would be more costly than that for a discharger just meeting technology-based standards.

There are several reasons why we have not been able to improve our costing procedure and address this issue:

- For POTWs. Note that this issue does not arise when we assume that the TMDL program will not require a "next treatment step" of POTWs that already provide better-than-secondary treatment. Under this assumption, we do not cost out any additional treatment for POTWs that already have advanced treatment. However, in the sensitivity analysis we showed in the previous section (e.g., Exhibit II - 1) where we investigate the impact if beyond-secondary POTWs are required to take the "next treatment step", we have assumed and costed "next treatment steps" that start from the wrong point for these POTWs. We would face a major difficulty in trying to remedy this. The CWNS capital cost functions for POTW upgrades involve projecting the cost of building a plant at the new treatment level less the salvage value of the existing plant at the current treatment level. The salvage value equations exist only for secondary plants, not for beyond-secondary plants. Upgrading a beyond-secondary plant to provide further improvements would, following the CWNS approach, get a salvage value credit for the existing plant as if it were only at secondary. The projected net costs for the upgrade from beyond-secondary to well-beyond-secondary would be unreasonably large.

- For industrial dischargers. There is no reasonable way to obtain information on the extent of treatment in place for each industrial discharger, and hence the starting point for each discharger from which the "next treatment step" will begin.

F. FLOW DATA FOR USE IN COST FUNCTIONS

Costs were estimated on a facility-by-facility basis using the previously discussed cost functions and facility flow information from PCS or CWNS.[24] Costs were then summed for all dischargers.

We encountered significant problems resulting from missing or obviously inaccurate facility flow information in PCS/CWNS. The set of assumptions and procedures adopted to address the issues that arose are outlined in Appendix F.

The set of assumptions and procedures to deal with flow issues has a substantial impact on the estimated costs for the affected sources to install the next treatment step. If the assumed limits on the flows to be treated were much higher, the estimated costs could as much as double. We believe, however, that our assumed upper limits on the flows presumed to be treated are conservative -- the great majority of minor and major dischargers will have flows needing additional treatment that are actually well below the upper limits that were assumed.

G. COSTS FOR SOURCES AFFECTING WATERS IMPAIRED BY NONPOINT SOURCES ONLY

Many States provide an assessment of the source types that impair each of their 303(d) waters. For the States that provide this information, the data can be compiled to determine whether each water is impaired by point sources only, by nonpoint sources only, by mixed point and nonpoint sources, by unknown sources, or by other categories of sources. Other States do not provide such information on their impaired waters. In our analysis to this point, we have identified all point sources that presumably discharge an impairment pollutant within a relevant distance upstream of or into an impaired water.[25] This set of point sources is likely the maximum that potentially might be addressed in water quality-based permitting or TMDLs. However, we believe we can use the information that States provide on source types responsible for the impairments in these waters to judge which of the maximum set of potentially relevant point sources are really likely to be addressed in the eventual TMDLs or water quality-based permits. As the most obvious examples:

- When a State indicates that point sources are the source of impairment in a water body, we expect that the TMDL or alternative approaches <u>would</u> likely address all the point sources discharging the impairment pollutant within a relevant distance upstream (i.e., all of the point sources we have identified in this analysis); but

- When a State indicates that nonpoint sources -- and not point sources -- are the source of impairment in a water body, we expect that the TMDL or water quality-based permitting process most likely <u>would not</u> address point sources, even if there are some point sources

24 For POTWs, flow information from CWNS was used preferentially over flow information from PCS.

25 We say "presumably" because we do not have information particular to each point source on whether it actually does or does not discharge any given pollutant. Instead, we make a judgment for each SIC as to whether all dischargers in that SIC presumably discharge each class of pollutants. These broad judgments may be inaccurate with respect to any particular point source discharger.

that apparently (according to our engineering judgment approach) discharge the impairment pollutant within a relevant distance.

In this step of the analysis, we use the information provided by States on the source types responsible for impairment of each 303(d) water body to reduce the set of point sources that could potentially be considered in TMDLs or water quality-based permitting (the maximum set) down to a smaller set of point sources that are likely to be considered in these processes.

In the *"within and upstream"* case, there are 4,234 impaired water bodies that we identify as impaired by one or more of the five pollutant classes that we analyze (BOD, nutrients, metals, toxic organics, and ammonia) and that have one or more point source dischargers within a relevant distance upstream that presumably discharge the impairment pollutant.[26] The following exhibit shows what States report as the sources of impairment for these water bodies, and also shows, in the final column, our judgment as to whether point sources affecting these water bodies are likely to be addressed in TMDLs or water quality-based permitting.

In essence, we assume that a State will consider requiring further controls for relevant point sources via TMDLs when dealing with water bodies that States say are impaired by point sources, and a State will not consider requiring further controls for point sources when dealing with water bodies that are not impaired by point sources. This assumption is supported by findings among our "groundtruthing" sample of actual TMDLs (see Appendix A). For a final category of waters – those for which States have not reported information about the types of sources that are responsible for impairment – we will extrapolate information derived from the waters for which States have reported information on sources of impairment.

Our procedure for using the information from States on the source types responsible for impairment is described fully in Appendix G. In essence, we assume that a State will not require further controls for point sources if the water body is cited by the State as impaired by source types other than point sources. This assumption has the effect of reducing estimated point source costs by roughly 35 % (varying slightly across Scenarios and cases) relative to the costs that would be incurred if further controls were to be required of all point sources discharging the impairment pollutant within a relevant distance of any impaired water.

At this point, costs for Scenario 1 ("Least Flexible TMDL Program") are estimated. The major assumptions in estimating costs for Scenario 1 are summarized in Exhibit II-3.

26 These 4,234 water bodies are for the "within and upstream" case. They represent a little more than one-quarter of the 16,143 impaired water bodies that we cover in our analysis. (Our procedure for matching impaired water bodies against point sources is operable in 44 States plus the District of Columbia. In these 44 States plus DC, there are 18,162 303(d)-listed waters, of which 16,143 have been georeferenced.) Interpreting the "within and upstream" case as an upper bound, we thus believe that at most about 1/4 of all TMDLs have the potential to trigger additional controls for point sources. In contrast, the "within only" case provides a reasonable lower bound. In the "within only" case, there are XXX water bodies that are impaired by one or more of the five pollutants and have one or more point sources discharging the impairment pollutant directly into the impaired water. This suggests that there may be as few as XXX percent of all TMDLs that have the potential to trigger additional controls for point sources.

Exhibit II-2
Sources of Impairment Reported for Water Bodies That Have Point Sources Within/Upstream That Presumably Discharge the Impairment Pollutant

Sources of Impairment Reported by States	Number of Water Bodies (Within and Upstream Case)	For These Water Bodies, are TMDLs or Water Quality-Based Permits Likely to Address Point Sources?
PS only	141	Yes
NPS only	829	No
other only	71	No
unknown only	110	Unclear – scale to these waters
not reported	1,727	Unclear – scale to these waters
PS + NPS only	368	Yes
PS + NPS + other only	339	Yes
PS + NPS + unknown only	15	Yes
PS + other only	53	Yes
PS + unknown only	6	Yes
PS + other + unknown only	5	Yes
NPS + other only	425	No
NPS + unknown only	48	No
NPS + other + unknown only	35	No
other + unknown only	25	No
PS + NPS + other + unknown	37	Yes
Total	**4,234**	

Exhibit II - 3
Assumptions in Estimating Costs for Scenario 1 – Least Flexible TMDL Program

1. Under a least flexible TMDL program, States would write water quality-based permits for every point sources identified as discharging an impairment pollutant into ("Within only" case) or into or near upstream of ("Within and upstream case") an impaired water body, except:

- This applies only to water bodies cited as impaired in part by point sources. WQBELs will not be developed for point sources affecting impaired waters cited as not impaired by point sources.

2. The WQBEL will require each such point source to implement an appropriate "next treatment step" beyond whatever controls the source now has in place, except:

- We assume that POTWs already providing better-than-secondary treatment will not be required to implement the "next treatment step";
- The costs for POTW upgrades that were sufficiently far along in planning as of 1996 to be included in the 1996 CWNS are counted as part of the baseline and should not be attributed to Scenario 1.
- We lack information on treatment in place at industrial dischargers, and assume that the cost of the "next treatment step" for an industrial discharger is the same whether treatment in place is just sufficient to meet technology-based standards, or exceeds this minimum.

3. The sum of the "next treatment steps" that get implemented consistent with these assumptions is sufficient to abate the point source contributions to impairment of all waters that are impaired at least in part by point sources.

Using these major assumptions, we estimate the costs to point sources under the "Least Flexible TMDL Program" scenario to be:

Exhibit II - 4
Estimated Costs for Point Sources -- Least Flexible TMDL Program

Type of Source	Annual Costs (2000 $ in millions)		Number of Affected Facilities	
	Low Est.	High Est.	Low Est.	High Est.
Industrial dischargers	676	1,465	3052	8557
Indirect dischargers (metals)	10	16	at 148 POTWs	at 312 POTWs
POTWs	396	697	1094	3335
Total	**1,082**	**2,178**	**4,146**	**11,893**

H. COSTS FOR SCENARIO 2 (Moderately Cost-effective TMDL PROGRAM)

In Scenario 1 ("Least Flexible TMDL Program"), we assume that States will require load reductions for every point source identified as contributing to impairment of a 303(d) water body. In estimating the costs of Scenario 2 ("Moderately Cost-effective TMDL Program"), the costs estimated for Scenario 1 are scaled down to reflect the load reductions typically required of point sources in actual TMDLs relative to the load reductions simulated in Scenario 1. Based on a sample of 15 recent TMDLs (see Appendix A),[27] we project that:

- About half of all TMDLs will require an aggregate load reduction from point sources approximately equal to the load reduction that would be obtained if all contributing point sources were to implement the "next treatment step" (roughly 50 - 85 %).

- The remaining half of all TMDLs will require an aggregate load reduction from point sources (roughly 10 - 40 %) that is only about half as much as the load reduction that would be obtained if all contributing point sources were to implement the "next treatment step" (roughly 50 - 85 %). In these TMDLs, the cost for point source dischargers to achieve their aggregate load reduction might be only about half of that if all contributing point sources were to have to implement the "next treatment step".[28]

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27 The sample of 15 actual TMDLs is used to inform and test the assumptions applied in this analysis. The sample will be expanded and our assumptions will be revised accordingly for the final version of this analysis.

28 Perhaps only half of all the contributing point sources would need to implement the "next treatment step", perhaps all the contributing point sources would need to implement something substantially less than the "next treatment step", or perhaps the outcome would be somewhere in between. In any case, the costs for point source dischargers to achieve a 10 - 40 % aggregate load reduction would be roughly half of the

This information suggests that total national costs for point sources if TMDLs are developed would be only about 3/4 as much as their costs would be if States proceeded to develop water quality-based permits for all point sources without making more careful TMDL calculations. For about half of the waters where point sources contribute to impairment, the holistic assessment conducted during a TMDL will likely determine that the aggregate load reduction needed from point sources is much less than the reduction that would be obtained if each point source were addressed individually through water quality-based permitting. For point sources, we estimate the costs under the "Moderately Cost-effective TMDL Program" scenario to be 3/4 of the costs that would prevail under the "Least Flexible TMDL Program" scenario.[29] The major assumptions in estimating costs for the Moderately Cost-effective TMDL Program scenario are summarized in Exhibit II-4.

Exhibit II - 4
Major Assumptions in Estimating Costs for Scenario 2 – Moderately Cost-effective TMDL Program

1. A State will develop a TMDL for an impaired water in a careful, holistic manner. The State will determine the maximum pollutant load the water body can tolerate while meeting water quality standards (with a margin of safety), and will then allocate this allowable load among the sources contributing the pollutant. The totaled allowable loads assigned to all sources will be less than but close to the maximum that the water body can tolerate. In contrast, the water quality-based permitting approach will address each point source in isolation, and States will often require load reductions that in total overshoot the aggregate load reduction needed to meet standards.

2. Costs for the WQBEL approach (Scenario 1) are estimated based on the assumption that the State will require all point sources that contribute to impairment to implement an appropriate "next treatment step" (subject to the assumptions previously noted regarding waters impaired by nonpoint sources rather than point sources, POTWs that already provide better-than-secondary treatment, etc.).

3. For about half of all TMDLs involving point sources, the aggregate load reduction required of point sources will be approximately equal to the load reduction that would be obtained if all contributing point sources were to implement the "next treatment step". For the remaining half of the TMDLs involving point sources, the aggregate load reduction required of point sources will be approximately half of the load reduction that would be obtained if all point sources implemented the "next treatment step".

- Costs of Scenario 2 for point sources are thus estimated at 3/4 the costs of Scenario 1.

Using these major assumptions, we estimate the costs to point sources under the "Moderately Cost-effective TMDL Program" scenario to be:

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costs to achieve a 50 - 85 % aggregate load reduction.

29 Note again that we have not defined the "Least Flexible TMDL Program" scenario or the "Moderately Cost-effective TMDL Program" scenario to involve the worst case for point sources in which States pursue point sources for load reductions in an attempt to eliminate impairments in waters that are affected primarily or entirely by nonpoint sources.

Exhibit II - 5
Estimated Costs for Point Sources Under the Moderately Cost-effective TMDL Program

Type of Source	Annual Costs (2000 $ in millions)		Number of Affected Facilities	
	Low Est.	**High Est.**	**Low Est.**	**High Est.**
Industrial dischargers	507	1,099	2289	6418
Indirect dischargers (metals)	8	12	at 111 POTWs	at 234 POTWs
POTWs	297	523	821	2502
Total	**812**	**1,634**	**3,110**	**8,919**

I. SAVINGS WITH "COST-EFFECTIVE WASTE LOAD ALLOCATIONS"

Neither the Clean Water Act nor EPA's implementing regulations prescribe how a total maximum daily load is to be allocated among the sources that discharge the impairment pollutant. The State may assign responsibilities among sources for load reductions as the State wishes. Different allocations will result in different total costs of achieving the desired total load reduction, as a function of the differing costs per pound for the various pollutant sources to reduce their loads. In general, the total costs of achieving the target load reduction will be lower if the sources with lower per unit control costs are assigned responsibility for achieving the bulk of the desired total load reduction. We use the term "cost-effective wasteload allocation" to denote a situation in which the State attempts to minimize aggregate costs by assigning responsibility for achieving most of the total desired load reduction to sources that have relatively low costs of achieving load reductions. Alternatively, the same economically efficient result (achieving a desired total load reduction in the least-cost manner) can be achieved, in theory, given any initial allocation of control responsibilities, if "trading" is allowed. With trading, any source that is assigned responsibility for a load reduction is free to achieve that load reduction itself, or to buy the equivalent load reduction from another source that might be able to provide it at lesser cost. Whatever the initial allocation, trading will tend ultimately to elicit load reductions from the lowest cost sources.

The "More Cost-Effective TMDL Program" scenario recognizes the possibility of reducing TMDL costs to dischargers through either additional "cost-effective wasteload allocations" or through trading, or both. Either of these approaches would reduce the eventual costs to dischargers well below what they would be if TMDLs assigned load reductions on a cost-neutral basis (e.g., if sources were assigned load reductions that required each of them to implement the "next treatment step"; or if load reductions were assigned on a simple proportional rollback basis). We expect that pressure to adopt cost-minimizing approaches will build as the TMDL program grows in the future, and more TMDLs will tend toward this "more cost-effective" model. Note, though, that there may be some instances where other concerns (e.g., equity, concern about implementation and enforcement complexities attendant to trading) prevent use of these cost-minimizing approaches.

Many factors account for differences across sources in costs to abate additional pounds of a pollutant:

- General differences between point sources and nonpoint sources in their typical costs of controlling pollutants. In many cases, nonpoint sources have been found able to abate additional pounds of nutrients, BOD and sediment at much lower costs than can point sources.[30]

- Idiosyncratic differences between dischargers that reflect differing pollution abatement options available to different dischargers. These differences may have some component that reflects systematic differences across industries (e.g., metal finishers are likely able to abate metal discharges at lower cost per pound than food processors, while food processors are likely able to abate BOD dischargers at lower cost per pound than metal finishers). However, there are also very often substantial additional differences across dischargers in cost per pound of control that are essentially unpredictable.

- Systematic differences between pollutant sources involving economies of scale (e.g., other things being equal, a large AFO will be able to abate additional nutrient loadings at lower cost per pound than a small AFO) and increasing marginal costs of control (e.g., other things being equal, a POTW currently providing secondary treatment will likely be able to abate additional nutrient loadings at lower cost per pound than a POTW providing tertiary treatment).

Such differences in per pound abatement costs provide opportunities for many sorts of cost-effective waste load allocations: in allocations among several point sources, in allocations between point and nonpoint sources, in allocations among several nonpoint sources, in allocations (developed by a POTW) among several indirect dischargers, etc.. Or, restating this in terms of trading, there are many ways that trading may save money: point/point trading, point/nonpoint trading, nonpoint/nonpoint trading, pretreatment trading, etc.. Because so many of these trading or cost-effective waste load allocation opportunities are idiosyncratic and not predictable, we are unable to simulate them in this analysis. <u>In this analysis, we have been able to simulate savings only from cost-effective waste load allocations in which additional control of nonpoint sources is substituted for additional control of point sources (e.g., point/nonpoint trading)</u>. This form of trading is the most common form that has occurred to date in the water program.[31] However, experience in other programs suggests that other forms of trading may also yield important cost savings (e.g., air program trading among point sources involving SOx, NOx, VOCs, greenhouse gases, etc.). Ultimately, the savings achievable in restoring impaired waters via cost-effective waste load allocations are likely to be much greater than those we can estimate here.

The cost-effective waste load allocation activity that we simulate here as representative of Scenario 3 involves shifting some responsibilities for additional control responsibilities from point sources to nonpoint sources. This shift of some responsibilities from point sources to nonpoint sources may occur

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30 See: Environomics, Inc. *A Summary of U.S. Effluent Trading and Offset Projects*. November, 1999. www.epa.gov/owow/watershed/trading.

31 Ibid.

before the waste load allocation (WLA) is developed under the TMDL (e.g., the State considers the relative cost-effectiveness of controlling point and nonpoint sources and then allocates loads among the source types in a manner that reflects this and minimizes total compliance costs) or after the WLA is developed (e.g., the WLA is established and then point and nonpoint sources are allowed to trade -- typically a point source substitutes a lower cost reduction that it achieves by controlling nonpoint sources or by paying nonpoint sources to control for some of the load reduction that the point source is required to accomplish).

We believe the most likely circumstances in which there will be cost-effective opportunities for control of nonpoint sources to substitute for further control of point sources are as follows:

- *For water bodies that are impaired by both point and nonpoint sources*. Obviously both sorts of sources must contribute meaningful amounts of the impairment pollutant if there is to be any opportunity for control of one to substitute for control of the other.

- *For impairments involving nutrients or BOD.* Virtually all of the instances thus far in which point-nonpoint tradeoffs have occurred involve nutrients or BOD.[32] It is rare that a water body impaired by a toxic pollutant faces significant discharges of the toxic pollutant by both point and nonpoint sources that can allow for tradeoffs.

- *For non-flowing as opposed to flowing water bodies*. Impairment of lakes and estuaries typically results from an accumulated load of a pollutant from an entire watershed over a substantial period of time (ranging from a season to many years). In these circumstances, loads from different locations in the watershed and loads that occur at different times can relatively safely be traded off against each other -- a pound of the pollutant has a roughly similar impact largely independent of whether it comes from a point or nonpoint source and where and when it is discharged. In contrast, impairment of a flowing water body is often more localized (e.g., a particular river reach rather than an entire lake) and more episodic (e.g., the impairment occurs at particular times, such as during wet weather or during low flow conditions). In flowing waters, discharges of the same pollutant by various point and nonpoint sources often have differing impacts depending on the location, time, and nature of the discharge. It is much more difficult to implement an environmentally protective trading program under such circumstances.

We evaluated all the point sources affecting impaired waters with respect to these considerations, and assigned the point sources (and the costs we estimated they would incur under Scenario 2, the Moderately Cost-effective TMDL Program) to one of three groups reflecting their suitability for cost-effective waste load allocations involving point/nonpoint tradeoffs:

- *Group 1. Point sources* <u>*highly*</u> *suited to cost-effective WLAs/trading*. These point sources discharge BOD and/or nutrients to <u>non-flowing</u> waters that are impaired for these pollutants by both point and nonpoint sources. We estimate that this group comprises 9 % (upstream and within case) or 17 % (within only case) of all point sources that affect impaired waters. The potentially tradeable costs for these point sources amount to 8 %

32 Ibid.

(upstream and within case) or 10 % (within only case) of the total costs that we estimate point sources will incur under the Moderately Cost-effective TMDL Program (Scenario 2).

- *Group 2. Point sources moderately suited to cost-effective WLAs/trading*. These point sources discharge BOD and/or nutrients to flowing waters that are impaired for these pollutants by both point and nonpoint sources. We estimate that this group comprises 29 % (upstream and within case) or 47 % (within-only case) of all point sources that affect impaired waters. The potentially tradeable costs for these point sources amount to 21 % (upstream and within case) or 27 % (within only case) of the total costs that we estimate point sources will incur under the Moderately Cost-effective TMDL Program (Scenario 2).[33]

- *Group 3. Point sources not suited to cost-effective WLAs/trading*. These point sources fail one or more of the conditions that we presume necessary for cost-effective WLAs/trading. We estimate that this group comprises 62 % (upstream and within case) or 36 % (within only case) of all point sources that affect impaired waters. Non-tradeable costs for the point sources in this and the other groups amount to 71 % (upstream and within case) or 63 % (within only case) of the total costs that we estimate point sources will incur under the Moderately Cost-effective TMDL Program (Scenario 2).

Note that we have assigned point sources and costs to these three groups in a conservative manner:

- A point source is assumed to be able to save money from participating in a more cost-effective WLA only if all the impaired water bodies that the point source affects are amenable to more cost-effective WLAs. Thus, if as few as one impaired water body affected by a point source is not amenable to cost-effective WLA (i.e., if at least one water body does not have both point and nonpoint sources discharging the impairment pollutant), the source will be precluded by that water body from avoiding the next treatment step.[34]

- Even though a point source might seem able to avoid the cost of a "next treatment step" by participating in a more cost-effective WLA for nutrients or BOD, the point source will not be able to do so if it nevertheless is presumed to need the next treatment step to abate

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33 Note that the percentage of point sources apparently suited to participating in cost-effective WLAs (in either Group 1 or Group 2) is substantially greater than the percentage of costs that are amenable to cost-effective WLAs. This is because we have assumed that metals, toxic organics and ammonia are not amenable to cost-effective WLAs, and costs for any "next treatment step" controls needed to abate these pollutant classes are "off the table". Many point sources may be able to participate in cost-effective WLAs for BOD or nutrients ("tradeable" pollutants) while nevertheless incurring some control costs (for non-"tradeable" pollutants) that are not eligible for cost-effective WLAs.

34 It is important to note that many point sources affect multiple impaired waters, particularly in the upstream and within case, in which a point source's influence is presumed to be felt far downstream. Considering only non-metal pollutants (in our view, metals require wholly different treatment technologies than non-metals and have no impact on suitability or non-suitability for a point source to participate in a more cost-effective WLA), 44 % of the point sources contribute to impairment of multiple water bodies in the upstream and within case, and 12 % of the point sources do so in the within only case.

either toxic organics (advanced secondary treatment, the same upgrade as is needed for BOD) or ammonia (secondary treatment with nutrient removal, the same upgrade as is needed for nutrients). In effect, the presumed need to abate toxic organic loads precludes participating in a cost-effective WLA for BOD, while the need to abate ammonia precludes participating for nutrients.

- Any point source that affects multiple impaired waters and appears able to participate in a cost-effective WLA for each of them is assigned to Group 2 rather than Group 1 if as few as one of the impaired waters is non-flowing.

In estimating the potential savings to point sources from participating in more cost-effective WLAs (Scenario 3), we assume that: 1) All of the Group 1 (highly suited) point sources will participate; 2) Half of the Group 2 (moderately suited) point sources will participate; and 3) None of the Group 3 (unsuited) point sources will participate. We have no empirical basis for this particular assumption regarding participation rates. We are confident only that very few of the Group 3 sources will be able to participate in point/nonpoint sorts of cost-effective WLAs, while participation should be substantially higher in Group 2 and substantially higher again in Group 1. Different assumptions may be substituted for the participation rates we assume, and the effects will be proportional (if half of Group 1 sources were assumed to participate rather than all of them, the savings for them would be half as much).

With these assumptions, we can estimate the cost savings for point sources that could result from more cost-effective WLAs that shift some control responsibilities to nonpoint sources.

How much might it cost for nonpoint sources to control the quantity of pollutants that are no longer to be controlled by point sources? The answer is highly uncertain. In Appendix H we summarize the results from nine instances in which the costs for nonpoint source controls have been compared with the costs for point source controls. The nine cases involve TMDLs or water quality standard attainment studies that are very similar to the situations for which we are postulating more cost-effective WLAs -- instances in which nonpoint source controls for nutrients or BOD are being considered as alternatives to additional treatment efforts at point sources (typically advanced treatment at POTWs). The results of shifting control responsibilities from point to nonpoint sources are quite variable, ranging from more than 90 % savings in one case to an increase in cost in another case. The median figure across the seven instances where percentage cost comparisons have been quantified is a 75 % savings for nonpoint source controls relative to point source controls. On this basis, we will assume for our analysis that nonpoint sources can provide additional control of nutrients and BOD at a cost per pound equal to 25 % of that for additional point source controls. The additional nonpoint source controls that are needed to offset the increased point source loads allowed in a more cost-effective WLA will cost 25 % as much as the savings in point source costs.

Based on these assumptions, Exhibit II - 6 shows the estimated costs for Scenario 3, the "More Cost-Effective TMDL Program".

Exhibit II - 6
Estimated Costs for More Cost-Effective TMDL Program (Scenario 3) ($ in millions)

	TMDL Program		Cost-Effective TMDL Program							
	# of PS	Costs	% of PS	% of Costs	% Participating	# PS Participating	PS Cost Savings	Add'l NPS Cost	Net Savings	Net % Cost Savings
Upstream and within case										
Highly suited to cost-effective WLAs			8.81	8.46	100	786	$138	$35	$104	
Moderately suited to cost-effective WLAs			28.72	21.40	50	1281	$175	$44	$131	
Not suited to cost-effective WLAs			62.47	70.14	0	0	$0	$0	$0	
Total	8919	$1,634				2067	$313	$78	$235	14.37
Within only case										
Highly suited to cost-effective WLAs			16.79	9.50	100	522	$77	$19	$58	
Moderately suited to cost-effective WLAs			46.89	26.98	50	729	$110	$27	$82	
Not suited to cost-effective WLAs			36.32	63.52	0	0	$0	$0	$0	
Total	3110	$812				1251	$187	$47	$140	17.24

The gross savings to point sources from more cost-effective WLAs are estimated at $187 - 313 million/yr, constituting 19 - 22 % of point source costs under the Moderately Cost-effective TMDL Program (Scenario 2). 23 - 40 % of all point sources contributing to impairments are likely to participate in the more cost-effective WLAs. The net savings from more cost-effective WLAs are estimated at $140 - 235 million/yr (savings to point sources partly offset by increased costs of nonpoint source controls). These savings are estimated only for cost-effective WLAs involving shifting control responsibilities from point to nonpoint sources. Further savings are possible from other sorts of reallocations, but these have not been estimated.

Exhibit II - 7
Major Assumptions in Estimating Costs for Scenario 3 – More Cost-Effective TMDL Program

1. The estimates address potential savings from shifting control responsibilities from point to nonpoint sources. Savings have not been estimated for other sorts of reallocations.

2. Cost-effective WLA opportunities will focus on non-flowing waters impaired by nutrients or BOD from both point and nonpoint sources. Lesser opportunities will be available for similarly impaired flowing waters.

3. The following percentages of point sources are assumed to participate in more cost-effective WLAs: 100 % of highly suited point sources, 50 % of moderately suited point sources, and no unsuited point sources.

4. The cost per pound for nonpoint sources to abate nutrient or BOD loads is about 1/4 of that for point sources.

A more detailed description of some of our assumptions and procedures in simulating more cost-effective WLAs is provided in Appendix H.

J. SUMMARY COST ESTIMATES FOR POINT SOURCES

For Scenario 1 (Least Flexible TMDL Program), costs are estimated for the next treatment step for each point source identified as discharging the impairment pollutant into or within a relevant distance upstream of each point source-impaired water body. Costs are then summed across pollutant sources. We assume that a pollutant source affecting multiple impaired water bodies that are impaired for the same pollutant will need to implement the next treatment step only once -- we assume that the next treatment step will suffice to achieve this pollutant source's desired load reductions whether the pollutant source contributes to impairment of one or many water bodies.

The raw cost estimates calculated in this manner are then scaled to reflect two factors:

- *Incomplete coverage in the analysis*. The analysis is incomplete, in that it does not cover all impaired water bodies (some are not georeferenced with respect to Reach File 3 reaches) and all point sources (some point sources also have not been georeferenced), and the geographic procedure for matching water bodies against point sources is not operable in several States. As described in section I.C.3, the scaling factor to account for incomplete coverage in the point source analysis is 1.605.

- *The time at which pollutant sources will begin incurring implementation costs*. Costs are estimated initially as the annualized amounts that pollutant sources will pay once their implementation costs begin. In order to focus any comparison across Scenarios on technical differences rather than timing issues, we assume that pollutant sources will incur implementation costs at the same time under each of the three Scenarios. We assume that implementation costs for a source will not to begin until five years after the TMDL is developed that requires further controls for the source. We assume that TMDLs will be developed at an even pace over the years from now through 2015, the deadline for completing TMDLs for the 1998 303(d) list. As a result, the median source is not expected to begin incurring its implementation costs until 2013.[35] As described in section I.C.5, the scaling factor to reflect the assumed pace of TMDL development and compliance lag time is 0.4484.

Combining these two scaling factors, the raw implementation costs estimated for point sources from the cost equations are multiplied by 0.7197 (1.605 x 0.4484) to develop national estimates of annualized costs beginning in the year 2000.

Cost estimates for Scenario 2 (Moderately Cost-effective TMDL Program) are developed by adjusting downward the costs estimated for Scenario 1, assuming that TMDLs will result in a more precise calculation of how much load reduction is needed from point sources in order to meet water quality standards. More specifically, the costs estimated for Scenario 2 reflect the degree of aggregate load reduction that actual TMDLs have required of point sources, relative to the load reduction that would be achieved if all point sources were to implement the "next treatment step" as in Scenario 1.

Cost estimates for Scenario 3 (More Cost-Effective TMDL Program) are developed by applying to the cost estimates for Scenario 2: a) projections regarding how many point sources will participate in more cost-effective WLAs; and b) an estimate for the percentage cost savings when nonpoint source controls for nutrients and BOD are substituted for point source controls.

The resulting estimated annual costs for point source pollutant sources under each of the three scenarios are as follows:

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35 There are an estimated 36,225 TMDLs to be developed for the 1998 303(d) waters. The mid-point in the projected schedule over which these TMDLs will be developed will occur in 2008 -- half of the TMDLs will be developed before then, half afterwards (see Exhibit I-2). A point source required to implement further controls by a TMDL developed in 2008 is assumed to begin incurring costs five years later, in 2013.

Exhibit II - 8
Point Source Costs Under Scenario 1: Least Flexible TMDL Program
Annualized Costs by Type of Discharger

Within and Upstream Case

	SIUs - Metals Treatment	POTWs (non-Metals)	Industrial Dischargers	Total – All Sources
# Facilities	at 312 POTWs	3,335	8,557	11,893
Total Cost/yr	$16,493,652	$696,968,954	$1,464,694,468	$2,178,157,075
Average Cost/Facility/yr	$52,864	$208,986	$171,169	$183,146

Within Only Case

	SIUs - Metals Treatment	POTWs (non-Metals)	Industrial Dischargers	Total – All Sources
# Facilities	148 POTWs	1,094	3,052	4,146
Total Cost/yr	$10,120,959	$395,814,376	$676,345,333	$1,082,280,668
Average Cost/Facility/yr	$68,385	$361,805	$221,607	$261,042

Exhibit II - 9
Point Source Costs Under Scenario 1: Least Flexible TMDL Program
Annualized Costs by Type of Discharger

Within and Upstream Case

	Metals	All Other Pollutants	Total - All Pollutants
# Facilities	4,688	9,865	11,893
Total Cost/yr	$209,419,393	$1,968,737,682	$2,178,157,075
Average Cost/Facility/yr	$44,671	$199,568	$183,146

Within Only Case

	Metals	All Other Pollutants	Total - All Pollutants
# Facilities	1,707	3,289	4,146
Total Cost/yr	$93,827,202	$988,453,467	$1,082,280,668
Average Cost/Facility/yr	$54,966	$300,533	$261,042

Exhibit II - 10
Point Source Costs Under Scenario 2: Moderately Cost-effective TMDL Program
Annualized Costs by Type of Discharger

Within and Upstream Case

	SIUs - Metals Treatment	POTWs (non-Metals)	Industrial Dischargers	Total – All Sources
# Facilities	at 234 POTWs	2,502	6,418	8,919
Total Cost/yr	$12,370,239	$522,726,716	$1,098,520,851	$1,633,617,806
Average Cost/Facility/yr	$52,864	$208,924	$171,162	$183,162

Within Only Case

	SIUs - Metals Treatment	POTWs (non-Metals)	Industrial Dischargers	Total – All Sources
# Facilities	111 POTWs	821	2,289	3,110
Total Cost/yr	$7,590,719	$296,860,782	$507,259,000	$811,710,501
Average Cost/Facility/yr	$68,385	$361,584	$221,607	$261,000

Exhibit II - 11
Point Source Costs Under Scenario 2: Moderately Cost-effective TMDL Program
Annualized Costs by Type of Discharger

Within and Upstream Case

	Metals	All Other Pollutants	Total - All Pollutants
# Facilities	3,516	7,398	8,919
Total Cost/yr	$157,064,544	$1,476,553,261	$1,633,617,806
Average Cost/Facility/yr	$44,671	$199,588	$183,162

Within Only Case

	Metals	All Other Pollutants	Total - All Pollutants
# Facilities	1,280	2,467	3,110
Total Cost/yr	$70,370,401	$741,340,100	$811,710,501
Average Cost/Facility/yr	$54,977	$300,503	$261,000

We project that total costs for point sources under the Moderately Cost-effective TMDL Program (Scenario 2) will be 25 % lower than they would be with the Least Flexible TMDL program (Scenario 1). Although we show in the exhibits a similar 25 % reduction in the number of point sources affected under the Moderately Cost-effective TMDL Program compared with the Least Flexible TMDL Program, we do not intend this to be a conclusion of the analysis. The Moderately Cost-effective TMDL Program will require 25 % less aggregate load reduction from point sources than will be required under the Least

Flexible TMDL Program. This lesser load reduction can be accomplished by: 1) Requiring the same load reduction per source but requiring such load reductions from 25 % fewer sources (as we show); 2) Requiring a 25 % lower load reduction per source, but requiring these load reductions from all sources; or 3) Any combination of load reduction per source and number of sources addressed that results in 25 % less aggregate load reduction.

Costs for point sources under the More Cost-Effective TMDL program will be an estimated 19 -23 % lower than the costs under the Moderately Cost-effective TMDL Program.

Exhibit II-12
Projected Savings to Point Sources from Cost-Effective WLAs ($ in millions/yr)

	Moderately Cost-effective		**More Cost-Effective TMDL Program**		
	Costs	# PS w/ costs	Costs	Savings	#PS w/savings
Into + upstream case	$1,634	8919	$1,321	$313	2067
			% relative to TMDL program:	19.2%	23.2%
Into only case	$812	3110	$625	$187	1251
			% relative to TMDL program:	23.0%	40.2%

Finally, Exhibit II - 13 shows the costs for point sources estimated under each of the three scenarios.

Exhibit II-13
Costs for Point Sources Under All Three TMDL Program Scenarios ($ in millions/yr)

	Least Flexible TMDL Program	**Moderately Cost-effective TMDL Program**	**More Cost-Effective TMDL Program**
Into + upstream case	$2,178	$1,634 25 % savings	$1,321 39 % savings
Into only case	$1,082	$812 25 % savings	$625 42 % savings

Relative to the "Least Flexible TMDL Program" scenario, having the Moderately Cost-effective TMDL Program will save point source dischargers an estimated 25 %. A more cost-effective TMDL program could save 39 - 42 %.

III. IMPLEMENTATION COSTS FOR NONPOINT SOURCES

The implementation costs that nonpoint sources might incur under the three TMDL program scenarios are estimated for the following nonpoint source types:

- Agricultural land, including crop land, pasture land, and range land;
- Animal feeding operations (AFOs);
- Silviculture; and
- On-site wastewater treatment systems (including septic systems, cesspools, etc.)

Our approach for estimating implementation costs for these nonpoint sources is similar to our approach for point sources. For each 303(d) water impaired by one of these nonpoint source types, we identify the volume of nonpoint source activity contributing to the impairment, assume that some fraction (depending on the scenario) of this nonpoint source activity will need to implement the "next treatment step", and then estimate the costs associated with this amount of "next treatment step" controls. The Least Flexible TMDL Program scenario and the Moderately Cost-effective TMDL Program scenario are differentiated based on the degree to which actual TMDLs have required load reductions from nonpoint sources relative to the load reductions that we simulate for the Least Flexible TMDL program scenario. The Cost-Effective TMDL Program scenario adds the additional costs for nonpoint source controls that we estimated in the previous chapter as some point source control responsibilities are assumed shifted to nonpoint sources.

A. COVERAGE OF THE NONPOINT SOURCE ANALYSIS

There are many other nonpoint source types that contribute to impairment of 303(d) waters for which we were not able to estimate implementation costs, such as:

- abandoned mines,
- contaminated in-stream sediments,
- air deposition,
- natural sources,
- land disposal,
- many leaks and spills,
- hydrological modification,
- habitat alteration,
- dispersed petroleum and other resource extraction activities; and
- CSOs, SSOs and storm water (urban, construction, industrial) to the extent they are not addressed by existing technology-based requirements.

The nonpoint source categories that we do cover likely comprise the bulk of nonpoint source pollutant loadings to impaired waters in total, but there remain many waters that are impaired only by one or more of these omitted categories for which we do not estimate costs. For each of the omitted nonpoint source categories, at least one of the data sets required for estimating costs is not available:

- Information on the volume and location of the nonpoint source activity, at sufficiently fine geographic resolution so that the amount of the nonpoint source activity contributing to impairment of a specific water body can be identified; and

- Information on the level of water pollution-abating practices that are currently applied by the nonpoint source activity, and on unit costs for the "next treatment step" for the activity.

The following exhibit suggests the relative importance of the source types we cover in the implementation cost analysis and those we omit.

Exhibit III-1
Coverage of Different Source Types in Implementation Cost Analysis

Source	303(d) River Miles	303(d) Lake Acres (thousands)	Now Covered in Cost Analysis	Pollution, not Pollutants	Will be Mitigated by Tech-Based Standards	Omitted
Agriculture	108,284	2,548	X			
Hydromodification/Habitat Alteration	48,319	1,879		X		
Nonpoint Source (No Further Information)	30,223	1269				scaled to
Municipal Point Sources	23,136	930	X			
Resource Extraction	22,971	293				X
Other Source	20,821	1,899				X
Urban Runoff/Storm Sewers	18,732	1,908			X	
Source Unknown	16,206	992				scaled to
Silviculture	10,350	289	X			
Construction	9,805	409			X	
Septic Systems	7,009	1,394	X			
Industrial Point Sources	6,319	292	X			
Combined Sewer Overflow	3,918	436			X	
Atmospheric Deposition	1,696	1,080				X
Marinas	378	151				X
Total[36]	328,168	15,769				

Source: Tetra Tech, Inc. analysis of 303(d) data base, with sources of impairment aggregated into these 15 groups.

The exhibit shows the different source types listed by States as responsible for impairment of 303(d) waters and the river miles and lake acres of such impaired waters. Hydromodification and habitat

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36 The totals shown should not be interpreted as the total extent of impaired waters in the nation. Only about half of the States report source information for their 303(d) lists. This causes the totals shown in the exhibit to fall far short of the national total. On the other hand, for many impaired waters States cite multiple sources of impairment, and this will tend to make the figures in the exhibit exceed the national total. It is only by chance that the total river miles shown in the exhibit is close to the roughly 300,000 mile aggregate length of all impaired river segments on the 1998 303(d) lists.

alteration often involve physical changes to water bodies or their drainage areas without explicit pollutants, and these sources will often not be addressed by TMDLs. Most impairments due to urban runoff, storm sewers, construction and CSOs will be mitigated by full compliance with recently adopted technology-based standards for these sources, and implementation costs in these areas can be attributed to the baseline rather than to the TMDL program. This leaves several important source categories as potentially affected by the TMDL program but omitted from this implementation cost analysis:

- "Source Unknown" and "Nonpoint Source (No Further Information)" are categories that we cannot analyze presently because there is insufficient information available as to exactly what the responsible sources are. Our scaling process described earlier (Section I.C.3.b), however, extrapolates costs to these waters by scaling from costs estimated for waters with known nonpoint source types. In effect, TMDL implementation costs are estimated for waters impaired by such sources.

- "Resource extraction" includes mostly impacts from mining and, to a lesser degree, oil and gas development. Some mining impacts will be addressed (and have been costed in the point source analysis) through NPDES permits for mining discharges that involve discrete conveyances. Most impacts, though, involve abandoned mines or diffuse runoff and seepage from mined areas generally. Implementation costs will occur for these sources, but have not been estimated here. These costs could be significant.[37]

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37 Here are two estimates that suggest the magnitude of the costs that might be involved for control of some sorts of abandoned mines.

The U.S. Forest Service estimates that there are approximately 38,000 abandoned mines on National Forest lands, among which perhaps 10,000 pose important water quality problems. The 1,800 sites that have toxic discharges are being pursued under CERCLA and the point source program. The remaining 8,200 sites do not involve toxic pollutants, but are thought to cause significant resource damage. It is not known how many of these sites affect impaired waters specifically. The average cost of addressing these sites is estimated at $150,000 - $280,000 per site. USFS estimated that it will require $60 - $115 million per year to resolve water quality problems from these sites by the year 2022. (Note that these cost estimates are not directly comparable with the levelized annual costs continuing forever that we estimate in this report.) Source: USDA review of EPA's draft TMDL cost analyses, June/July, 2001.

EPA's Draft Nonpoint Source Gap Analysis (Tetra Tech, Inc., February 7, 2001, op cit.) estimates the cost to reclaim all coal-related abandoned mined lands at $5.7 billion. This estimate includes mines on all lands, including Federal lands. It excludes costs for non-coal mines, which are thought to be less numerous and costly than are coal mines. The estimate therefore overlaps to some degree with the USFS estimate. If this $5.7billion cost were incurred over the period from 2005 through 2020 and then converted into a levelized annual amount continuing forever, thus making these costs comparable to those estimated in this report, the annual cost would be $173 million/yr.

It is now known how many of either the USFS sites or the coal-related sites affect 303(d)-listed impaired waters specifically. For other nonpoint source types that we analyze, the fraction of all nonpoint source activity that affects 303(d) waters specifically (under the Least Flexible Scenario) ranges from 1% (for on-site wastewater treatment systems) to 53% (crop land).

- "Other sources" include a wide variety of activities that we did not break out individually, such as contaminated sediments, land disposal, and natural sources (e.g., salt springs, acid bogs). Most, if not all, of these sources will be addressed by TMDLs and implementation costs will often occur. In some cases, the costs to implement appropriate treatment or remediation will be substantial (e.g., dredging and disposing of contaminated sediments).

- "Atmospheric deposition" is a difficult issue for the TMDL program. Hopefully most atmospheric deposition problems will be resolved as air pollution control programs continue to progress (e.g., NESHAPs, NOx and SOx programs, controls on utility emissions of mercury, etc.). It is unclear how a TMDL developed by a State will be able to address atmospheric deposition originating from beyond the State's boundaries. The first TMDL for atmospheric deposition was recently approved by EPA (for the Savannah River, GA), and it was projected to add no costs for sources beyond what they will need to spend to meet existing air regulations.

In sum, the source types completely omitted from the implementation cost analysis (excepting the unknown and "nonpoint source (no further information)" categories that we scale to) account for about 14 % of the 303(d) river miles and 22 % of the 303(d) lake acres. The important omitted sorts of nonpoint sources that we would like to include in the analysis if the necessary data were available are: resource extraction (mining, petroleum activities), land disposal, and perhaps some sorts of contaminated sediments and natural sources. Developing methods and data for costing these omitted nonpoint source activities should be high priority in future efforts to improve our estimates of TMDL implementation costs.

B. WATERS IMPAIRED BY AGRICULTURE, AFOS, SILVICULTURE AND ON-SITE SYSTEMS

When one of these nonpoint source types is cited by a State as a source of impairment for a 303(d) water, we assume that the State will require or induce this nonpoint source type to implement further control measures, whether under the moderate and more cost-effective TMDL program scenarios (Scenarios 2 and 3) or under the least flexible TMDL program (Scenario 1). Our first step in estimating the implementation costs for these nonpoint sources is to identify the 303(d) waters that are impaired by each of the nonpoint source types that we cover.

States vary in the degree to which they provide information on the source types responsible for impairment of impaired waters. Some States do not report source information at all for their 303(d) waters, some report in modest detail (e.g., using only broad identifiers of source types such as "point sources", "nonpoint sources", "unknown sources", etc.), and some report in great detail (e.g., using specific identifiers of source types such as "municipal point sources", "CSOs", "silviculture", "irrigated crop land", etc.). Our procedure for identifying water bodies impaired by various nonpoint source categories relies on detailed source reporting by those States that provide such information, either in their 303(d) submissions or in their 305(b) submissions. For example, in analyzing silviculture, we:

- Identify the 303(d) water bodies that States report as impaired by silviculture as a source.

- Identify the 305(b) water bodies that States report as impaired by silviculture as a source. We then crosswalk from each of these silviculture-impaired 305(b) waters and determine whether there is a corresponding 303(d) water body. (Some States report 305(b) source information but not 303(d). This second step effectively increases the set of States within which we can find silviculture-impaired 303(d) waters.)

- Add the results of the first and second steps, thus obtaining a list of silviculture-impaired 303(d) waters. We note the States in which these waters are located. We then regard this set of States as a sample that we analyze. We assume that this sample is representative of the nation as a whole.

- States for which we can identify no silviculture-impaired water bodies may either:

  a) Actually have no silviculture-impaired water bodies; or
  b) Actually have them, but report source information in a manner that does not allow for identifying them.

  Conservatively, we assume the latter -- we assume that a State that reports no silviculture-impaired water bodies is effectively "non-reporting". We extrapolate the costs we estimate for controlling silviculture in the sample States (those that report silviculture impairments) to the assumed non-reporting States by scaling up based on the volume of silviculture occurring in the sample States relative to that occurring in the non-reporting States. The scaling factor we use for this extrapolation is the ratio between the total national annual timber harvest and the harvest volume in our "reporting" States. In this case, 10.91 million cubic feet of timber was harvested in the 30 "reporting" States and 16.35 million cubic feet was harvested in the nation as a whole. The scaling factor is thus 16.35/10.91, or 1.499.

We employ this approach for each of the different nonpoint source types we analyze; for crop land, pasture land, range land, AFOs and on-site wastewater systems as well as for silviculture. Different sets of States are considered to be "non-reporting" for the different nonpoint source types. For each nonpoint source type, we use a different volume-based scaling factor to extrapolate our cost estimates from the "reporting" States to the entire nation. The volume measures that we use in scaling are:

- *For silviculture.* The annual volume of timber harvested.

- *For agriculture.* Crop land-related costs are extrapolated based on the acreage of crop land. Similarly, pasture-related costs and range-related costs are extrapolated based on the acreage of pasture and range lands.

- *For AFOs.* The number of confined animal units (AUs).

- *For on-site wastewater systems.* The number of dwelling units served by on-site wastewater systems.

The exhibit below shows the States that reported (in either 303(d) or 305(b) reporting) 303(d) water bodies impaired by each nonpoint source type that we analyze. At the bottom of the exhibit we show the fraction of the total national volume of activity occurring in the "reporting" States, and the resulting scaling factor that we apply in extrapolating TMDL implementation costs from the "reporting" States to the nation as a whole.

Exhibit III-2
States Using NPS Categories in Reporting Sources of Impairment

STATE	Crop Land	Pasture or Range	AFOs	Silviculture	On-Site Wastewater
Alabama	X	X	X	X	X
Alaska				X	
Arizona	X	X		X	X
Arkansas				X	X
California	X	X	X	X	
Colorado					
Connecticut			X		X
Delaware			X		X
District of Columbia					
Florida				X	
Georgia					
Hawaii					
Idaho					
Illinois	X	X	X	X	X
Indiana					
Iowa			X		
Kansas	X		X		
Kentucky	X	X	X	X	X
Louisiana	X	X	X	X	X
Maine	X	X	X	X	
Maryland					
Massachusetts				X	X
Michigan	X	X	X	X	X
Minnesota				X	
Mississippi	X	X	X	X	X
Missouri	X		X		
Montana	X	X	X	X	X
Nebraska	X	X	X		
Nevada		X			
New Hampshire			X		
New Jersey			X		
New Mexico	X	X	X	X	X
New York				X	X
North Carolina	X	X	X	X	X
North Dakota	X	X	X	X	
Ohio	X	X	X	X	X
Oklahoma	X	X	X	X	X
Oregon					
Pennsylvania				X	X
Rhode Island		X	X	X	
South Carolina			X	X	
South Dakota	X	X	X	X	X
Tennessee	X	X	X	X	X
Texas	X	X	X		X
Utah					
Vermont	X	X	X	X	X
Virginia		X	X	X	X
Washington					
West Virginia	X	X	X	X	X
Wisconsin		X	X		
Wyoming			X	X	
Number of States using this category	23	25	32	30	24
Fraction of total in "reporting" States	.64	.59 .70	.65	.67	.58
Scale Factor	1.56	1.69 1.43	1.55	1.499	1.732

The exhibit shows that the number of States citing (in either their 303(d) or 305(b) lists) these nonpoint source types as responsible for impairment of waters ranged from 23 (for crop land) to 32 (for AFOs). We conservatively assumed that any State not citing one of these nonpoint source types as responsible for impairments actually had such impairments, but simply did not report sources at all or did not use an appropriate code in its system of reporting sources of impairments. The States that we classified as "reporting" accounted for a percentage of the total national volume of activity ranging from 58 % for on-site wastewater treatment systems land to 70 % for range land.

We noted each water body that was cited by a "reporting" State as impaired by one of the nonpoint source categories that we address. This set of water bodies impaired by each nonpoint source category was the starting point for the cost analysis. After estimating the costs that nonpoint sources affecting these water bodies in "reporting" States would incur, we scaled up these implementation costs to extend the cost estimate from the "reporting" States to the entire nation.

C. THE AMOUNT OF NONPOINT SOURCE ACTIVITY NEEDING FURTHER CONTROL FOR AN IMPAIRED WATER BODY

When a State identifies a water body as impaired by a nonpoint source type, we assume in the "Least Flexible TMDL Program" scenario that the State will require further control for the entire volume of that nonpoint source activity that occurs within the county or counties in which the impaired water body is located. Thus, for example, in addressing an AFO-impaired water body, we assume in this scenario that the State would require or somehow elicit load reductions from all the AFOs in the county or counties surrounding the impaired water body.

This assumption is based on the general belief that most nonpoint source management programs are targeted at a finer geographic level than an entire county. States, USDA and others typically direct nonpoint source management and assistance efforts at particular watersheds with water quality problems. Practices are eligible for cost-share in some watersheds but not others, technical assistance is focused on some watersheds and not others, etc.. Commonly the watershed is defined at the scale of roughly an 11-digit catalog unit (substantially smaller than a county), but sometimes the watershed is defined at a more gross scale approximating an 8-digit catalog unit (approximately similar in size to a county).[38] In reviewing a draft of this report, USDA staff believed that the "entire county" assumption represented a substantial overestimate of what typically occurs in practice: "While technically feasible, it is highly unlikely that Section 319 efforts will cover 100 percent of the county. This is not the level of activity being observed.."[39]

We believe the "entire county" assumption underlying the "Least Flexible TMDL Program" scenario represents for most impaired water bodies a substantial overestimate of the volume of nonpoint source activity that will actually be addressed in a TMDL as needing further controls. Most of the identified nonpoint source-impaired water bodies are relatively small (typical length of the impaired river segments is 5 to 25 miles). For most impaired water bodies, the upstream watershed from which the impairment pollutants derive is much smaller than the size of the entire county or counties within which the water body is located. The assumption that the typical TMDL will seek nonpoint source load reductions

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38 There are roughly 2200 8-digit watersheds (USGS hydrologic unit codes) in the U.S., 3000 counties, and XXX 11-digit watersheds.

39 USDA staff, personal communication, June 22, 2001.

from an area as large as the entire county or counties surrounding the impaired water seems likely to generate something close to a worst case.

Ideally we might like to delineate the watershed boundaries for each impaired water body and determine what volume of relevant nonpoint source activity occurs within each exact watershed. This was not possible – both because nonpoint source data is not available at the watershed or sub-county level, and also because the watershed boundaries corresponding to 303(d) water bodies have not yet been identified at a sufficiently fine level of detail.[40]

We have generated some limited information on the relationship in practice between the size of the geographic area from which actual TMDLs have required nonpoint source load reductions and the size of the county or counties surrounding a water body. Among the sample of 15 TMDLs we reviewed for "ground-truthing" purposes (see Appendix A), 13 required load reductions from nonpoint sources. In 7 of the 13 cases, the acreage needing controls is less than 10% as large as the acreage of the county or counties in which the water bodies are located. In 2 more cases, the acreage needing control is 10 - 50% as large as the acreage of the surrounding counties. In 2 cases, the acreage needing control is greater than the size of the surrounding counties, but both of these "TMDLs" is actually a single submission covering multiple impaired waters. Across our "ground-truthing" sample, the median acreage needing control is somewhat less than 10% as large as the acreage of the county(s) surrounding the water body.[41]

In Appendix A, we rank order the 13 TMDLs that require nonpoint source load reductions according to the size of the watershed area from which nonpoint source load reductions are required. The 25th percentile of this distribution is 3.2 % of the surrounding county (i.e., 25 % of this sample of TMDLs require nonpoint source controls for a watershed area with a number of acres less than 3.2% of the number of acres in the surrounding county). The 75th percentile of this distribution is 32.8 % of the number of acres in the surrounding county (i.e., 75 % of this sample of TMDLs require nonpoint source controls for a geographic area smaller than 32.8 % of the surrounding county). We use these 25th and 75th percentile figures to establish a rough range in estimating the size of the area for which a typical TMDL will require nonpoint source controls.[42] In simulating the costs of the Scenario 2 (Moderately Cost-

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40 It is currently possible to locate the boundaries of the 8-digit watershed within which each impaired water is located, but for most impaired waters this will include very large amounts of land that drain into waters downstream of the impaired water itself, and which thus will not be implicated in the TMDL for the impaired water. At present, it is not possible to locate the 11-digit watershed within which each impaired water is located. This level of detail will be necessary before watershed areas corresponding closely to impaired waters can be identified on a nationwide basis using a GIS.

41 As noted previously, we are expanding this sample of completed TMDLs that we analyze, and we will reflect the results from the expanded sample in the final report.

42 We seek comment on this approach. Although a range established by the 25th and 75th percentiles would seem to encompass the typical TMDL, our sample of 15 TMDLs includes an outlier on the high end. The TMDL for the Neuse River Estuary will require nonpoint source controls from a very large watershed encompassing most of 19 counties. (This TMDL will actually address another impaired water body within the watershed, so this TMDL seeks nonpoint source controls from nearly 9.5 counties per impaired water body.) This large geographic area for this one TMDL skews the distribution such that the mean (not median) area addressed per impaired water body across our sample is nearly 86 % of a county. For this sample of TMDLs, the mean area addressed (86 % of a county) is substantially greater than the median and greater than even the 75th percentile. This sort of pattern that we see in this sample of 15 TMDLs may be typical for all TMDLs. We believe it likely that the great majority of impaired waters

effective TMDL Program), we assume that the typical TMDL will require controls for acreage equal to 5% (lower estimate) to 40 % (upper estimate) of the number of acres in the county or counties within which the impaired water body is located.

In sum, for the "Least Flexible TMDL Program" scenario (Scenario 1), we assumed that load reductions would be required for all of the relevant nonpoint source activity that occurs within the entire county or counties within which the nonpoint source-impaired water body is located. We also assumed that it makes no difference how many impaired water bodies there are in single county. One impaired water body is sufficient to trigger the need for controls for all of the relevant nonpoint source type activity in the county; but once all the nonpoint source activity in the county is controlled we assume this will be sufficient to address the nonpoint source contribution to impairment for all the impaired water bodies in the county.

For the Moderately Cost-effective TMDL Program scenario, we assumed instead (based on the results from our sample of 15 actual TMDLs) that load reductions would be required for a geographic area ranging in acreage from 5 % to 40 % of the number of acres in the surrounding county or counties. Absent any data on how the nonpoint source activity is distributed within a county, we assumed that 5 % to 40 % of the area of the county would comprise 5 % to 40 % of the relevant sort of nonpoint source activity within the county. We assumed for the Moderately Cost-effective TMDL Program scenario that this need for nonpoint source controls was cumulative with multiple impaired water bodies within a county until 100 % of the county's nonpoint source activity had been controlled.

The following exhibit provides numerical examples demonstrating how much nonpoint source activity we assumed would need control under the two scenarios. For the purpose of these examples, the nonpoint source type under consideration is silviculture.

Exhibit III-3
Examples Showing Amount of Nonpoint Source Activity Needing Further Control for Scenarios 1 and 2

# of Silviculture-Impaired Water Bodies in the County	Amount of Silviculture Needing Further Control in the County	
	Least Flexible TMDL Program (Scenario 1)	Moderately Cost-effective TMDL Program (Scenario 2)
1	100 % of silviculture in the county	5 - 40 % of silviculture in the county
2	100 % of silviculture in the county	10 - 80 % of silviculture in the county
3	100 % of silviculture in the county	15 - 100 % of silviculture in the county
4	100 % of silviculture in the county	20 - 100 % of silviculture in the county

(and the great majority of TMDLs) are for streams or lakes with small to modest watersheds. However, a few impaired waters may be major estuaries or large lakes whose eventual TMDLs will require reduction of nonpoint source loads from very large upstream watersheds. Our procedure looking at the 25th and 75th percentiles of a range ignores the impact of such rare TMDLs requiring controls for large areas. However, these rare TMDLs may, in fact, account for an important fraction of the total land area for which controls will ultimately be required across all TMDLs. Perhaps we should develop a cost estimation procedure that explicitly accounts for the impact of these outliers. We welcome suggestions.

We thus employed the following procedure to determine the volume of nonpoint source activity that will likely be required to implement further controls under the three TMDL program scenarios that we analyze:

- The Research Triangle Institute (RTI) identified all 303(d) waters that States had cited (in either their 303(d) or 305(b) submissions) as impaired by any of the nonpoint source types that we cover in this analysis;

- RTI provided us with further information on each of these nonpoint source-impaired water bodies, including the county or counties in which it is located, its size, and its type (e.g., lake, river, estuary, coastal shoreline); and

- Environomics and Tetra Tech extracted information from various national data bases on the volume of nonpoint source activities in each of the counties with nonpoint source-impaired waters.

County-level nonpoint source information was extracted from the most current national data bases relevant to each nonpoint source type. The information that was obtained included data on the volume of the nonpoint source activity occurring in each impairment county and further data on characteristics of that activity in each county that affect the potential costs of management measures for the nonpoint sources. We used the following data bases:

- For agricultural land (crop, pasture and range), the 1997 National Resources Inventory (NRI) [43] as it existed prior to some corrections released in early 2001. Data obtained from NRI included the acreage of crop, pasture and range land in each county, the average slope of such land, and the acreage of crop land eroding at greater than 15 tons/acre/year.

- For AFOs, the 1997 Census of Agriculture.[44] From the Census of Agriculture, we obtained information by county on the number of farms with confined beef, dairy cows, swine, broilers and layers, and on the size distribution of these farms.

- For silviculture, the Timber Product Output Data File.[45] This provides information on the amount of timber harvested and on characteristics of the land from which it was harvested (e.g., slope). Regional timber yield estimates were applied to convert the harvest data to county-by-county estimates of the timber acreage harvested and the acreage undergoing artificial regeneration.

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43 USDA. December 1999 (unrevised version). *1997 National Resources Inventory*. Natural Resources Conservation Service. http://www.nhg.nrcs.usda.gov/NRI/1997.

44 USDA. 1997. *1997 Census of Agriculture*. National Agricultural Statistics Service. http://www.nass.usda.gov/census.

45 USDA Forest Service. Timber Product Output Datafile. Timber Product Output (TPO) Database Retrieval System. http://srsfia.usfs.msstate.edu/rpa/tpo/. The TPO provides timber harvest data that is updated at different times for different States. At any point in time, the data in TPO derive from different years for different States.

- For on-site wastewater systems, the 1992 Census of Housing (USDOC cite...). This provides information on the number of dwelling units served by on-site wastewater systems.

As noted, for most nonpoint source BMPs, we assumed under Scenarios 1 and 2 that differing fractions of the nonpoint source activity in a county would be required to reduce their loads and implement the next treatment step. However, for those BMPs that are intended to be applied specifically in riparian zones -- for example streamside buffer strips to arrest runoff and trap sediment, or fencing to keep grazing animals out of streams -- we assumed they would be applied in a band alongside impaired waters rather than throughout some percentage of the surrounding county. For these riparian BMPs, we did not vary the amount of the BMP needed with the scenario (i.e., we assumed the same amount of riparian BMPs would be necessary under the Moderately Cost-effective TMDL Program scenario as for the Least Flexible TMDL Program scenario. The riparian BMPs include:

- For crop land: a riparian forest buffer comprising a 75-foot wide corridor on each side of every crop-impaired water body.
- For pasture land: a similar 50-foot wide riparian forest buffer on each side of every pasture-impaired water body.[46]
- For range land: fencing along the entire bank length of every range-impaired water body or, alternatively, conservation practices encompassing "stream protection" and/or "streambank stabilization" applied to a riparian zone of 100 feet on each bank of every range-impaired water body.
- For AFOs: a riparian forest buffer similar to that for crop land, on each side of every AFO-impaired water body.
- For on-site wastewater systems: a zone extending for 100 yards from the shoreline of every septic system-impaired water body within which all malfunctioning septic systems must be rehabilitated.

For all of these riparian BMPs, the key data elements we used in estimating the volume of nonpoint source activities that will need to implement the BMP include: the length of the impaired water body and the width of the riparian zone within which the BMP is to be applied.

D. BMPS FOR REDUCING NONPOINT SOURCE LOADS

We assume that the nonpoint sources addressed under either the Least Flexible TMDL Program Scenario or the Moderately Cost-effective TMDL Program will be required to achieve load reductions that can be accomplished by implementing a set of basic BMPs specific to each source type. For each nonpoint source type, we chose a set of basic BMPs that would constitute the "next treatment step" for cost-estimating purposes for that nonpoint source type. We did this in two steps. First, we chose a set of broad practice groups that we assumed the nonpoint source type would need to implement. For crop land, for example, we assumed that farms contributing to water quality impairments would implement five groups of practices:

1. Conservation tillage;

46 USDA recommends a wider buffer strip when adjoining crop land than when adjoining pasture land.

2. Nutrient management;
3. Practices to reduce sediment transport within or at the edge of the field;
4. Practices to protect and restore riparian areas; and
5. Management of highly erosive crop land.

For each chosen practice group, we then selected a single BMP that we would use to represent what the costs of implementing the practice group might be. Each practice group includes a range of possible BMPs (e.g., in-field or edge-of-field measures to reduce sediment transport can include many different contouring, buffer and runoff management measures). For costing purposes, though, we chose a single, relatively expensive BMP to represent what it might cost to implement whatever specific BMP among the practice group is appropriate in each individual circumstance. To represent costs for riparian practice groups, for example, we chose riparian forest buffers, a BMP which is generally more expensive than other sorts of buffer, filter strip or stream protection measures. To represent costs for managing highly erosive crop land, we chose retirement with establishment of permanent vegetative cover, a BMP that again is generally more costly than alternatives such as conservation strip cropping, contouring, etc..

We believe our selected BMPs yield a conservative cost estimate in two respects:

- We have chosen to simulate the implementation of each of a broad set of several practice groups, even though many impairment situations may not require all of the practice groups. In most circumstances, the entire package of practices that we assume and then estimate costs for will be more than enough to achieve the desired load reduction from the nonpoint source.

- For costing purposes, we represent each practice group with a relatively expensive specific BMP.

Note that we have selected these practice groups and specific BMPs only for the purpose of estimating costs. We do not mean to imply that our particular selected measures should or must always be implemented by nonpoint sources in order to mitigate water quality problems. The selection of appropriate BMPs in practice must be highly site-specific. One or more of our particular selected BMPs may be poor choices in many circumstances. Riparian forest buffers, for example, are not cost-effective for areas where trees are very difficult to plant and grow.

In sum, the set of practice groups we chose are intended to represent the initial, broadly applicable measures that each nonpoint source type can be expected to implement to minimize impacts on water quality. Relatively more expensive BMPs were selected to represent the costs of each practice group. Our selected practice groups and BMPs are broadly consistent with guidance published by EPA (national nonpoint source management measures developed pursuant to CZARA and subsequently updated) and USDA (National Handbook of Conservation Practices). The BMPs chosen for agriculture and AFOs derive largely from discussions with EPA and USDA experts.[47] USDA does not, however, in any way endorse the specific selection of BMPs, or, more broadly, the assumptions or findings of this report. In fact, USDA staff have suggested many changes or improvements in this analysis that we have not yet accomplished.

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47 Personal communications with: Clay Ogg (EPA, 9/00, 10/00), Matt Moore (ARS, 10/00), Seth Dabney (ARS, 10/00), Jim Fouss (ARS, 10/00), Glen Weesies (NRCS, 11/00), and Wayne Skaggs (North Carolina State University, 11/00). Also, comments from numerous USDA staff during USDA's review of the draft TMDL cost studies in June and July, 2001.

The basic sets of BMPs that we chose for each nonpoint source type are as follows:

Exhibit III-4
Basic BMPs Assumed for Each Nonpoint Source Type

Nonpoint Source Type	Practice Group and BMP	Purpose
Crop land	1. Conservation tillage 2. Nutrient management planning 3. In-field, edge-of-field measures: vegetative barrier 4. Riparian measures: riparian forest buffers 5. Management of erosive land: retirement and cover	1. Reduce sheet and rill erosion and sediment transport from tilled land 2. Avoid over-application of nutrients 3. Prevent concentrated (gully) erosion in upland fields 4. Remove sediment and nutrients from runoff before reaching water bodies 5. Avoid disturbing highly erosive land
Pasture land	1. Riparian measures: riparian forest buffers 2. Upland measures: rotational stocking	1. Remove sediment and nutrients from runoff before reaching water bodies 2. Rotate stock sequentially through fenced pastures to prevent overgrazing and erosion of any one area
Range land	Riparian measures: 1. Use exclusion or 1A. Stream protection/bank stabilization	 1. Fence stock away from watersides to avoid damage to stream banks and bottoms, avoid manure in water 1A. Repair and prevent further damage by animals to riparian zone
AFOs	1. On-farm manure collection and management (facilities and equipment to collect, store, manage and use manure on nearby land, control runoff, and compost dead animals) 2. Manure transport from nutrient-surplus to nutrient-deficient areas 3. Nutrient management planning (plans, soil and manure testing, training, record-keeping)	1. Prevent nutrients, pathogens and BOD from reaching waters through runoff, spills from lagoons, and groundwater 2. Avoid over- application of manure nutrients relative to local crop needs, with resulting buildup of N and P and release to local waters 3. Avoid over-application of nutrients (both chemical fertilizers and manure)
Silviculture	Various BMPs addressing: 1) Preharvest planning; 2) Streamside management areas; 3) Road construction/reconstruction; 4) Road management; 5) Timber harvesting; 6) Site preparation and forest regeneration; 7) Fire management; 8) Revegetation of disturbed areas; 9) Chemical management; 10) Wetlands forest management	Minimize erosion, siltation, and bank destabilization. Avoid loss of vegetative cover and increase in water temperature. Avoid slash and other material in streams. Avoid runoff of forest management chemicals
On-site wastewater systems	Rehabilitate all failing septic systems within a wide riparian zone	Prevent nutrients, pathogens and BOD from reaching water bodies through runoff and infiltration

These BMPs are assumed to be applied to:

- For the Least Flexible TMDL Program scenario, the entire volume of the nonpoint source activity that occurs in the county or counties within which the nonpoint source-impaired water body is located; or

- For the Moderately Cost-effective TMDL Program scenario, per impaired water body in the county, 5 - 40 % of the volume of the nonpoint source activity that occurs in the county; and

- (For riparian BMPs) the entire riparian zone surrounding the nonpoint source-impaired water body.

E. UNIT COSTS FOR THESE BMPS

Many sources of unit cost information are used in estimating the cost of implementing these nonpoint source BMPs as a function of the volume and characteristics of the nonpoint sources. The costing relationships and the underlying sources are described fully in Appendix I. The more important cost references we used include:

- *For all nonpoint source categories.* EPA's recent " "Draft Nonpoint Source Gap Analysis".[48]

- *For agriculture (crop, pasture and range land).* Numerous studies supported by EPA and USDA on costs or savings from various BMPs. Information summarized in EPA's recent Draft National Management Measures to Control Nonpoint Source Pollution from Agriculture (cite..). Information provided by USDA staff in the course of the USDA review during June and July, 2001, of EPA's draft TMDL cost studies.[49]

- *For AFOs*. Costing studies supporting EPA's promulgation of recommended management measures for AFOs in the "Management Measures Guidance for Coastal Zone Nonpoint Source Pollution" required by the Coastal Zone Management Act Reauthorization Amendments of 1990.[50] Also, to a much lesser degree, some information has been used from preliminary costing studies supporting EPA's proposed new effluent guidelines for feedlots.[51] Note here that EPA's cost studies supporting the effluent guidelines are much

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48 Tetra Tech, Inc. *Draft Nonpoint Source Gap Analysis*. Drafts of July, 2000; February 7, 2001. Some of the unit cost information used in developing the cost estimates in this report will be updated and revised for the final report to bring it into better conformity with unit cost information cited in the most recent draft of the Nonpoint Source Gap Analysis.

49 USDA. "Comments on EPA documents 'Cost of Restoring the Nation's Impaired Waters' dated June 13, 2001 and 'Total National Costs for Pollutant Sources to Implement TMDLs' dated June 13, 2001". June 22, 2001

50 DPRA, Incorporated. *Economic Impact Analysis of National Nonpoint Source Management Measures Affecting Confined Animal Facilities*. May 17, 1995.

51 U.S. EPA, Office of Water, Office of Science and Technology. *Final Cost Methodology Report for Beef and Dairy AFOs. Final Cost Methodology Report for Swine and Poultry Sectors*. January, 2001.

newer and more comprehensive than EPA's CZARA costing effort, and they differ from the CZARA cost estimates in some important respects. However, EPA's feedlot effluent guideline cost studies are currently being revised, and we did not believe that we could effectively use them while they were still in flux. As a result, our AFO cost estimates in this report rely on unit cost information that we know in some instances is outdated and has been supreseded. The AFO cost estimates in this report are inconsistent in important ways with EPA's AFO cost estimates published thus far in support of the feedlots effluent guidelines. We intend to conform our estimates to the effluent guideline cost information before this report is finalized. Finally, important information relevant to needs for transporting manure from AFOs was obtained from a series of USDA studies by Lander, et al.[52]

- *For silviculture.* Costing studies supporting EPA's promulgation of the management measures for silviculture under CZARA.[53]

- *For on-site wastewater systems*. Information drawn from the National Census of Housing[54] on the proportion of septic systems found to be failing was combined with information from EPA's "nonpoint source gap analysis" on the costs of rehabilitating a failed septic system.

These references provided both information on the unit costs of implementing the chosen BMPs for these nonpoint source categories and information on the extent to which these BMPs have already been implemented.

In some cases, BMPs anticipated to be adopted by nonpoint sources in order to meet load reduction targets may yield savings that partly or perhaps even completely offset the costs of the BMPs. BMPs that likely involve such cost savings include:

- *Nutrient management planning for crop farmers and AFOs*. Nutrient management planning includes as a major objective balancing the amount of nutrients applied to crops to crop needs. Most farmers overapply nutrients relative to crop needs; better planning can save the cost of the no longer applied excess nutrients. Many studies have found that the costs of developing nutrient management plans (including costs for soil and manure testing, training, and record-keeping) are outweighed by the cost savings that result as less chemical fertilizer is purchased and applied. Few studies, though, provide a comprehensive before/after comparison that also considers effects on crop yield and overall farm profitability.

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52 Lander et al. *Manure Nutrients Relative to the Capacity of Cropland and Pastureland to Assimilate Nutrients: Spatial and Temporal Trends for the United States.* USDA. Publication No. ps00-0579. 2000. Also, Lander et al. *Nutrients Available from Livestock Manure Relative to Crop Growth Requirements.* USDA. Resource Assessment and Strategic Planning Working Paper 98-1.1998.

53 Research Triangle Institute. *Economic Analysis of Coastal Nonpoint Source Pollution Controls: Forestry.* 1992.

54 U.S. Census Bureau. *American Housing Survey for the United States.* 1997. Www.census.gov/prod/99pubs/h150-97.pdf

- *Conservation tillage*. Conservation tillage is widely agreed to reduce costs for labor, fuel and equipment maintenance as less tillage is performed. On the other hand, conservation tillage involves purchase of new equipment and likely increased costs for herbicides and seed. It is also perceived as being more risky. Effects on yields are variable.[55]

- *Transporting manure from a nutrient-surplus area to a nutrient-deficient area.*. Manure increases in value when it is shipped from a location where manure nutrients are in excess to a location where the manure's full nutrient content is needed. The increase in value is likely not sufficient to pay for the shipping cost (otherwise one would expect that market forces would have already prompted the shipping to occur). Nevertheless, there will likely be some increase in value that will partly offset the shipping cost.

- *Repairing a malfunctioning septic system.* In many cases, repairing a poorly functioning septic system forestalls more expensive responses that will be needed if the system is allowed to deteriorate to the point where it fails completely.

It is very difficult to project what these sorts of savings might amount to if these BMPs were applied on a widespread basis, as we simulate in this analysis. There are both conceptual and empirical difficulties:

- In theory, farmers, livestock operators and homeowners as economically rational actors would adopt these BMPs in the circumstances in which the BMPs would pay for themselves. These individuals do not need a TMDL to induce them to act in their self-interest. We might reasonably assume that, in all instances where these BMPs have not yet been adopted, the cost savings would not be large enough to offset the costs.

- On the other hand, lack of information and adherence to traditional ways are significant barriers to adoption of newer BMPs, even in instances where they would appear to be profitable.

- On the other hand again, farmers and others are risk averse. Overapplication of nutrients, for example, may cost a little more than is necessary but it also provides a relatively inexpensive sort of insurance against disasters that could occur as a result of weather, pests, or miscalculations.

- Analytically, the cost savings from adoption of these BMPs tend to have been studied in the circumstances for which the BMPs are best suited. It is questionable whether the savings found in instances where the BMPs have been adopted can be extrapolated to other settings where the BMPs have not yet been adopted. One might expect the circumstances

55 USDA concludes in one analysis: "Generally speaking, no-till systems offer a slight to fairly significant reduction in input costs. If proper management of conservation tillage is used, yields will most likely be maintained and costs will decrease. An overall improvement in the efficiency of a farm operation will result and thus enhance profitability. In areas where moisture retention is improved and soil productivity rises, yield increases can be expected together with improved profits." USDA, Natural Resource Conservation Service. *CORE4 Conservation Practices, the Common Sense Approach to Natural Resource Conservation*. 1999.

in which the BMPs have been adopted to differ systematically from the circumstances where they have not yet been adopted, and extrapolation may be inappropriate.[56]

In view of these very large uncertainties in estimating the national savings that might result from widespread implementation of TMDL-prompted BMPs, we decided to treat the potential savings from the BMPs in a different manner from the costs. We explicitly estimate the costs of the BMPs and display them as our estimate of TMDL implementation costs. We also develop some very rough quantified estimates of the potential cost savings from the BMPs, but, -- in an effort both to be conservative and to recognize the much greater uncertainty of the savings estimates -- we choose not to display these savings estimates and not to net them out in the tables summarizing TMDL implementation costs. Note that this decision not to display the savings estimates does not mean that we believe the potential savings to be unimportant or nonexistent. To the contrary, we believe that in many circumstances these BMPs will engender substantial savings that offset some portion of the BMP costs. We are unable, however, to estimate these savings with much confidence. For the final version of this analysis, we intend to gather additional data that will allow us to narrow the range of uncertainty in our national savings estimates.

Unit costs and cost savings drawn from these references were applied to the volume of nonpoint source activity assumed to need further controls as estimated in the previous step. To the extent that some portion of the nonpoint sources have already implemented some of the BMPs, the implementation cost and savings estimates were reduced to reflect the practices that are already in place.

F. SUMMARY COST ESTIMATES FOR NONPOINT SOURCES

For each type of nonpoint source activity, we sum the costs across impaired water bodies and scale appropriately to reflect missing data and obtain a nationwide estimate.

We have previously discussed the three scaling steps involved in developing a national implementation cost estimate for nonpoint sources:

- Scaling to reflect the portion of the national total of each nonpoint source activity that occurs in States that report on impairment of their waters by the particular nonpoint source activity. (Different scaling factor for each nonpoint source type.)

- Scaling to reflect the likelihood that the nonpoint source types we analyze will eventually be found responsible for a share of the waters reported by States as impaired by "unknown sources" or by "nonpoint sources (no further information)". (Scaling factor of 1.13.)

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56 For example, in the "CORE4" study cited above, USDA estimates for a sample farm that adopting a no-till system plus nutrient management reduces net costs for corn and wheat but increases costs for soybeans. Considering positive yield changes for all three crops, the total impact of adopting no-till and nutrient management appears to be positive for all three crops.

Should we use this information as a basis for estimating the cost savings that might occur if no-till and nutrient management were adopted more generally as a result of TMDLs? We think not. Recent figures indicate that conservation tillage is used for 33% of all wheat (small grains) acreage, 54% of soybean acreage, and 40% of corn acreage. There must be reasons why farmers have not adopted conservation tillage for most of these three crops' acreage, and we are wary of projecting that acreage that doesn't use this measure will benefit from it to the same degree as the acreage that already does use it. Furthermore, what should we surmise about the likely impact of conservation tillage on other crops, particularly ones where it is currently used much less than for these three crops (e.g., cotton, for which conservation tillage is used on only 12% of the acreage)?

- Scaling to reflect the assumed pace of TMDL development for the 1998 303(d)-listed waters and the assumed 5-year lag between TMDL development and when affected sources begin to incur implementation costs. (Scaling factor of .4484.)

The estimated national nonpoint source implementation costs are as follows:

Exhibit III-5a
Implementation Costs for Nonpoint Sources -- Crop Land ($ in millions/yr)

Number of States analyzed	23	
Number of counties in these States with crop-impaired waters	710	
Fraction of crop acreage in these States that is in impairment counties	.53	
Scale factor from these States to the nation	1.56	
National total annualized implementation costs (millions of 2000 dollars/yr):	**Scenario 1 Least Flexible TMDL**	**Scenario 2 Reas. TMDL**
Conservation tillage		19 - 644
Nutrient management planning	85 - 785	70 - 641
Riparian forest buffers	317 - 781	41 - 104
Vegetative barriers	41 - 104	12 - 88
Retirement of highly erosive crop land	49 - 108	42 - 154
	154 - 177	
Total costs		183 - 1632
	645 - 1956	
National total potential savings from implementing these BMPs (millions of 2000 dollars/yr):	**Scenario 1 Least Flexible TMDL**	**Scenario 2 Reas. TMDL**
Conservation tillage		0 - 340
Nutrient management planning	0 - 414	0 - 660
	0 - 804	
Total potential savings		0 - 999
	0 - 1218	

Exhibit III-5b
Implementation Costs for Nonpoint Sources –Pasture Land ($ in millions/yr)

Number of States analyzed	25	
# of counties with pasture and/or rangeland-impaired waters in these States	511	
Fraction of pasture acreage in these States that is in impairment counties	.363	
Scale factor from these States to the nation	1.69	
National total annualized implementation costs (millions of 2000 dollars/yr):	**Scenario 1 Least Flexible TMDL**	**Scenario 2 Reas. TMDL**
Riparian forest buffers	5.0 - 10.7	5.0 - 10.7
Rotational stocking	0	0
Total costs	5.0 - 10.7	5.0 - 10.7

Exhibit III-5c
Implementation Costs for Nonpoint Sources –Range Land ($ in millions/yr)

Number of States analyzed	25	
# of counties with pasture and/or rangeland-impaired waters in these States	511	
Fraction of rangeland acreage in these States that is in impairment counties	.459	
Scale factor from these States to the nation	1.43	
National total annualized implementation costs (millions of 2000 dollars/yr):	**Scenario 1 Least Flexible TMDL**	**Scenario 2 Reas. TMDL**
Riparian fencing only; OR	5.1 - 16.4	5.1 - 16.4
Stream protection/bank stabilization	2.3 - 5.1	2.3 - 5.1
Total costs	2.3 - 16.4	2.3 - 16.4

Exhibit III-5d
Implementation Costs for Nonpoint Sources -- AFOs ($ in millions/yr)

Number of States analyzed	32	
Number of counties with AFO-impaired waters in these States	451	
Fraction of animal units in these States that is in impairment counties	.31	
Scale factor from these States to the nation	1.55	
National total annualized implementation costs (millions of 2000 dollars/yr):	**Scenario 1 Least Flexible TMDL**	**Scenario 2 Reas. TMDL**
Riparian forest buffers	4.0 - 10.2	4.0 - 10.2
Facilities upgrades	28.3	4.3 - 19.9
Additional manure hauling	41.0 - 68.2	3.8 - 41.2
Nutrient management planning	3.0	0.4 - 2.1
Total costs	76.4 - 109.8	12.5 - 73.4
National total potential savings from implementing these BMPs (millions of 2000 dollars/yr):	**Scenario 1 Least Flexible TMDL**	**Scenario 2 Reas. TMDL**
Value of additional collected manure	0 - 17.3	0 - 11.3
Increased valued from additional manure hauling	7.5 - 18.2	0.2 - 11.9
Nutrient management planning	0 - 31.2	0 - 19.6
Total potential savings	7.5 - 66.7	0.2 - 42.7

Exhibit III-4e
Implementation Costs for Nonpoint Sources -- Silviculture ($ in millions/yr)

Number of States covered	30	
Number of counties with silviculture-impaired waters in these States	294	
Fraction of timber harvest in these States that is in impairment counties	.2106	
Scale factor from these States to the nation	1.499	
National total annualized BMP costs (millions of 2000 dollars/yr)	**Scenario 1 Least Flexible TMDL**	**Scenario 2 Reas. TMDL**
	29.7 - 41.7	7.2 - 30.6

Exhibit III-5f
Implementation Costs for Nonpoint Sources – On-Site Wastewater Treatment Systems ($ in millions/yr)

Number of States covered	24	
Number of counties with OWTS-impaired 303(d) waters in these States	318	
Fraction of OWTS-served dwelling units in these States that is in riparian zones and will be addressed by TMDLs	0.013	
Scale factor from these States to the nation	1.732	
National total annualized implementation costs (millions of 2000 dollars/yr)	**Scenario 1 Least Flexible TMDL** 24.1 - 27.7	**Scenario 2 Reas. TMDL** 24.1 - 27.7

Total nonpoint source costs are estimated as follows:

Exhibit III-6
Total Implementation Costs for Nonpoint Sources

Type	Scenario 1 Least Flexible TMDL Program	Scenario 2 Moderately Cost-effective TMDL Program
Agricultural land crop land pasture land range land *Potential savings*	 645 - 1,159 5 - 11 2 - 16 *(not estimated)*	 183 - 1,632 5 - 11 2 - 16 *(not estimated)*
AFOs *Potential savings*	76 - 110 *(not estimated)*	13 - 73 *(not estimated)*
Silviculture	30 - 42	7 - 31
On-site wastewater treatment systems	24 - 28	24 - 28
Total ***Potential Savings***	**783 - 2,162** ***(not estimated)***	**234 - 1,791** ***(not estimated)***
ADDITIONAL COSTS TO NONPOINT SOURCES UNDER SCENARIO 3 (MORE COST-EFFECTIVE TMDL PROGRAM)	**47 - 78**	

In the final row of this exhibit showing total nonpoint source costs, we show the estimated costs for additional nonpoint source control measures under our simulated "More Cost-Effective TMDL Program" Scenario. These are the costs for nonpoint sources to provide increased load reductions to offset the additional loads to be discharged by point sources under this scenario (see section II - I). We have not estimated which specific nonpoint source types will incur these costs for additional nonpoint source controls.

IV. MAJOR ASSUMPTIONS, BIASES, AND UNCERTAINTIES

Any estimate of the nationwide costs to pollutant sources of meeting water quality standards through the TMDL program or other means will necessarily be imprecise. The analysis must cover nearly 22,000 impaired waters, at least 60,000 point sources, and millions of acres of diverse nonpoint source activities. Accurate estimation of the amounts by which loads from these sources to these waters exceed desired levels, and identification of the specific sources that are responsible and the load reductions that they will need to achieve must await development of the actual TMDLs for these waters. Projecting these elements in the absence of TMDLs, years in advance and on a nationwide basis, is a difficult task. In developing our estimates of the implementation costs likely to arise in meeting water quality standards, we have made many simplifying analytical assumptions. In this section of the report, we note these assumptions and discuss the potential biases and uncertainties that likely result from them. We first discuss each major assumption in some detail, and we then provide a exhibit summarizing the implications of all the major assumptions.

A. HOW THE "LEAST FLEXIBLE TMDL PROGRAM" SCENARIO IS DEFINED

Assumption

For point sources, we assume that a reasonable least flexible case is that States will continue writing WQBELs as required by the Clean Water Act. We assume that each point source that contributes to impairment will have a WQBEL written that will require the source to implement an appropriate "next treatment step". (An even-worse case might be envisioned, in which nonpoint sources are left out of the TMDL and States attempt to make up for not including nonpoint sources by developing ever-tighter limits for point sources. We consider this option unrealistic.)

For nonpoint sources, we assume that States will either induce or require all nonpoint sources that contribute to impairment similarly to implement an appropriate "next treatment step". We assume, based on how many nonpoint source programs are currently managed, that a least flexible case would be that these further nonpoint source controls will be sought for all of the relevant nonpoint sources within the county or counties in which the nonpoint source-impaired water body is located.

Impact of Assumption

For both point and nonpoint sources, these assumptions will usually cause the "Least Flexible TMDL Program" to overshoot the load reduction that would actually be required to meet water quality standards. One might question whether States would be so short-sighted as to require controls of individual point and nonpoint sources that in the aggregate far overshoot the overall load reduction needed. Despite the high cost of this approach, though, we find it plausible that this could occur in some TMDLs. Water quality-based permitting often does proceed for each point source discharger in isolation, without considering the aggregate load reduction that is being obtained from all dischargers. Nonpoint source management programs, particularly when they confer some benefit on participating nonpoint sources (e.g., agricultural cost-share programs) sometimes find it difficult to direct resources at one part of a county and exclude the remainder of the county from participation.

B. HOW MUCH LOAD REDUCTION FROM POINT SOURCES WILL THE "MODERATELY COST-EFFECTIVE TMDL PROGRAM" SEEK?

Assumption

Based on the results from a sample of 15 completed TMDLs, we assume that about half of the TMDLs in practice will require an aggregate load reduction from point sources approximately equal to that which would be obtained if all point sources that contribute to impairment were to implement an appropriate "next treatment step". The remaining half of the TMDLs will require an aggregate load reduction from point sources that is about half of that which would be obtained if all point sources that contribute to impairment were to implement the "next treatment step".

Impact of Assumption

This specific assumption results in point source costs for the "Moderately Cost-effective TMDL Program" scenario being only about 3/4 of the costs that would prevail if all point sources that contribute to impairment were to implement the "next treatment step". Basing such an important assumption on a relatively small sample of only 15 TMDLs is unfortunate. We will expand the sample and revise this assumption accordingly for the final report.

C. HOW MUCH LOAD REDUCTION FROM NONPOINT SOURCES WILL THE "MODERATELY COST-EFFECTIVE TMDL PROGRAM" SEEK?

Assumption

First, we assume that TMDLs are legally required for waters impaired by nonpoint sources only. Second, based on the results (25^{th} and 75^{th} percentile figures) from a sample of 15 completed TMDLs, we assume that a typical TMDL for a single impaired water will require load reductions from a watershed acreage amounting to an area ranging in size from about 5 % to 40 % of the surrounding county. Third, we assume that the percentage load reduction that a typical moderately cost-effective TMDL will require of nonpoint sources within this geographic area is roughly similar to the percentage load reduction that would be achieved by our chosen "next treatment steps" for nonpoint sources.

Impact of Assumption

The latter two assumptions make nonpoint source costs under the "Moderately Cost-effective TMDL Program" scenario much lower than under the "Least Flexible TMDL Program" scenario. This seems sensible – typically the watershed for a 303(d) water is much smaller than a county. However, a few TMDLs will address water bodies (particularly estuaries) that will require nonpoint source load reductions throughout a very large upstream watershed. These few instances where very large areas need further controls may make the average size of the geographic area needing controls larger than even the 75^{th} percentile figure. We seek suggestions from reviewers about how to deal with this issue.

Again, the sample of 15 completed TMDLs is undesirably small.

We have very little data on the load reduction effectiveness of the BMPs we have selected as the "next treatment step" for the various nonpoint source types. We believe that the BMPs we selected may generally abate a greater proportion of nonpoint source loads than is typically required in actual TMDLs, particularly because for several nonpoint source types we include several BMPs simultaneously as constituting the next treatment step. If so, somewhat less than 5 - 40 % of all the nonpoint sources in the county would need to implement our "next treatment step" in order to obtain the desired aggregate load reduction. If so, this assumption leads us to overestimate nonpoint source costs.

D. WHAT COST SAVINGS OPPORTUNITIES ARE AVAILABLE UNDER THE "MORE COST-EFFECTIVE TMDL PROGRAM?

Assumption

We simulate only one sort of more cost-effective WLA opportunity – instances where some point source control responsibilities may be shifted to nonpoint sources. We do not simulate any of several other potential cost-saving approaches, including point/point tradeoffs and nonpoint/nonpoint tradeoffs. For the point/nonpoint allocations that we do simulate, we adopt a rather restrictive set of rules as to when such allocations or trading is possible (e.g., for nutrients or BOD only, for nonflowing waters preferentially). We assume (based on nine case examples of point/nonpoint trading) that nonpoint sources can abate nutrients and BOD at roughly 1/4 the cost per pound as can point sources.

Impact of Assumption

The potential cost savings associated with More Cost-Effective TMDLs are sharply underestimated because we have not been able to simulate many of the available mechanisms. On the other hand, the administrative costs of investigating, implementing and overseeing more cost-effective WLAs or trades have not been estimated, and they could consume some of the projected savings and/or deter these allocations from being implemented.

E. UNDER WHICH OF THE THREE SCENARIOS WILL THE IMPAIRED WATERS BE RESTORED SOONEST?

Assumption

We do not address this issue. We assume that the timing of compliance spending by pollutant sources will be identical across the three scenarios.

Impact of Assumption

We have made this assumption so that the estimated cost differences between the scenarios result only from differences between them in how much load reduction they will require and how efficiently they will achieve this load reduction. We do not want to complicate this comparison by introducing differences in the timing when load reduction efforts will be made.

F. THE DISTANCE UPSTREAM OF AN IMPAIRED WATER WITHIN WHICH POINT SOURCES CONTRIBUTE TO IMPAIRMENT

Assumption

We simulate two cases. In the "within only" case, only point sources discharging the impairment pollutant directly into the impaired water are assumed to contribute to impairment. In the "within and upstream" case, the point sources contributing to impairment are those that discharge the impairment pollutant: 1) Within 25 miles upstream of impairments for BOD, ammonia or toxic organics; and 2) Within 50 miles upstream of impairments for nutrients or metals.

Impact of assumption

The "within and upstream" case likely "pulls in" too many point sources. Most impaired stream segments are relatively short (more than 80 % are less than 20 miles). Unless the stream segments immediately upstream and immediately downstream of these short impaired segments are impaired also, we can conclude that most impairments are localized – they begin and end within a short distance. This suggests that the source of impairment is also local. If pollution from a more distant source (up to 25 or 50 miles away) were the cause of impairment, the impaired stretch of river would tend to be much longer.

On the other hand, the "within only" case likely pulls in too few point sources. Several of the "ground-truthing" TMDLs that we reviewed address point sources located upstream of the impaired segment itself. Several address all the point sources in the watershed upstream of the impairment.

The two cases likely bracket the true average.

G. DETERMINING WHETHER OR NOT A POINT SOURCE IS LIKELY TO DISCHARGE THE IMPAIRMENT POLLUTANT IN A QUANTITY WARRANTING FURTHER CONTROLS BEYOND TECHNOLOGY-BASED STANDARDS

Assumption

We test several different decision rules that involve the SIC code in which the point source is classified and what we know about the typical nature of discharges from facilities in that SIC. A first alternative assumption is that if at least 15 % of the facilities in an SIC monitor for a pollutant, then all facilities in the SIC discharge the pollutant in quantities warranting further treatment. An alternative set of assumptions involves SIC-by-SIC engineering judgments as to whether or not a facility that meets applicable technology-based standards is likely to discharge a sufficient remaining quantity of the pollutant to warrant serious consideration for further control.

Impact of assumption

Sensitivity analysis suggests that alternative assumptions have relatively little impact (+ or - 15 % or so) on estimated implementation costs.

H. POINT SOURCES THAT ARE LEFT OUT OF THE ANALYSIS

Assumption

The need for further control measures is considered for every point source discharger in PCS, as well as for all indirect industrial dischargers connected to major POTWs. Point sources that do not have individual NPDES permits are thus omitted, including, for example, CAFOs that are not yet permitted, and the many small point sources covered by general permits. Point source discharges from inactive and abandoned mines (IAMs) also are not estimated here. (Note that costs for further controls needed for urban wet weather point sources are viewed as attributable to existing technology-based standards and are counted as part of the baseline. These include costs associated with CSOs, SSOs., municipal and industrial storm water dischargers.)

Impact of assumption

Some of the omitted point source dischargers are not likely to be significant targets in TMDLs, and their omission probably results in only a small underestimate of point source compliance costs (e.g many of the small dischargers covered under general permits). Other of the omitted point source pollutant sources are effectively covered in our nonpoint source cost analysis (e.g., CAFOs). Discharges from IAMs, however, could be costly to mitigate. Currently we do not have accurate estimates of the proportion of listed waters that are impaired by IAMs. Omitting this category from the cost assessment underestimates point source implementation costs, but it is difficult to predict the exact magnitude of this underestimation without further detailed analysis.

I. WILL TMDLs FOR WATERS CITED BY STATES AS IMPAIRED BY NONPOINT SOURCES ONLY REQUIRE CONTROLS ALSO FOR POINT SOURCES?

Assumption

We assume not. If the State indicates that a water body is impaired by nonpoint sources only, we presume that the TMDL will not require controls for point sources even if, in our analysis, there appear to be point sources within a relevant distance that discharge the impairment pollutant.

Impact of the assumption

This assumption reduces our cost estimates by roughly 35 %. We believe the assumption is reasonable. We suspect that many of the point sources we identify as apparently discharging the impairment pollutant into or near a nonpoint source-impaired water body are "false positives". Presumably the State is well aware of any point sources that may be contributing to an impairment, and will note any such point sources when listing the sources of impairment. We probably often incorrectly attribute the discharge of an impairment pollutant to a point source as a result of our crude SIC-by-SIC engineering judgments.

J. SOURCE TYPES COVERED BY THE NONPOINT SOURCE ANALYSIS AND SOURCE TYPES THAT ARE LEFT OUT

Assumption

The need for further control measures is considered for four sorts of nonpoint sources: agricultural land (including crop, pasture and range), AFOs, silviculture, and on-site wastewater treatment systems. Many potentially important types of nonpoint and other sources are omitted: abandoned mines, contaminated sediments, unintended stream modification, atmospheric deposition, etc..

Impact of assumption

In omitting these categories of nonpoint sources, we underestimate total costs to nonpoint sources of meeting water quality standards. The categories of nonpoint source activities that we cover are responsible for the majority of nonpoint source impairments; the categories that we omit account for about 14 % of the 303(d) river miles and 22 % of the 303(d) lake acres. However, some of the omitted nonpoint source categories, although they are occur less frequently, can be costly to mitigate: contaminated sediments and abandoned mines, for example.

K. IDENTIFYING THE WATER BODIES THAT ARE IMPAIRED BY EACH OF THESE NONPOINT SOURCE ACTIVITIES

Assumption

We rely on the data provided by States on the sources responsible for impairment of each listed water. If a State does report some impairments due to a particular nonpoint source type, we assume that the State has reported all such impairments (except that we assume some fraction of the "source unknown" and "nonpoint source – no further information" waters will also eventually prove to be impaired by the source type of interest). We also assume that a State that does not report any impairments due to a particular nonpoint source type is, in fact, not reporting at all -- the State may really have impairments due to the nonpoint source type. We scale from the "reporting" States to the "non-reporting" States, presuming that there are impairments dues to the nonpoint source type in the "non-reporting" States also.

Impact of assumption

This likely results in a modest overestimate of the number of water bodies actually impaired by the nonpoint source type in question. Some of the States that do not report any impairments due to the nonpoint source type in fact have no such impairments.

L. WILL STATES REQUIRE FURTHER CONTROLS OF POTWs THAT ALREADY PROVIDE BETTER-THAN-SECONDARY TREATMENT?

Assumption

We assume not. POTWs that now provide better-than-secondary treatment are identified using CWNS data, and we assume that TMDLs as a matter of equity will focus requirements for load reductions on other sources that have not yet implemented control measures beyond the applicable technology-based requirements.

Impact of assumption

This assumption has a large impact. It reduces estimated costs for POTWs by approximately 63 % (Moderately Cost-effective TMDL Program scenario, "upstream and within" case), from $1.40 billion/yr to $523 million/yr. The ground-truthing information suggests that some TMDLs are requiring further controls from POTWs that already provide advanced treatment, while other TMDLs are not requiring further controls from such POTWs. This assumption represents one of the most important respects in which we may underestimate the costs of the TMDL program.

M. THE SPECIFIC FURTHER CONTROLS THAT POINT OR NONPOINT SOURCES WILL NEED TO IMPLEMENT

Assumption

We assume that each source that needs to reduce its load will do so by implementing "the next treatment step" beyond whatever technology-based requirements are currently applicable to that source. If the source has already implemented all or part of "the next treatment step", we reduce the estimated costs accordingly (e.g., no costs are estimated for POTWs that already provide better-than-secondary treatment, and nonpoint source costs are reduced to the extent that the nonpoint source already has some of the "next treatment step" BMPs in place). However, we are unable for industrial dischargers to apply this credit when treatment in place exceeds technology-based requirements because we have no means of identifying which or how many industrial dischargers have such treatment in place.

Impact of assumption

Uncertain. Some water bodies are so seriously impaired that all contributing sources will need to implement controls well beyond the next treatment step. Other water bodies are only slightly impaired, and they will need only modest further source controls, well short of the next treatment step for all sources. For the Moderately Cost-effective TMDL Program Scenario, we have attempted to match the extent of point and nonpoint sources that we assume will need to implement the next treatment step against the typical aggregate load reductions from point and nonpoint sources that have been required in a sample of actual TMDLs. Hopefully this procedure calibrates our cost estimates so that, although we may be far from accurate about costs for any particular water body, our total national estimate is reasonably accurate.

Costs for industrial dischargers are overestimated because we do not have the data that would allow us to reduce their estimated costs by recognizing the extent to which they have already implemented the next treatment step.

Many point and nonpoint pollutant sources currently have more treatment in place than is needed to meet technology-based requirements. If we were to assume that all pollutant sources need to implement the "next treatment step", even those who currently surpass technology-based requirements, we would face the difficult task of developing cost functions for many additional treatment technologies that represent "next steps" beyond the wide variety of technologies currently in place.

N. THE "NEXT TREATMENT STEP" A POINT OR NONPOINT SOURCE WILL NEED TO IMPLEMENT

Assumption

The assumed next treatment step varies with the type of point or nonpoint source and (for point sources) the pollutant needing further control. All sources are assumed to have treatment in place to meet applicable current technology-based-standards. For point sources, this means treatment measures sufficient to meet effluent guideline (BPT, BAT, PSES, etc.) and secondary treatment requirements. For nonpoint sources, no treatment is assumed to be in place to meet Federal regulatory requirements (i.e., for most nonpoint source types, there are no technology-based standards currently applicable), but we attempt to reflect the degree to which treatment is in place for other reasons. For urban wet weather sources, we assume that controls are in place or are being implemented to meet CSO, SSO and storm water requirements under current CWA programs. The following exhibit shows the treatment assumed to be in place and the assumed next treatment step for all types of sources.

Impact of assumption

These assumptions regarding treatment in place and what the next treatment step would be are undoubtedly inaccurate in many specific instances. To improve on these assumptions, though, we would need to acquire source-specific information on treatment actually in place and potential further control options for tens of thousands of point and nonpoint sources -- a formidable task. We do not believe there is any systematic bias resulting from the assumptions we have made.

Exhibit IV-1
Treatment Technology Assumptions

Type of Source	Pollutant or Activity	Treatment in Place	Next Treatment Step
Industrial point sources	Metals	Chemical precipitation	Polishing filtration
	BOD, nutrients, ammonia, or toxic organics	Biological treatment (secondary)	Advanced secondary treatment
POTW	Metals	Pretreatment program requiring metals dischargers to meet effluent guidelines (chemical precipitation)	Enhanced pretreatment program with tighter limits (polishing filtration)
	BOD, nutrients, ammonia, or toxic organics	Biological treatment (secondary)	Advanced secondary treatment, secondary treatment with nutrient removal, or both
Agricultural land (nonpoint source)	Tillage	Partial adoption of conservation tillage	Conservation tillage
	Fertilizer use	Partial adoption of nutrient management planning	Nutrient management planning
	Riparian zones	Minimal	Riparian forest buffers for crop and pasture land; use exclusion or stream protection for range land
	Concentrated runoff on sloped fields	None	Vegetative barriers
	Farming on highly erosive land	Some land already retired in Conservation Reserve	Retire and cover remaining highly erosive cropped land
AFOs (nonpoint source)	Collect manure and spread it on nearby fields	Most necessary facilities are commonly in place	Comprehensive set of manure management measures
	Manure hauling	Virtually none	Transport manure to locations where it can be spread at agronomic (P-based) rates
	Manure and fertilizer use	Partial adoption of nutrient management planning	Nutrient management planning
Silviculture (nonpoint source)	Harvesting-related activities	As prevailed in roughly 1990	Comprehensive set of measures to minimize impacts
	Artificial forest regeneration	As prevailed in roughly 1990	Comprehensive set of measures to minimize impacts
On-site wastewater treatment	Failing systems	Actual rate of failure	Repair and failing systems in riparian zone

O. ESTIMATING COSTS FOR SOURCES TO IMPLEMENT THESE CONTROL MEASURES

Assumption

For each type of source and type of control, we estimate costs using a control cost function drawn from an appropriate EPA reference. Each cost function projects costs as a function of the size (e.g., wastewater flow, number of animals at an AFO, number of acres cut for silviculture) of the source.

Impact of assumption

Unknown. Perhaps these cost models overestimate the ultimate costs for meeting LAs and WLAs. Ex post analyses of the actual costs that sources have incurred to meet pollution control standards have often found that ex ante engineering cost models overestimated costs -- process modifications or material substitutions were implemented that reduced emissions at costs lower than the add-on control equipment that provided the basis for the original cost estimate.

The capital cost functions drawn from the CWNS for the next treatment step for point sources for BOD, nutrients, toxic organics and ammonia seem potentially likely to overestimate costs of upgrades because they simulate building a new plant and receiving a credit for the salvage value of the existing plant.

For nonpoint sources, we generally selecte a more expensive specific BMP to represent the costs of the entire variety of possible BMPs within any given practice group.

P. FLOW OR VOLUME INFORMATION USED FOR EACH SOURCE IN TREATMENT COST FUNCTIONS

Assumption

For point sources, wastewater flow information is obtained from PCS. This is despite our impression that flow information reported in PCS is poorly quality-controlled and often in error. We use the flow information reported in PCS for any facility for which such information is available. For the many dischargers with no flow information reported, we assign the source the average flow reported for other sources in that SIC or group. We assume that dischargers with large flows will segregate their waste streams such that advanced treatment will be applied to only the small, most contaminated portions of their total flow. We thus limit in various ways the maximum flows that we assume each point source discharger will need to treat. For nonpoint sources, we use the following measures of volume in the cost functions: acreage (for agricultural land), acreage and volume cut (for silviculture), number of animals or animal units (for AFOs), and number of dwelling units served by on-site wastewater treatment systems (for OWTS).

Impact of assumption

The implementation costs we estimate for point sources are substantially affected by the set of assumptions and procedures to deal with flow issues. On the whole, we believe that our assumed upper limits on the flows that will be treated are conservative -- that is, the great majority of point sources will have flows to be treated that are actually well below the upper limits that we assumed, and costs therefore are likely overestimated. For nonpoint sources, we believe the volume information used for costing is reasonably accurate.

Q. ADJUSTMENTS OF THE IMPLEMENTATION COST ESTIMATES TO REFLECT MISSING DATA

Assumption

The data that we use to estimate costs are not complete. Some impaired water bodies are not georeferenced. Without location information for these water bodies, they can not trigger any implementation costs for nearby point or nonpoint sources. Similarly, some point sources are not georeferenced; we cannot estimate whether or not they will incur costs because we do not know whether or not they are within or upstream of impaired waters. We use a scaling procedure to adjust our cost estimates to reflect this missing data. Implementation costs are estimated for the subset of States and sources for which we have data, and we then extrapolate the results to the remainder of the Nation using a scaling factor reflecting the portion of the Nation for which we do have data. Our key assumption is that the portion of the Nation for which we do not have data has impairments and will incur compliance costs at the same rate as a function of source activities as does the portion of the Nation for which we do have data.

Impact of assumption

This scaling adjustment for missing data adds some uncertainty, but probably entails little bias. Our extrapolation from the areas where we have data to the areas where data are missing is problematic only if there is something systematically different in the relationships between sources and impairments in the areas with data compared with these relationships in the areas without data. We do not expect any such systematic differences to arise because of missing georeference information for some point sources, as it appears to be generally random whether or not point sources are georeferenced. However, there are systematic differences in whether or not water body location information is available. Georeference information is not available for about 35 % of all impaired waters, including all waters in CA and Region 10 (which include about 17 % of all impaired waters). Our extrapolation procedure may be inaccurate if source/impairment relationships are generally different in these far-western States than in the rest of the country. If, for example, silviculture is either more or less likely to cause water quality impairments in the far-western States than in the rest of the country, then extrapolating silviculture implementation costs based on volume cut from the remainder of the Nation to these States is inaccurate. We believe, for example, that silviculture is significantly more tightly regulated in these States than elsewhere, suggesting that it may cause fewer water quality problems in the far West. On the other hand, the generally steep slopes in the areas where logging is conducted in the far West suggest perhaps greater problems there than elsewhere. On the whole, we believe that these sorts of possibilities for bias in our extrapolation procedure are not substantial.

USDA has suggested in reviewing a draft of this report that using national average figures for the unit costs of agricultural BMPs may result in underestimating national costs if costs are typically higher in the specific areas where TMDLs will most frequently require load reductions. For example, although we have estimated the costs to retire crop land based on national averages for this practice, USDA surmises that much of the crop land retirement that may be prompted by TMDLs will occur in the midwestern agricultural heartland, where crop land values are particularly high. We will investigate this sort of possibility before finalizing this report.

R. TIMING ASSUMPTIONS CHOSEN FOR THE IMPLEMENTATION COST ANALYSIS

Assumption

We have estimated the costs for point and nonpoint sources to achieve water quality standards for the currently listed 303(d) waters. We estimate these costs assuming a steady pace of TMDL development from now through 2015 (and we further assume that costs will be incurred under the other scenarios at the same time as under the TMDL Program scenario). We assume that the average source will begin incurring its compliance costs five years after the TMDL is developed. We discount costs that will be incurred in the future back to the present, and calculate an equivalent level, annualized amount beginning in the year 2000 and continuing forever.

Impact of assumption

The implementation costs we estimate would be substantially different if different analytical ground rules were chosen. Our chosen TMDL pace/compliance time lag scenario reduces the costs we show as annualized costs beginning now to an amount that is 44.84 % of what annual costs will be after all affected sources have had to meet TMDL requirements.

On the other hand, the costs for a pollutant source to achieve its allowed load under a TMDL developed far in the future may be greater than if the TMDL were developed today. Growth in the population served by a POTW or growth in production by an industrial discharger may make achieving the same discharge limit in, say, 2010 more costly than achieving that limit in 1999. In addition, as States assess more of their waters, additional water bodies will be listed for which TMDLs will need to be developed. In this analysis, we estimate the costs associated with implementing TMDLs only for waters that are currently listed.

APPENDICES

APPENDIX A: GROUNDTRUTHING THE ASSUMPTIONS

In estimating the costs to pollutant sources from TMDLs or alternatives to them, this study makes many assumptions that simplify the analysis and reduce the extent of data needed. To assess the validity of these assumptions, we would like to compare them against actual experience among the TMDLs that have been completed thus far. We have only begun to do this. We have reviewed 15 completed TMDLs and compiled information from them that is relevant to the analytical assumptions we have made. In this appendix, we "groundtruth" the assumptions by comparing them against what has happened among this sample of completed TMDLs. Given the wide variation in the sorts of waters and impairments that actual TMDLs will address, a sample of 15 completed TMDLs is obviously far short of an ideal data base from which to draw conclusions. Nevertheless, this initial groundtruthing effort provides some preliminary indications of patterns across actual TMDLs, and the results are sufficiently interesting to warrant a substantially increased effort to develop a larger and more representative database of completed TMDLs for groundtruthing.

Tetra Tech selected 15 recently completed TMDL submissions for analysis. No formal statistical sampling or selection procedure was employed. Tetra Tech simply selected TMDLs that the firm was familiar with, and which would cover a substantial range of impairment pollutants, source types (both point and nonpoint sources) and geographic locations. Tetra Tech then abstracted information from the selected TMDLs to fill in a common data collection template. This information was further condensed to develop a one-page summary for each TMDL (attached at the end of this appendix) and a summary exhibit for the entire set of 15 TMDLs (appearing on the next page). On the following pages, we review what can be learned from the 15 TMDLs that is relevant to the major assumptions adopted for this analysis.

Exhibit A -1
Summary of Groundtruthing Information From 15 TMDLs

TMDL Submission	# of 303(d) Waterbodies Covered	Pollutants	% Reduction	Source Types Assigned Reductions	Are All Relevant PS Assigned Reductions?	Geographic Extent of NPS Assigned Reductions
Anderson Run, WV	1	Fecal coliform bacteria	42	NPS	N/A	Entire watershed, 7% of county
Appoquinimink River, DE	1	CBOD NBOD P	56 52 68	PS NPS	Yes	Entire watershed, 11% of county
Bayou Nezpique, LA	1 (or more, unclear)	CBOD NH3	For both pollutants, 0-50% reduction from PS, 85-90% reduction from NPS	PS NPS	No	Entire watershed, 22.3% of four counties
Buckhannon River, WV	1	Al Fe Mn	8 8 3	NPS	No	Loads were addressed in the entire watershed, which encompasses 18% of total land area of three counties. Reductions were assigned to 3 of 14 subwatersheds within this land area.
Coeur d'Alene River Basin, ID	28 plus	Dissolved Metals (Pb, Cd, Zn)	Unknown. Target load is assigned but current loads unknown	PS NPS	Yes	Entire watershed, comprising most of 3 counties
Duck Creek, AK	1	Sediment/ Turbidity	42-62	NPS	N/A	Entire watershed, 0.03% of county
Elk Creek, OK	1	BOD NH3	50-67 Unknown	PS	Yes	N/A

TMDL Submission	# of 303(d) Waterbodies Covered	Pollutants	% Reduction	Source Types Assigned Reductions	Are All Relevant PS Assigned Reductions?	Geographic Extent of NPS Assigned Reductions
Garcia River Watershed, CA	1	Sediment	60	NPS	N/A	Entire watershed, 3.2% of county
Hurricane Lake, WV	1	Sediment P Fe	30 45 30	NPS	No	Entire watershed, 0.7% of county
Lake Thonotosassa, FL	1	N P	Unknown. Target load is assigned but current loads unknown 86	NPS	No	Entire watershed, 5.2% of county
Muddy Creek, VA	1	Fecal coliform bacteria	99	NPS	No	Entire watershed, 3.7% of county
Nanticoke River and Broad Creek, DE	2	BOD5 N P	29 23 32	PS NPS	No	Entire watershed, 42% of county
Neuse River Estuary, NC	1 (large estuary)	N	30	PS NPS	Yes	Entire watershed, includes most of 19 counties
Noyo River Watershed, CA	1	Sediment	67	NPS	N/A	Entire watershed, 3.2% of county
Sanders Branch/ Coosawhatchie River, SC	2	CBOD NBOD	Unknown	PS	No	N/A

I. COMPARISON OF KEY ANALYTICAL ASSUMPTIONS WITH INFORMATION FROM 15 TMDLS

A. ASSUMPTIONS RELEVANT TO POINT SOURCE COSTS

- Are controls for point sources triggered by pollutants other than BOD, nutrients, metals, toxic organics, or ammonia?
  - No. Among this set of TMDLs, the pollutants triggering point source controls include: BOD (5 instances), nutrients (3), ammonia (2), and metals (1).

- Are the only point sources assigned reductions those that discharge directly to the impaired segment, or are upstream point sources addressed also?
  - In many instances, point sources upstream of the impaired segment are addressed also. In some instances, some upstream point sources are believed to be too distant to warrant further controls.

- At what distance upstream of the impairment are point sources that discharge the impairment pollutant still considered to need controls? (e.g. 25/50 miles?)
  - We can't tell from the available information how far upstream each point source is located (whether the point source is addressed or not addressed). Further investigation would be necessary to ascertain distances.

- Are all point sources thought to be discharging the impairment pollutant within a relevant distance of the impairment assigned a load reduction?
  - No. In 4 of 11 cases, all relevant point sources are assigned reductions. In 4 cases the point sources contributing minimally to impairment are assigned no reductions and all important point source pollutant sources are assigned reductions. In 2 cases explicit decisions were made that some significant pollutant sources would need reductions while others would not. In one case an aggregate load reduction was assigned to all point sources and trading was expected.

- Do the TMDLs often require further load reductions from point sources that already provide treatment in excess of technology-based standards?
  - Yes, in at least two cases point sources that already provide advanced treatment are being required to do more. In many cases, it is difficult to tell from the limited information available.

  - In two other cases, particular point sources are not required to reduce their loads further because they have already adopted some form of advanced waste treatment (even though they could reduce loads further anc achieve zero discharge).

- How does the percentage load reduction required of point sources in the aggregate compare with the load reduction that would be achieved if all relevant point sources implemented "the next treatment step"?
  - See the exhibit and detailed conclusions that follow below.

Exhibit A-2
Information From 11 Groundtruthing TMDLs Regarding % Reductions Sought from Point Sources

Water Body	Overall Approach to Point Sources in This TMDL	Our Judgment About Overall % Reduction That This TMDL Requires for Total Load from Point Sources
Appoquinimink River, DE	River is affected by only one point source; it is assigned load reductions	CBOD: 57% NBOD: 83% P: 85%
Bayou Nezpique, LA	Is significantly affected by 9 PS and insignificantly affected by 16 PS. The 9 are assigned varying load reductions ranging from 0 - 50 % for BOD and NH3. The 16 are assigned no load reductions	BOD, NH3 both likely 10 - 40 %
Buckhannon River, WV	Very small contributions from numerous PS in the watershed. No load reductions assigned to PS	Waterbody is affected by NPS only. This TMDL is not relevant in assessing typical % reduction required of PS.
Coeur d'Alene River Basin, ID	Numerous PS identified as contributing metals, the impairment pollutants. Allowable loads were assigned to PS in the aggregate, but current loads are unknown and hence % reduction is unknown	Unknown
Elk Creek, OK	Creek is affected by only one point source; it is assigned load reductions	BOD: 50 - 67 %, depending on season
Hurricane Lake, WV	Lake may be affected trivially by only one small PS. It is not assigned a load reduction	Waterbody is affected by NPS only. This TMDL is not relevant in assessing typical % reduction required of PS.
Lake Thonotosassa, FL	Lake may be minimally affected by numerous PS that already employ land treatment/zero discharge	Waterbody is affected by NPS only. This TMDL is not relevant in assessing typical % reduction required of PS.
Muddy Creek, VA	Very small contributions (of pathogens) by PS. They are not assigned load reductions	Waterbody is affected by NPS only. This TMDL is not relevant in assessing typical % reduction required of PS.
Nanticoke River & Broad Creek, DE	Significant contributions from many point sources. Explicit decision made to require load reductions from some and not from others	BOD: roughly 30 % Nutrients: roughly 30 %

Neuse River Estuary, NC	Significant contributions from many, many point sources. Uniform permit limits assigned to each that will achieve the desired aggregate load reduction. Trading expected	N: 30 %
Sanders Branch/Coosawhatchie R, SC	Several important, several lesser PS identified. Significant reductions assigned to the important PS, while no reductions required of lesser PS	BOD: unclear, but likely significant (50 - 80 %?)

B. Conclusions Regarding % Reductions Sought from Point Sources:

- Among the sample of 15 TMDLs, 4 do not involve point sources at all, leaving 11 to be reviewed in this analysis.

- Many waters identified as impaired essentially by nonpoint sources nevertheless have point sources nearby that contribute small or insignificant amounts of the impairment pollutant. We have 4 examples of this sort among the 11 groundtruthing TMDLs. In each of these 4 cases, the TMDL requires no load reductions from the point sources. These cases support our assumption in the implementation cost analysis that TMDLs for NPS-only waters will not require further controls for point sources.

- Among the 7 cases where point sources are seriously addressed by the TMDL, 3 involve an aggregate load reduction across all point sources in the 10 - 40 % range, 3 involve aggregate load reductions in the 50 - 85 % range, and one is unknown.

- The "next treatment steps" that we simulate for point sources will yield very roughly the following percentage load reductions: (Note, further work is proceeding on this issue)

- metals from industrial dischargers	90 %
- metals from POTWs (enhanced pretreatment)	70 %
- BOD	50 %
- nitrogen	75 %
- phosphorus	50 %
- ammonia	75 %
- toxic organics	? (not addressed in this sample)

- For perhaps half of the TMDLs, the aggregate load reduction that will be obtained by implementing the next treatment step at all relevant point sources (50 to 90 %) is much greater than the aggregate load reduction needed (10 - 40 %). For the other half of the TMDLs, the aggregate load reduction that will be obtained by the next treatment step for all relevant point sources will yield approximately the same aggregate load reduction as that called for by the TMDL.

- Based on this, in analyzing the "Moderately Cost-effective TMDL Program" Scenario, we will assume that:

    - In half of the TMDLs, all the point sources will need to take the next treatment step;

    - In the other half of the TMDLs the next treatment step for all point sources will provide twice the load reduction that is needed. In this half of the TMDLs, in effect, only half the point sources will need to implement the next treatment step and half of the point sources will likely be able to avoid the next treatment step.

    - **We will thus assume that Moderately Cost-effective TMDL Program costs can be reduced by 1/4 from Scenario 1 costs.**

C. ASSUMPTIONS RELEVANT TO NONPOINT SOURCE COSTS

- What is the geographic extent of the nonpoint source watersheds from which load reductions are sought?

  - In 12 of 13 cases, nonpoint sources throughout the entire upstream watershed will be affected. In one case, nonpoint sources were singled out in only a few of the key subwatersheds.

- Relative to the acreage in the county or counties within which the impaired waters is located, how many acres are in the zone within which nonpoint sources will need to be controlled?

  - For Scenario 1 ("Least Flexible TMDL Program"), we assumed that the acreage to be controlled was equal to the acreage of the surrounding county or counties. This appears nearly always to be a substantial overestimate relative to what actual TMDLs have required. See the exhibit on the next page. Across the 13 TMDLs requiring nonpoint source controls, the median watershed acreage needing controls per waterbody amounted to 7.0 % of the acreage of the county or counties. The 25th percentile was controls for acreage amounting to 3.2 % of the county's acreage per waterbody, while the 75th percentile was controls for acreage amounting to 32.8% of the acreage of the county per waterbody. The mean figure is substantially higher, due to one TMDL covering two waterbodies that will require nonpoint source controls for acreage amounting to that for 19 surrounding counties. See the exhibit on the following page.

  - **For this analysis, for Scenario 2 ("TMDL Program"), we will assume that the TMDL for a nonpoint source-impaired water body will controls for acreage equal to 5 % of the number of acres in the surrounding county (lower estimate, slightly larger than the 25th percentile figure) or 40 % of the number of acres in the surrounding county (upper estimate, slightly larger than the 75th percentile figure).**

- How does the percentage load reduction required of NPS within the area needing controls compare with the percentage likely to result from our assumed "next treatment step" packages for nonpoint sources?

  - The percentage reduction required by the TMDLs from nonpoint sources within the targeted areas is: 0 - 25%, 1 case; 25 - 50%, 4 cases; 50 - 75%, 4 cases; 75%+, 2 cases.

  - We need to do further research to determine what percentage reduction is likely achieved by each of our NPS "next treatment step" packages. As a very rough guess, if our NPS packages were to reduce loadings by 75%, we would be overestimating costs somewhat.

Exhibit A-3

Extent of Nonpoint Source Controls Required by TMDLs

Comparison of Number of Acres in County with Number of Acres of Watershed Controlled

TMDL	# of 303d waterbodies addressed in TMDL	Additional 303d waterbodies subsumed in controlled area	Total # waterbodies	# Counties within which NPS load reductions are sought	% of these counties' area affected	% of one typical county's area affected	% of a typical county's area affected per waterbody
Duck Creek, AK	1		1	1	0.03	0.03	0.03
Hurricane Lake, WV	1		1	1	0.7	0.7	0.7
Garcia River, CA	1		1	1	3.2	3.2	3.2
Noyo River, CA	1		1	1	3.2	3.2	3.2
Muddy Creek, VA	1		1	1	3.7	3.7	3.7
Lake Thonotosassa, FL	1		1	1	5.2	5.2	5.2
Anderson Run, WV	1		1	1	7.0	7.0	7.0
Coeur d'Alene, ID	28		28	3	100.0	300.0	10.7
Appoquinimink, DE	1		1	1	11.0	11.0	11.0
Nanticoke River, Broad Creek, DE	2		2	1	42.0	42.0	21.0
Bayou Nezpique, LA	1	1	2	4	22.3	89.2	44.6
Buckhannon, WV	1		1	3	18.0	54.0	54.0
Neuse River, NC	1	1	2	19	100.0	1900.0	950.0
Elk Creek, OK	1		1				
Sanders Branch/ Coosawhatchie, SC	2		2				
				mean			85.7
				median			7.0
				25th percentile			3.2
				75th percentile			32.8

APPENDIX B: TMDL PACE AND TIME LAG SCALE FACTOR

Scale Factor for Pace of TMDL Development and Compliance Time Lag

Assume, once all sources have begun incurring costs, that the total annualized compliance costs for all these so
is $1.00 per year, continuing forever

				Discount Rate:	0.07	0.03		0.07	0.03
Year	**# TMDLs Completed**	**% TMDLs Completed**	**Cumulative % TMDLs Completed**	**After 5-Year Lag, % of Sources Incurring Compliance Costs**	**Present Value of Compliance Costs**	**Present Value of Compliance Costs**	**Baseline: $1 per year, beginning 2000 and continuing forever**		
2000	2000	5.52%	5.52%		0.0000	0.0000	1.0000	1.0000	1.0000
2001	2281.666667	6.30%	11.82%		0.0000	0.0000	1.0000	0.9346	0.9709
2002	2281.666667	6.30%	18.12%		0.0000	0.0000	1.0000	0.8734	0.9426
2003	2281.666667	6.30%	24.42%		0.0000	0.0000	1.0000	0.8163	0.9151
2004	2281.666667	6.30%	30.72%		0.0000	0.0000	1.0000	0.7629	0.8885
2005	2281.666667	6.30%	37.01%	5.52%	0.0394	0.0476	1.0000	0.7130	0.8626
2006	2281.666667	6.30%	43.31%	11.82%	0.0788	0.0990	1.0000	0.6663	0.8375
2007	2281.666667	6.30%	49.61%	18.12%	0.1128	0.1473	1.0000	0.6227	0.8131
2008	2281.666667	6.30%	55.91%	24.42%	0.1421	0.1927	1.0000	0.5820	0.7894
2009	2281.666667	6.30%	62.21%	30.72%	0.1671	0.2354	1.0000	0.5439	0.7664
2010	2281.666667	6.30%	68.51%	37.01%	0.1882	0.2754	1.0000	0.5083	0.7441
2011	2281.666667	6.30%	74.81%	43.31%	0.2058	0.3129	1.0000	0.4751	0.7224
2012	2281.666667	6.30%	81.10%	49.61%	0.2203	0.3480	1.0000	0.4440	0.7014
2013	2281.666667	6.30%	87.40%	55.91%	0.2320	0.3807	1.0000	0.4150	0.6810
2014	2281.666667	6.30%	93.70%	62.21%	0.2413	0.4113	1.0000	0.3878	0.6611
2015	2281.666667	6.30%	100.00%	68.51%	0.2483	0.4397	1.0000	0.3624	0.6419
2016				74.81%	0.2534	0.4662	1.0000	0.3387	0.6232
2017	36225	1		81.10%	0.2568	0.4907	1.0000	0.3166	0.6050
2018				87.40%	0.2586	0.5134	1.0000	0.2959	0.5874
2019				93.70%	0.2591	0.5344	1.0000	0.2765	0.5703
2020				100.00%	0.2584	0.5537	1.0000	0.2584	0.5537
		Present value for years 2000 through 2020:			3.1622	5.4484		11.5940	15.8775
		PV in 2020 for all years after that:			14.2857	33.3333		14.2857	33.3333
		PV in 2000 for annual costs after 2020:			3.6917	18.4559		3.6917	18.4559
		PV for all years:			6.8539	23.9042		15.2857	34.3333
		Annuity value:			0.4798	0.7171		1.0700	1.0300
Scale factor, relative to cost of $1/yr forever, beginning in 2000:					**0.4484**	0.6962		1.0000	1.0000

APPENDIX C: POLLUTANTS FOR ANALYSIS

In order to limit the analytical workload (e.g., developing and applying cost functions for the next treatment step for each pollutant), we chose to analyze only those particular pollutants for which TMDLs are most likely to require further controls (beyond technology-based standards) for point sources. We considered the most frequent causes of impairment, and asked whether each of these causes would commonly trigger the need for further controls of point sources that are already meeting technology-based standards.

Exhibit C - 1 summarizes our judgments and rationale. The exhibit shows the number of point sources upstream within 50 miles of 303(d) waters impaired for different pollutants. Pollutants are listed in descending order of the frequency with which they implicate point sources for potential further control needs. For example, the exhibit shows that there are 4386 point sources upstream within 50 miles of water bodies that are impaired for BOD/DO and that States have cited as impaired by both point and nonpoint sources. There are 460 point sources upstream within 50 miles of water bodies that are impaired for BOD/DO and that States have cited as impaired by point sources only.

Exhibit C - 1
Decisions on Causes/Pollutants to Analyze as Triggers for Further Point Source Controls

Cause/pollutant	# of point sources w/in 50 mi. upstream of waters impaired by		Include this as a pollutant for analysis?	Rationale
	Waters Impaired by PS + NPS	Waters Impaired by PS only		
BOD/DO	4386	460	Yes	
Metals	4277	776	Yes	
Nutrients	3965	293	Yes	
Sediment	3656	86	No	Probably rare that PS process water discharges are worth controlling for sediment beyond BPT. PS sediment problems in wet weather will likely be handled by eventual compliance with storm water and construction technology-based requirements.
Pathogens	3564	131	No	Problems are likely CSOs, SSOs and other wet weather discharges, to be controlled by compliance with technology-based standards. Unlikely that other PS are worth controlling for pathogens beyond BPT.
Habitat	2420	37	No	TMDL necessary only if a pollutant can be identified
Suspended solids	2165	130	No	Same as sediment
PCB	1599	126	No	Problems are likely legacies, not ongoing, controllable process water discharges needing control beyond BAT
Flow alteration	1570	NA	No	No TMDL necessary
Ammonia	993	64	Yes	Which SICs might be worth controlling? POTWs? Others?

Pesticides	971	24	No	Very few PS likely worth controlling for pesticides beyond BAT. Which SICs?
Dioxin	794	27	No	Most problems are likely due to air deposition or legacy, not ongoing, controllable discharges. Any SICs worth controlling beyond BAT? Pulp/paper?
pH	622	8	No	Unlikely that PS at BPT could be causing a problem
Oil and grease	560	21	No	Unlikely that PS process discharges are worth controlling beyond BPT. Compliance with existing wet weather requirements will help.
Salinity	532	4	No	Highly likely to be NPS problem
Toxics	517	35	Yes	Absent more specificity, though, it is unclear what controls to implement.
Chlorine	293	1	No	Why is this a frequent problem in PS/NPS waters, but not in PS only waters? Could use further investigation. Candidate for addition to analysis.
Thermal mod.	288	17	No	Expect that any PS problems should be taken care of by BPT
Unknown	275	43	No	Unclear what controls to implement. Scale up to cover this.
Organics	274	30	Yes	Assume this means toxic organics.
Odor	150	0	No	Interesting that this shows up for PS/NPS waters, but not for PS waters. Unclear what treatment measures might be considered.
Dissolved solids	123	15	No	Likely a NPS problem only
Fish advisories (w/no mention of the pollutant)	84	NA	No	Usually due to NPS, legacies, air deposition. Candidate for addition to analysis if can get more data on which pollutant and whether any suspected contribution from PS process discharges.
Bacteria	78	0	No	Same as pathogens
Sulfates	48	0	No	Likely a NPS problem only
(Next most frequent)	24	23	No	Do not address very infrequent causes/pollutants
Cyanide	4	140	No	Surprisingly high frequency in PS-only waters. Why? Candidate for addition to analysis.
Total (Note: this exceeds the number of point sources upstream of impairments. Many PS are counted for multiple causes.)	43,747	4,136	xxx	xxx

We chose to analyze further those pollutants for which point sources are most frequently likely to need additional controls beyond technology-based standards. Several sorts of considerations are reflected in Exhibit C - 1:

- We chose not to analyze causes of impairment when no pollutant was identified. Examples included flow or habitat alteration or fish consumption advisory when no pollutant was listed also.

- We chose not to analyze pollutants that are extremely unlikely to be discharged in sufficient quantity to be problematic by a point source meeting technology-based standards. Examples included temperature or pH.

- We chose not to analyze pollutants for which only a very small fraction of point sources might require additional beyond-technology-based controls for process water discharges. Examples include sediment or pathogens. We believe that the great majority of instances where waters are impaired for these causes and point sources are cited as a source involve wet weather discharges from point sources. We believe these problems will largely be remedied when existing technology-based standards for wet weather discharges -- storm water, construction, CSO and SSO requirements -- are complied with.

- We chose not to analyze in this study pollutants representing a very small fraction of causes that would require specialized treatment technologies as the"next step". Examples include chlorine and cyanide. We could consider such infrequent causes of point source impairment in a future study.

APPENDIX D: APPROACHES FOR DETERMINING WHETHER A POINT SOURCE IS LIKELY TO BE CONSIDERED FOR FURTHER CONTROLS

The objective of this portion of the analysis was to make a judgment about whether each point source within a relevant distance upstream of an impairment for a specific pollutant would likely be considered by the eventual TMDL or water quality-based permit to implement further controls. We sought to determine whether an identified point source meeting applicable technology-based standards was likely to discharge the impairment pollutant in sufficient quantity to warrant consideration for further controls. This judgment was particularly difficult to make because there is little data available at the national level on the pollutants that individual facilities discharge and their amounts. For the majority of dischargers, the Permit Compliance System (PCS) -- EPA's major data base on point source dischargers that we used to identify potentially relevant facilities -- provides information only on which pollutants a facility is required to monitor for. Only for a very few facilities does PCS provide reliable information on the amount of the monitored pollutants that are discharged. PCS provides no information on whether a facility discharges unmonitored pollutants or their amounts.

We tested three alternative approaches for determining whether or not a specific point source (after meeting applicable technology-based requirements) discharges the impairment pollutant in an amount sufficient to contribute to impairment and making the source likely to be considered in the TMDL or water quality-based permit.

I. USE OF PCS INFORMATION: "SCREEN #1"

Our first approach to making this judgment was to use the information in PCS on frequency of monitoring to judge by 4-digit SIC code whether each upstream facility is likely to discharge each impairment pollutant. If the facility was judged to discharge the impairment pollutant, we would then assume conservatively that the TMDL would require the facility to provide further controls beyond technology-based standards. This approach, which we term Screen #1 rests on three assumptions:

- Assume that if facilities in a SIC generally monitor for a particular pollutant, all facilities in that SIC likely discharge that pollutant. This assumption is probably nearly always accurate.

- Assume also the converse: if facilities in a SIC rarely monitor for a pollutant then all facilities do not discharge the pollutant. This assumption will often be untrue.

- Assume that if a facility discharges the impairment pollutant, the TMDL will likely require further controls beyond technology-based standards. This assumption is likely often untrue, but yields a conservative cost estimate.

Consistent with these assumptions, Screen #1 was implemented as follows:

- If no facilities in the SIC monitor for any pollutant, discard all facilities in the SIC. No such facilities will be required to control further by the TMDL.

- If less than 15% of the facilities in the SIC monitor for the pollutant, assume that none of the facilities without monitoring information discharge that pollutant. Assume that any facility that does monitor for the pollutant does discharge it.

- If more than 15% of the facilities in the SIC monitor for the pollutant, assume that all of the facilities without monitoring information (as well as those with monitoring information) discharge that pollutant

The result when Screen # 1 was implemented that the roughly 20,000 point sources identified as located upstream within 25/50 miles of impaired waters declined to 10,838 facilities.[57] This Screen eliminated about half of the identified facilities as being unlikely to discharge the impairment pollutant, and thus unlikely to be required to control further by the TMDL.

The results of Screen #1 included many apparent anomalies. For example, metal finishers appeared to need beyond-BPT/BAT controls for nutrients. Facilities in the "fabricated metal products" industry did not appear to be candidates for further metals controls.

II. USE OF ENGINEERING JUDGEMENT: "SCREEN #2"

Screen #2 involves an engineering judgment as to whether each 4-digit SIC is likely, after meeting BPT/BAT/secondary treatment requirements, to discharge each pollutant at levels that could warrant potential further control. Two EPA engineers experienced in industrial water pollution control made these judgments for each of more than 500 different SIC codes.

An example page among the engineers' judgments follows. The page lists the facilities in SICs that had passed Screen #1. For SIC 8062 (general hospitals), for example, 24 facilities had been identified using Screen #1 as discharging the impairment pollutant within the relevant distance upstream of an impaired water body. 4 hospitals discharged BOD upstream of a BOD/DO impairment, 22 discharged metals upstream of a metals impairment, and 10 discharged a nutrient upstream of a nutrient impairment. Screen #1 would lead to these hospitals being costed for the next treatment step for these pollutants. Screen #1 did not identify any hospitals as discharging ammonia or toxic organics upstream of an impairment for either of these pollutants. In contrast, the engineers' judgment was that hospitals were likely candidates for further controls for BOD, metals, nutrients <u>and toxic organics</u> whenever they were upstream within the relevant distance of an impairment for any of these pollutants. The engineers believed that hospitals were not a likely candidate for further controls if ammonia was the impairment pollutant. In Screen #2, engineering judgment was used to over-ride the conclusions drawn from the monitoring-based Screen #1. Some pollutants were crossed out as being unlikely to warrant beyond-technology-based controls for some SICs, and other pollutants were added as being likely candidates for further controls even though the monitoring information for facilities in that SIC suggested that perhaps the pollutants were not being discharged by the SIC. Engineering judgments were also provided for several hundred SICs that Screen #1 had eliminated from consideration altogether because no facilities in these SICs monitored for any impairment pollutants.

Screen #2 reflecting the engineers' judgments was ultimately implemented in two alternative ways, resulting in high and low estimates for the number of point sources likely to be required by TMDLs to implement further controls. The high estimate adopts more liberal rules for matching sources and impairments than does the low estimate. For the high estimate, when a water body is impaired by a specific metal (except mercury) or a specific toxic organic (except PCBs or dioxin) and the facility (based on engineering judgment for its SIC) is expected generally to discharge metals or toxic organics, then further

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57 These are raw figures, not yet scaled to reflect the incomplete coverage of the analysis.

controls are assumed to be required for that facility. For the low estimate, the match must be exact in order for controls to be required at a facility: if a water body is impaired for metals generally then facilities that discharge metals generally are assumed to require controls, but if a water body is impaired for a specific metal or toxic organic (e.g., zinc, phenol), only those facilities discharging that specific metal or toxic organic are assumed to require controls.

Screen #2 resulted in a variety of changes relative to Screen #1. Many SICs were dropped as unlikely to discharge the impairment pollutant in sufficient quantity to make the SIC a likely target for beyond-technology-based controls. Some new SICs were added with many facilities that appear to be mostly storm water (surface coal mining [600 facilities], crude petroleum & natural gas [46], oil & gas field services [40]) and may not be reasonable targets for further controls under TMDLs. Other SICs were added that may reasonably be targets for further controls: private households (11 facilities) and car washes (23).

INSERT PHOTOCOPY PAGE OF ENGINEERS' JUDGMENT

Ultimately Screen #1 and Screen #2 (high and low estimates) gave surprisingly similar results, in terms of the number of point sources likely to need further controls under TMDLs and in terms of implementation costs for these sources:

Exhibit D-1
Summary Results of Alternate Screening Processes

Screen	# of Point Sources Incurring Costs	Annualized Projected Costs (1999 $ in millions)
#1, based on PCS monitoring information	9,101	1,499
#2, engineering judgment, higher estimate	9,492	1,378
#2, engineering judgment, lower estimate	8,533	1,141

On the whole, we believe that the pattern of pollutant/SIC combinations for which further controls are projected to be necessary is most reasonable under Screen #2 (higher estimate). We adopted this screening approach for our final cost estimating procedure. Note that the three screens give very similar results despite rather different underlying rationales, lending some credence to our conclusions.

Also note that this comparison of alternate screening processes was developed relatively early in the implementation cost analysis. We made several important changes in our analytical procedures subsequent to choosing among the three screening approaches. As a result, the estimates shown in Exhibit B-1above are not comparable to other estimates shown elsewhere in this report. Most importantly, the cost functions for next step treatment technologies that we ultimately use in the cost analysis are different from the preliminary cost functions that underlie Exhibit D-1 and that we were using at the time we made the choice among screening processes.

APPENDIX E: DETAIL ON COST FUNCTIONS FOR POINT SOURCES

This appendix provides additional information on all the cost functions used in the point source analysis. The functions themselves are also shown.

I. CAPITAL COSTS FOR POTWS AND INDUSTRIAL DISCHARGERS FOR "NEXT STEP" TREATMENT

The relevant CWNS capital cost functions are as follows:

Capital Cost = \$1,000,000 x A x (flow)^B

where A and B are coefficients selected from the exhibit below based on the type of function requested, and flow is expressed in million gallons per day.

Exhibit E-1
CWNS Capital Cost Functions (1996 dollars)

Function	flow < 0.35 mgd		flow 0.35 to 1 mgd		flow > or = 1 mgd	
	A	B	A	B	A	B
Secondary treatment	1.188	0.396	5.488	1.854	5.488	0.673
Secondary treatment w/ nutrient removal			5.903	1.923	5.903	0.754
Advanced treatment I			7.215	2.114	7.215	0.740
Advanced treatment I w/ nutrient removal			8.651	2.287	8.651	0.728
Filtration	NA	NA	0.770	0.527	0.770	0.527
Secondary treatment salvage	NA	NA	1.195	0.840	1.195	0.840

The CWNS applies these capital cost functions as follows:

- For most plants with flow greater than 0.35 mgd currently providing secondary treatment, the cost of an upgrade is estimated as the cost of a new plant at the desired level of treatment (e.g., advanced treatment I) as given by the correct function, less the salvage value of the former secondary treatment facility, as given by the "secondary treatment salvage" function.

- For plants employing lagoon systems with no mechanical process units (generally smaller plants), the cost to upgrade from secondary treatment is given by the filtration cost function.

- For plants of less than 0.35 mgd flow, the cost to upgrade from secondary treatment is 0.35 x the cost of a new plant, as given by the function shown above for these small plants.

The capital costs for treatment upgrades estimated using these functions are in January, 1996 dollars. They are updated to March, 2000 dollars by multiplying by 1.0662 to represent the change over this period in the producer price index for materials and components for construction.

II. O&M COSTS FOR POTWS AND INDUSTRIAL DISCHARGERS FOR "NEXT TREATMENT STEP"

Our cost estimate is developed by subtracting a regression equation estimating the O&M cost for secondary treatment as a function of flow from another regression equation estimating the O&M cost for tertiary treatment as a function of flow. The two equations are as follows:

- O&M cost for secondary treatment (\$/yr) = 261,396 x $flow^{0.855}$ (1)

- O&M cost for tertiary treatment (\$/yr) = 399,749 x $flow^{0.780}$ (2)

where flow is measured in mgd.

Costs are given in these equations in 1999 dollars. We update to March, 2000 dollars based on the producer price index for finished goods (factor of 1.0286).

The O&M cost increment in upgrading from secondary to tertiary treatment is given by equation (2) minus equation (1). Although this gives the cost difference in upgrading from secondary to tertiary treatment as AMSA defines it, we use this relationship also to estimate the cost of upgrading from secondary to advanced secondary treatment.

There is an important quirk in this relationship. At flows exceeding about 80 mgd, the relationship predicts that the O&M cost differential will decline as flow increases. The relationship predicts, for example, that the O&M cost increase in upgrading a 100 mgd plant would substantially exceed the cost increase in upgrading a 200 mgd plant. We believe this is unlikely to be true in reality. We have adjusted the O&M cost function for upgrades to linearize the relationship at flows in excess of 80 mgd. At flows greater than 80 mgd, we assume that the O&M cost increase varies linearly with flow. Thus, for example, we assume that the O&M cost increase when upgrading a 120 mgd plant is 1 ½ times the O&M cost increase that would be experienced in upgrading a 80 mgd plant.

There are several complexities in developing the regression equations using AMSA's data. AMSA presents information by sewerage authority, not by plant. Thus, AMSA might report that an authority operates 3 plants providing secondary treatment and 2 plants providing tertiary treatment, and AMSA then gives data on the total flow and total O&M costs for the 3 secondary plants and on total flow and total O&M costs for the 2 tertiary plants. Lacking data on individual plants, we thus perform the regressions on data aggregated at the authority level. Assuming that there is some non-linearity in the relationship between flow and O&M cost for an individual plant, performing regressions with the data aggregated at the authority level results in increased statistical imprecision.

AMSA also excludes sludge management costs in reporting the authority's O&M costs. Sludge management costs are reported in total for the entire authority, and are not broken out and attributed separately to the authority's primary, secondary and tertiary plants. We thus don't know the authority's full O&M costs, including sludge costs, for its plants providing secondary treatment and for its plants providing tertiary treatment. We address this shortcoming in a rough manner by allocating sludge management costs to the authority's primary, secondary and tertiary plants in proportion to their flow. If, for example, sixty percent of an authority's flow occurred in secondary plants and forty percent in tertiary plants, we would allocate 60 % of the sludge costs to the secondary plants and 40 % to the tertiary plants.

This proportional allocation is inaccurate; a tertiary plant will likely generate significantly more sludge than a secondary plant of the same flow.

Nevertheless, the regression equations come out quite well despite these rough adjustments. The regression equations explain a high fraction of the variance in the dependent variables (secondary and tertiary O&M costs), and the coefficient estimates for the independent variables (secondary and tertiary flow) are both significant at beyond the 99 % level.

III. TREATMENT FOR METALS FROM DIRECT DISCHARGERS EXCEPT POTWs

Polishing multi-media filtration was assumed as the "next treatment step", assumed to be incremental over the technologies assumed to be in place to meet BAT (flow reduction, chemical precipitation, clarification). The capital and O&M cost functions for polishing filtration are drawn from EPA's development document for the centralized waste treatment industry.[58] The equations are:

- Capital cost: $\ln(Y1) = 12.0126 + 0.48025\ln(X) + 0.04623(\ln(X))^2$
- O&M cost: $\ln(Y2) = 11.5039 + 0.72458\ln(X) + 0.09535(\ln(X))^2$

where: Y1 = capital costs (1989 dollars)
Y2 = O&M costs (1989 dollars/yr)
X = flow rate (mgd)

To update to March, 2000 dollars, we multiplied the capital costs by 1.2473 (PPI for materials and components for construction) and O&M costs by 1.2042 (PPI for all finished goods).

The applicable flow rate range for these equations is 0.023 - 1.0 mgd. For a discharger with flow needing additional metals treatment of less than 0.023 mgd, we assumed costs as if flow was 0.023 mgd. For a discharger with flow needing additional metals treatment of greater than 1.0 mgd, we assumed a proportional increase in costs relative to costs for treating a flow of 1.0 mgd. Thus, for example, for a discharger needing to treat 2.0 mgd, we assumed that costs would equal twice what the EPA cost equations gave for a flow of 1.0 mgd.

IV. TREATMENT FOR METALS FROM POTWs

An enhanced pretreatment program with tighter local limits (tighter than PSES) for significant metals indirect dischargers was assumed as the "next treatment step" when POTWs need to provide enhanced control of metals. The enhanced pretreatment program was assumed to be incremental over a baseline pretreatment program in which local limits match effluent guideline requirements for indirect dischargers.

The key steps in developing the cost function for this enhanced pretreatment program were as follows:

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58 U.S. EPA, Office of Water. *Development Document for Proposed Effluent Limitations Guidelines and Standards for the Centralized Waste Treatment Industry*. December, 1998.

- We assumed that any major POTW within the 50 mile distance upstream of a metal-impaired water will need to implement an enhanced pretreatment program. We assumed that no minor POTWs will need to implement such a program..

These two assumptions may overstate the number of POTWs that will ultimately need to enhance their pretreatment programs as a result of TMDLs. There are approximately 1,600 POTWs required to have pretreatment programs. All of them are majors. They account for about 30 billion gpd of flow, or approximately 80 % of total national POTW flows. There are many additional major POTWs that are not required to have pretreatment programs, but we could not in the time available single out the pretreatment POTWs and cost metals controls only for them.

- For each major POTW needing to implement an enhanced pretreatment program, we determined from the CWNS data base the POTW's average daily industrial flow.

- EPA's RIA for the Great Lakes Water Quality Guidance[59] estimated that the typical POTW needing to meet more restrictive Guidance-based limits for toxic pollutants would focus its tightened pretreatment requirements on 30 % of its significant industrial users (SIUs).[60] We adopted this estimate, and further assumed that 2/3 of such SIUs might be affected by tighter requirements primarily for metals, while 1/3 of the affected SIUs would be affected primarily by tighter requirements for other toxic pollutants (organics, cyanide, pesticides, etc.) Thus, we assumed that a typical POTW facing tighter metals discharge requirements will require further metals treatment for 20 % of its SIUs (30 % x 2/3) and 20 % of its SIU flow.

- We assume that half of total industrial flow to pretreatment POTWs is from SIUs, while half is from other industrial users. Across the major POTWs identified in our analysis as needing enhanced pretreatment for metals, industrial flow averages about 20 % of total flow. Thus, we assume that SIU flow averages about 10 % of flow for these POTWs.

- If this 10 % average figure holds also for all pretreatment POTWs nationally, the average SIU has a flow of approximately 0.1 mgd. (30 billion gpd in total pretreatment POTW flow) x (10 % of this flow that is attributable to SIUs) ÷ (32,000 SIUs) = approximately 0.1 mgd/SIU.

- For each POTW needing an enhanced pretreatment program for metals, we take the assumed 20 % of SIU flow that will need further metals treatment (equivalent to 10 % of the POTW's industrial flow) and divide this by the average flow for an SIU (0.1 mgd). This calculation yields the number of SIUs that will need to implement enhanced treatment for metals at each POTW. For example, assume a POTW with 20 mgd total flow and 35

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59 RCG/Hagler Bailly, Inc. *Regulatory Impact Analysis of the Final Great Lakes Water Quality Guidance. Final Report*, March, 1995.

60 The 1,600 pretreatment POTWs serve 270,000 industrial users, of which 31,842 are SIUs. The average pretreatment POTW thus serves about 169 industrial users, of which about 20 are SIUs. SIUs are defined as those indirect industrial dischargers that are either: 1) subject to categorical standards (14,914 SIUs) or 2) greater than 25,000 gpd flow or greater than 5 % of POTW flow or have reasonable potential for pass-through or interference.

% industrial flow (7 mgd). This POTW will have 3.5 mgd of SIU flow, 20 % of which (0.7 mgd) will need enhanced treatment for metals. At 0.1 mgd for the average SIU, 7 indirect discharger SIUs will thus need to adopt enhanced treatment for metals.

- We assume that the enhanced treatment for metals that SIUs will implement is polishing filtration -- similarly as for direct dischargers needing additional treatment for metals. The cost function for polishing filtration for SIUs is the same as the cost function previously discussed for direct dischargers.

- In sum, the costs for an enhanced pretreatment program for a major POTW needing additional control of metals is calculated as follows:

  # of SIUs needing polishing filtration =
  POTW industrial flow (mgd) x 0.5 x 0.2 ÷ 0.1 (mgd)

  cost for each of these SIUs =
  polishing filtration cost functions given previously, at 0.1 mgd flow

Such costs apply only for major POTWs. Minor POTWs are assumed unlikely to have important indirect dischargers and unlikely to be targeted in TMDLs for additional metals treatment.

APPENDIX F: PROCEDURES FOR ESTIMATING FLOW NEEDING TREATMENT

I. DEALING WITH MISSING FLOW INFORMATION

What if information on flow was not available in PCS/CWNS for a facility for which we wanted to cost additional controls? This was common. For example, for the facilities identified as discharging the impairment pollutant within a relevant distance upstream in the "within or upstream" case:

42.1 % had positive reported flows
2.6 % had zero reported flow
55.3 % had no flow reported (mostly industrial dischargers, which are addressed only in PCS)

We used the flow information in PCS/CWNS for any facility for which flow information was reported. We assumed that a facility with zero reported flow was exactly that, a permitted facility with zero discharge (perhaps land treatment or some such). For a facility with no flow information reported, we assigned it the average flow across all facilities of its SIC code for which flow information was reported. For facilities in SICs for which no facilities have reported flows, we assigned the average flow observed in our data base for major industrials (2.505 mgd for metals, 6.313 mgd for non-metals), minor industrials (0.186 mgd for metals, 0.309 mgd for non-metals), major POTWs (8.537 for metals, 8.137 mgd for non-metals), or minor POTWs (0.189 mgd for non-metals), as appropriate.

II. DEALING WITH LIKELY INACCURATE OR INAPPROPRIATE FLOW INFORMATION

Flow information in PCS has not been well quality-controlled, and some very high numbers reported for facility flows undoubtedly represent errors.[61] In other cases, the flow listed in PCS appears likely to be cooling water or perhaps storm water, not process waste water. It is extremely unlikely that anyone would consider applying the advanced control technologies that we are costing to huge cooling water or storm water flows.

In order to avoid estimating costs for technologies to treat clearly unreasonable flows, we adopted the following assumptions:

- Generally, dischargers with large flows will segregate their waste streams in order that advanced treatment (polishing filtration for metals, or advanced secondary for BOD, nutrients, ammonia or toxic organics) can be applied to only the smaller, more concentrated portions of their total flow.

61 Flow information that is reported in CWNS for the POTWs appearing in CWNS appears to have fewer problems than the flow information in PCS.

- We assumed that a minor industrial NPDES permittee will need to apply advanced treatment for the lesser of its flow reported in PCS and these flows:

For metals	1 mgd
For BOD, nutrients, etc.	5 mgd

- We assumed that a major industrial NPDES permittee will need to apply advanced treatment for the lesser of its flow reported in PCS and these flows:

For metals	5 mgd
For BOD, nutrients, etc.	25 mgd

- However, for electric utilities specifically (SIC 4911 and related), whether they are major or not, we assumed they will apply advanced treatment for the lesser of their flows reported in PCS and these flows:

For metals	1 mgd
For BOD, nutrients, etc.	0.5 mgd

- We adjusted any flow shown in CWNS/PCS for a minor POTW that exceeded 1 mgd (the maximum that a minor POTW can have) downward to the 1 mgd limit. (Two minor POTWs, for example, were shown in PCS as having flows of 55 mgd and 1003 mgd.)

APPENDIX G: EXCLUDING COSTS FOR POINT SOURCES AFFECTING WATERS THAT ARE IMPAIRED BY NONPOINT SOURCES ONLY

Many States provide an assessment of the source types that impair each of their 303(d) waters. For the States that provide this information, the data can be compiled to determine whether each water is impaired by point sources only, by nonpoint sources only, by mixed point and nonpoint sources, by unknown sources, or by other categories of sources. Other States do not provide such information on their impaired waters. In our analysis to this point, we have identified all point sources that presumably discharge an impairment pollutant upstream within a relevant distance upstream of or into an impaired water.[62] This set of point sources is likely the maximum that potentially might be addressed in water quality-based permitting or TMDLs.

I. USING STATE DATA ON SOURCE TYPES TO IDENTIFY LIKELY POINT SOURCES

However, we believe we can use the information that States provide on source types responsible for the impairments in these waters to judge which of the maximum set of potentially relevant point sources are really likely to be addressed in the eventual TMDLs or water quality-based permits. As the most obvious examples:

- When a State indicates that point sources are the source of impairment in a water body, we expect that the TMDL or alternative approaches would likely consider all the point sources discharging the impairment pollutant within a relevant distance upstream (i.e., all of the point sources we have identified in this analysis); but

- When a State indicates that nonpoint sources -- and not point sources -- are the source of impairment in a water body, we expect that the TMDL or water quality-based permitting process most likely would not address point sources, even if there are some point sources that apparently (according to our engineering judgment approach) discharge the impairment pollutant within a relevant distance.

In this step of the analysis, we use the information provided by States on the source types responsible for impairment of each 303(d) water body to reduce the set of point sources that could potentially be considered in TMDLs or water quality-based permitting (the maximum set) down to a smaller set of point sources that are likely to be considered in these processes.

In the *"within and upstream"* case, there are 4,234 impaired water bodies that we identify as impaired by one or more of the five pollutant classes that we analyze (BOD, nutrients, metals, toxic organics, and ammonia) and that have one or more point source dischargers within a relevant distance upstream that presumably discharge the impairment pollutant.[63] The following exhibit shows what States

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62 We say "presumably" because we do not have information particular to each point source on whether it actually does or does not discharge any given pollutant. Instead, we make a judgment for each SIC as to whether all dischargers in that SIC presumably discharge each class of pollutants. These broad judgments may be inaccurate with respect to any particular point source discharger.

63 These 4,234 water bodies are for the "within and upstream" case. They represent a little more than one-quarter of the 16,143 impaired water bodies that we cover in our analysis. (Our procedure for matching impaired water bodies against point sources is operable in 44 States plus the District of Columbia. In

report as the sources of impairment for these water bodies, and also shows, in the final column, our judgment as to whether point sources affecting these water bodies are likely to be addressed in TMDLs and water quality-based permitting.

Exhibit G-1
Sources of Impairment Reported for Water Bodies That Have Point Sources Within/Upstream That Presumably Discharge the Impairment Pollutant

Sources of Impairment Reported by States	Number of Water Bodies (Within and Upstream Case)	For These Water Bodies, are TMDLs or Water Quality-Based Permits Likely to Address Point Sources?
PS only	141	Yes
NPS only	829	No
other only	71	No
unknown only	110	Unclear – scale to these waters
not reported	1,727	Unclear – scale to these waters
PS + NPS only	368	Yes
PS + NPS + other only	339	Yes
PS + NPS + unknown only	15	Yes
PS + other only	53	Yes
PS + unknown only	6	Yes
PS + other + unknown only	5	Yes
NPS + other only	425	No
NPS + unknown only	48	No
NPS + other + unknown only	35	No
other + unknown only	25	No
PS + NPS + other + unknown	37	Yes
Total	**4,234**	

Several aspects of this exhibit need explanation:

- The first column provides a comprehensive list of categories into which we have grouped the information provided by the States on the sources of impairment for each of their 303(d) waters. States use hundreds of different terms or codes in describing sources of impairment, ranging from the general (e.g., "nonpoint sources") to highly specific (e.g., "Duenweg Mines Area", "zebra mussels", "I-95 culvert has inadequate passage"). For this analysis, Tetra Tech grouped all the source terms and codes in a particular manner. "PS" includes any codes referring to discharges from point sources likely to be included in PCS. "NPS" includes any source codes involving nonpoint sources that produce pollutants that could reasonably be addressed with controls in TMDLs (e.g., agriculture, silviculture, urban runoff, abandoned mines, road maintenance). "Other" includes any source codes that are unlikely to be addressed with controls in TMDLs, either because they

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these 44 States plus DC, there are 18,162 303(d)-listed waters, of which 16,143 have been georeferenced.) Interpreting the "within and upstream" case as an upper bound, we thus believe that at most about 1/4 of all TMDLs have the potential to trigger additional controls for point sources. In contrast, the "within only" case provides a reasonable lower bound. In the "within only" case, there are XXX water bodies that are impaired by one or more of the five pollutants and have one or more point sources discharging the impairment pollutant directly into the impaired water. This suggests that there may be as few as XXX percent of all TMDLs that have the potential to trigger additional controls for point sources.

involve pollution rather than pollutants (e.g., habitat alteration, hydrologic modification), or because they are very unlikely to be controllable by a State (e.g., air deposition). "Unknown" is where a State reports that a source of an impairment is unknown. "Not reported" includes instances in which the State provides no information of any sort about the sources responsible for an impairment.

- As shown in the exhibit, States may report several sources of impairment for a single water body. The various sources of impairment may all contribute to a single cause of impairment (e.g., both point sources and nonpoint sources may contribute excessive nutrients), or one source of impairment may be responsible for one cause while another source is responsible for another cause (e.g., a water body is impaired by BOD from a point source and by undetermined toxicity from an unknown source), or there can be various other combinations.

- Unfortunately, there is no information available on the sources of impairment for many 303(d) water bodies. Among the 4,234 water bodies identified in the "within and upstream" case, for example, more than 43 % have either no source information reported or report unknown sources only.

The final column of the exhibit presents our judgment as to whether point sources affecting these water bodies are likely to be addressed in TMDLs. For example, if the State cites the water body as impaired by point sources only, we presume that a TMDL is likely to consider further control requirements for all relevant point sources. The opposite would be true for a water body that the State cites as impaired by nonpoint sources only -- for this water body, we would not expect a TMDL to consider further controls for the point sources that we have identified as presumably discharging the impairment pollutant. The decision rules underlying the conclusions in the final column are:

- Point sources will be addressed in TMDLs for any water for which a State cites point sources as being among the sources of impairment;

- Point sources will not be addressed in TMDLs for any water for which a State: a) Cites one or more sources of impairment (except for "unknown"); and b) Does not include point sources among the cited sources; and

- For water bodies for which a State provides no information on sources of impairment ("not reported") or cites only "unknown sources", we have no information suggesting whether point sources will or will not likely be addressed in TMDLs.

We regard the first two sets of waters -- those for which we have information suggesting whether point sources are among the source types responsible for impairment -- as a sample, and extrapolate data from them to the third set of waters for which we do not have such information. We assume that the degree to which various source types are responsible for impairments in the third set of waters is the same as it is in the first two sets of waters.[64]

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64 We are not aware of any reason why the third set of waters should be systematically different from the first two sets of waters. Among the 44 States plus DC that we cover in the analysis, we do not find any important differences between the States that do not report 303(d) source information (which contribute the great majority of the third set of waters) and those that do.

II. EXTRAPOLATING INFORMATION FROM WATERS WITH KNOWN SOURCES OF IMPAIRMENT TO WATERS WITHOUT KNOWN SOURCES OF IMPAIRMENT

Our process for using information on these three sets of waters in order to estimate point source implementation costs is rather complex.

At this point, we introduce a new, "shorthand" terminology. We refer to an impaired water as "tagging" a point source if the point source presumably discharges the impairment pollutant directly to the impaired water (for the "within only" case) or directly to the impaired water or within 25/50 miles upstream (for the "within and upstream" case). All the point sources in our analysis are tagged one or more times by impaired waters. Many point sources are tagged multiple times. If a water body is impaired for several pollutants, a particular point source may be tagged multiple times by that water body for different pollutants. For example, according to the EPA engineers' judgments, a major POTW is presumed to discharge all five pollutant classes that we analyze -- BOD, nutrients, metals, ammonia, and toxic organics -- in sufficient quantity so as potentially to warrant further controls beyond applicable technology-based standards. A water body that is impaired for all five of these pollutants thus could "tag" a major POTW that discharges into this water body five times, once for each pollutant class. A point source can also have multiple tags because it is tagged by multiple water bodies. Particularly in the "within and upstream" case, there can be several impaired water bodies within 25/50 miles downstream of a point source. Even in the "within only" case, impaired water bodies may overlap and point sources are sometimes tagged by multiple water bodies.

When a point source is tagged multiple times for different pollutants by water bodies of different sorts (i.e., by some water bodies that are presumed to impose costs on the point sources they tag, by some that are presumed not to impose costs on the point sources they tag, and by some that are in the undetermined and "to be scaled to" category), it becomes complex to determine whether the point source should or should not be expected to incur costs for further controls. We take the following steps:

- Point sources that are tagged by one or more waters with reported source types become the set of facilities that we scale from. We estimate for this set of "scale from" facilities: A) What their costs would be if <u>all impaired waters</u> (not just those waters impaired by point sources, among other source types) were assumed to impose costs on relevant point sources; and B) What their costs are when we assume that <u>only those waters impaired by point sources</u> impose costs on relevant point sources. Among the "scale from" facilities, our assumption that point sources do not incur costs when they are tagged by waters not impaired by point sources results in reducing the total estimated implementation costs from A to B. Expressed another way, the fraction B/A represents the degree to which the potential total cost of all tags (among the "scale from" facilities) gets reduced by recognizing that some tags do impose costs on point sources and that some do not.

- Point sources that are tagged exclusively by waters that are uncertain in whether or not they will impose costs on point sources ("source not reported" or "source unknown" waters) become the set of facilities that we scale to. We estimate the costs these facilities would bear if all the waters that tag them were of a sort that would impose costs on point sources (C). We then multiply this raw cost by the fraction B/A, representing the degree to which (based on the "scale from" facilities) the raw cost is reduced by recognizing that some tags do not impose costs on point sources.

- The resulting total costs for point sources is given by:

  B + [(B/A) x C].

  where A = the costs among "scale from" facilities if all tags were to impose costs on point sources
  B = the costs among "scale from" facilities from tags only by those water bodies that we assume do impose costs on point sources (i.e., water bodies that states cite as impaired by PS, as well as perhaps additional source types)
  C = the costs among "scale to" facilities if all tags were to impose costs on point sources.

Sample calculations of this sort are shown in the exhibit below, for Scenario 1 ("No TMDL Program")

Exhibit G-2
Calculations Reflecting Information from States on Sources of Impairment (Scenario 1)

	Within Only Case		Within and Upstream Case	
	Costs (billion $/yr)	**# of PS**	**Costs (billion $/yr)**	**# of PS**
All tagged facilities, assuming all water bodies impose costs on point sources	$1.684	7012	$3.369	19438
A. "Scale from" facilities (those tagged by water bodies with information on responsible source types)	$1.060	4324	$2.078	12086
B. "Scale from" facilities that do incur costs (tagged by water bodies impaired by PS)	$0.681	2557	$1.343	7394
"Scale from" facilities that don't incur costs (tagged by water bodies not impaired by PS)	$0.379	1767	$0.734	4691
Scaling factor: B/A	0.64	0.59	0.65	0.61
C. "Scale to" facilities (those tagged exclusively by water bodies without information on responsible source types)	$0.624	2688	$1.291	7353
"Scale to" facilities that will incur costs, after application of scaling factor: (B/A)xC	$0.401	1590	$0.835	4498
Total estimated costs and number of facilities: B + (B/A)xC	$1.082	4146	$2.178	11893

Referring to the figures for the "within only" case, if we were to assume that water quality-based permits would be developed for all tagged point source facilities, even those that discharge into waters impaired by nonpoint sources only, 7012 point sources would incur costs of $1.684 billion/year. However, we assume that tagged point source facilities that discharge only into waters impaired by nonpoint sources will not have water quality-based permits issued for them, and costs thus decline to $1.082 billion/year for 4146 facilities. Our assumption that waters impaired by nonpoint sources only will not give rise to control obligations for point sources has the effect in this case of reducing costs by 36% and the number of point sources affected by 41%. This assumption has roughly similar impacts in reducing costs and the number of sources affected for other cases (i.e., "upstream and within") and Scenarios (i.e., Scenarios 2 and 3).

APPENDIX H: DETAIL ON SIMULATING "COST-EFFECTIVE WASTE LOAD ALLOCATIONS"

I. CIRCUMSTANCES WHERE COST-EFFECTIVE WLAs MAY BE POSSIBLE

We assumed that a cost-effective WLA could occur only if both point sources and nonpoint sources were believed by the State to be responsible for impairment of the water body. If point sources alone were responsible for the impairment, there would presumably be no or few contributing nonpoint sources to whom some of the point sources' responsibilities for further controls could be shifted. The following exhibit shows the source combinations for which we assumed cost-effective WLAs to be possible:

Exhibit H-1
Impairment Source Combinations for Which Cost-Effective WLAs are Assumed Possible

Sources of Impairment Reported by States	Are TMDLs for These Water Bodies Likely to Require Further Controls for Point Sources?	Are Point Sources Affecting These Waters Then Candidates for Cost-Effective WLAs?
PS only	Yes	No
NPS only	No	No
other only	No	No
unknown only	Unclear – scale to these waters	Unclear – scale to these waters
not reported	Unclear – scale to these waters	Unclear – scale to these waters
PS + NPS only	Yes	Yes
PS + NPS + other only	Yes	Yes
PS + NPS + unknown only	Yes	Yes
PS + other only	Yes	No
PS + unknown only	Yes	No*
PS + other + unknown only	Yes	No*
NPS + other only	No	No
NPS + unknown only	No	No
NPS + other + unknown only	No	No
other + unknown only	No	No
PS + NPS + other + unknown	Yes	Yes
Total		

The final column of the exhibit indicates that we assume cost-effective WLAs to be possible only for waters for which the State indicates that both point and nonpoint sources are responsible for the impairment. Waters for which there is no information about the source types responsible for impairment are scaled to.

Note that point sources may be "tagged" as needing further controls by multiple water bodies. We assume that a point source can benefit from a more cost-effective WLA and avoid the next treatment step for a particular pollutant if and only if:

- It is tagged by at least one "yes" water body for that pollutant (i.e., the point source needs further treatment for a pollutant as a result of a water body that also has nonpoint sources that contribute that pollutant)

- It is not tagged by any "no" water bodies for that pollutant. A single "no" water body that tags a point source will preclude the point source from avoiding the next treatment step for that pollutant.

- "No*" water bodies have no effect. They represent situations in which it is not clear whether or not cost-effective WLAs will be possible -- point sources will incur costs (the first condition for possible trade offs), but it is uncertain whether or not there will be nonpoint sources also found to contribute to impairment. Perhaps the "unknown" sources will eventually prove to be nonpoint sources and a cost-effective WLA will be possible, perhaps not. In our simulation, a tag by a "no*" water body neither enables cost-effective WLAs nor precludes them.

The assumption that a tag by a single "no" water body precludes a source from participating in a cost-effective WLA is conservative and has an important effect in reducing the number of point sources that we estimate as likely to be able to reduce their needs for additional treatment. Many point sources are tagged by several water bodies, all but one of which would be amenable to cost-effective WLAs. We assume, however, that the one non-amenable water body precludes such sources from avoiding the next treatment step for the impairment pollutant.

We assumed there would be an opportunity for a more cost-effective WLA only for water bodies impaired by nutrients and/or BOD. However, even if a water body is impaired for one of these pollutants and is amenable to a cost-effective WLA, a point source discharging one of these pollutants may not be able to participate in the more cost-effective WLA if the point source discharges another pollutant that requires the point source to implement the next treatment step notwithstanding the cost-effective WLA.

More specifically, the assumed next treatment step for nutrients (secondary treatment with nutrient removal) is also the next treatment step that we assume is required if the point source needs to provide further controls for toxic organic compounds. Thus, a point source that needs further control of both nutrients and toxic organics will need to implement secondary treatment with nutrient removal to address the toxic organics, whether or not there is a cost-effective WLA for nutrients. In effect, a need to control toxic organics prevents a point source from saving any money by participating in a cost-effective WLA for nutrients. Likewise, a need to control ammonia prevents a point source from saving any money (avoiding the need for advanced secondary treatment) by participating in a cost-effective WLA for BOD. In sum, we assume that a point source may avoid the need for a next treatment step by participating in a more cost-effective WLA if the point source needs additional control for:

- Nutrients and not toxic organics; and/or
- BOD and not ammonia.

II. COSTS FOR CONTROLLING NONPOINT SOURCES RELATIVE TO POINT SOURCES

The following are several examples suggesting the magnitude of costs for nonpoint sources to abate a pollutant load in comparison to the costs for point sources to abate a similar load. Most of these examples involve point/nonpoint effluent trading. Nearly all involve nonpoint source controls substituting for additional point source control efforts for nutrients or BOD. Most of the following are prospective studies of the savings if trading were to be implemented. Few are retrospective estimates of what actual trades have saved.

Long Island Sound, CT - The State of Connecticut estimated that to reach the 15 year goal of nitrogen reduction in the absence of trading would cost point sources (mostly POTWs) $960 million, while the inclusion of trading would reduce costs to $760 million. Thus trading is expected to result in a $200 million savings over 15 years. The great majority of the trading simulated here is point/point trading, not point/nonpoint.

Tar-Pamlico, NC - A Great Lakes Trading Network report cites an estimate by a member of the Tar-Pamlico Basin Association that nutrient reduction for point sources would cost approximately $70 million compared with $11 million for similar reductions through increased NPS controls.

Saginaw Basin, MI - Modeling performed by World Resources Institute. Establishing a 0.5 mg/L phosphorus limit for point sources would reduce loadings by 16% at a cost of $23.89/lb reduced. A broad subsidy program to non-point sources would cost $16.00/lb reduced. The least cost solution -- a targeted and performance-based subsidy to only some non-point sources -- would reduce loadings 15% and cost $1.87/lb. What was identified as a best solution (not the least cost) would be a combination of point source controls and point/non-point trading (including targeting the most cost-effective NPS reductions) using 2:1 ratios; this would reduce loadings 26% and cost $4.37/lb reduced.

Minnesota River Basin, MN - Modeling performed by WRI, very similar to the Saginaw study. The Study projects that the costs per lb of controlling P could be reduced from $18 for point source controls only to $4-5 for trading coupled with "targeted" BMPs.

Boulder Creek, CO - Estimated savings (thought 12/96) of $3 - $7 million as a result of in-stream restoration efforts rather than plant upgrades alone. No information regarding what percentage savings this represents.

Virginia Tech Study (Watershed'96) - Paper showed a range of non-point source control costs typical for Virginia compared with Biological Nitrogen Removal. BNR costs were listed as $20-$50/lb. Most non-point source costs listed were less expensive; some were more expensive.

Lower Boise River, ID - Municipalities were asked to consider what their 20 year plan would be in the face of a mandated 20%, 40% or 80% phosphorus reduction, given a low population growth scenario and a high population growth scenario. The municipalities responded that the cost range for an 80% reduction would be $12-$178/lb of P. For non-point sources, the stakeholders looked at a few BMP studies that focused primarily on sediment reductions at sites on the Boise River and the mid-Snake River, and factoring in what is known about the sediment-phosphorus relationship, determined that the costs of phosphorus reductions would be in the range of $2-$20/lb of P. The implied cost savings are therefore $10-$158/lb. of P, but with some uncertainty as to what will actually occur in the market.

Lake Chatfield, CO - A high level of further point source reductions would be necessary before NPS reductions and trading become economical.

Stamford, CT (Watershed '96) - It was calculated that reductions from the treatment plant would be more cost-effective than reductions from non-point sources.

Exhibit H-2
Percent Savings in Cost per Pound for Nonpoint Source Controls
Relative to Point Source Controls

Long Island Sound, CT	21
Tar-Pamlico, NC	84
Saginaw Basin, MI	82 - 92
Minnesota River Basin, MN	75
Boulder Creek, CO	Unknown
Virginia Tech study	Variable
Lower Boise River, ID	83 - 89
Lake Chatfield, CO	Minimal
Stamford, CT	Negative

Among the seven instances where the percentage savings can be rank-ordered (all except for Boulder Creek and the Virginia Tech study), the median figure is a 75 % savings.

APPENDIX I: DETAIL ON ESTIMATED COSTS FOR NONPOINT SOURCES

This Appendix provides detail on how the costs for nonpoint sources were estimated for the "Least Flexible TMDL Program" scenario (Scenario 1). Under this Scenario, we assume when a State identifies a water body as impaired by a nonpoint source type that the State will require further control for the entire volume of that nonpoint source activity that occurs within the county or counties in which the impaired water body is located. Costs under Scenarios 2 and 3 are estimated by adjusting the information and estimates developed for Scenario 1 in the manner described in Chapter III, Section C.

I. AGRICULTURE

A. CROP LAND

We found 2,228 water bodies on States' 303(d) lists that States have identified as impaired by crop land. These water bodies were either cited directly in a State's 303(d) submission as impaired by crop land, or they were cited as impaired by crop land in a State's 305(b) submission and corresponded to a 303(d)-listed water body. These water bodies are in 710 counties[65] in 23 States. We assume conservatively that the remaining States may have crop land-impaired water-bodies, but either did not report sources of impairment at all or reported them in a manner that was insufficiently specific to identify crop land as a source of impairment. The 23 States reporting crop land-impaired 303(d) waters contain 240.3 million acres of crop land. In the Nation as a whole, there are 375 million acres of crop land. We assume that the degree to which crop land impairs waters in the 23 "reporting" States is replicated in the remaining States. The scale factor to extrapolate from whatever crop land costs we estimate for the 23 States to the entire nation is thus 1.56 (375 million divided by 240.3 million).

1. Extent of nonpoint source activity requiring BMPs

We determined the amount of crop land in these 710 counties, located in 23 States, using crop land acreage data from USDA's 1997 National Resources Inventory (NRI) as it existed prior to recently released corrections. We also acquired data from NRI on the acreage of this crop land that is eroding at greater than 15 tons/acre/year, and on the average slope of the crop land in each of these counties.

There are 128.1 million acres of crop land in the 710 counties within which the crop land-impaired water bodies are located. We assume for the "Least Flexible" scenario that the TMDLs for these impaired water bodies will require the implementation of BMPs for the entire acreage of crop land in these counties. The 128.1 million acres of crop land needing BMPs in these 23 States represent 53.3 percent of all the crop land in the 23 States. Applying a scale factor of 1.56 to extrapolate from the 23 States to the entire nation, we estimate that there are 199.9 million acres of crop land in the nation that will need to implement BMPs under the Least Flexible scenario.

2. Description of the BMPs required where controls are needed

We assumed that owners of crop land identified as contributing to impairment of a 303(d) water will achieve the load reductions required by TMDLs by implementing BMPs that are widely available, relatively low cost, effective, and easily put in place. Based on these criteria and the ability to slow or

65 3 of the 710 counties have no crop land.

prevent soil erosion and phosphorus and nitrogen loss from crop lands, five broad groups of practices were selected for use on crop lands contributing to impairment of 303(d) waters:

1. Conservation tillage
2. Nutrient management
3. Practices to reduce sediment transport within or at the edge of the field
4. Practices to protect and restore riparian areas
5. Management of highly erosive crop land

These conservation practices or groups of practices are described as follows:

a) *Conservation tillage.* Management of planting and tillage practices and crop residues so as to maintain at least 30 % of the soil surface covered by residue after planting. Three varieties of conservation tillage include no-till, mulch till and ridge till. Conservation tillage increases the water-holding capacity of the soil and reduces sheet and rill erosion.

b) *Nutrient management.* Balancing the amount of nutrients provided with crop nutrient requirements so as to prevent nutrient loss to the environment. Requires proper timing of nutrient application and control of the amount of nutrients applied.

c) *Practices to reduce sediment transport within or at the edge of the field.* In general, physical measures to reduce slope length and steepness (e.g., contour farming, terraces, contour strip-cropping) reduce runoff velocity and increase infiltration. Vegetative measures (e.g., grassed waterways, filter strips, vegetative barriers, field borders) will also slow runoff, increase infiltration and trap sediment. A wide variety of different practices can be appropriate in different circumstances. In order to develop a reasonably conservative (i.e., not likely to be too low) estimate for the costs of applying appropriate practices to reduce in-field or edge-of-field sediment transport, we will assume costs as if vegetative barriers were to be implemented. Vegetative barriers are intended to reduce concentrated (gully) erosion on sloped crop land by planting a series of 4 - 6 feet wide barriers of stiff, tall grasses across a field at specified increments of elevation. Vegetative barriers entail installation and management costs that likely exceed the costs for most other in-field or edge-of-field measures to reduce sediment transport.

d) *Practices to protect and restore riparian areas.* These may include practices that intercept runoff before it reaches streams or lakes (e.g., riparian filter strips, riparian forest buffers) and practices that protect the waterway's banks and channel (e.g., streambank and shoreline protection, livestock exclusion, stream channel stabilization). Again in order to develop a reasonably conservative estimate for the costs of such practices, we will assume costs as if riparian forest buffers were to be implemented. Riparian forest buffers include: 1) a permanent zone of trees and shrubs adjoining the water, 2) an additional adjoining zone of trees and shrubs from which modest harvesting may occur; and 3) an additional vegetated filter strip when the buffer is adjacent to cropland or other erosive areas. Such a corridor of permanent vegetation on the banks of a water body will reduce sediment, nutrients and other pollutants in surface runoff, and will also reduce excess nutrients and other chemicals in shallow ground-water flow. The riparian buffer will also create shade to lower water temperatures, stabilize banks, provide wildlife habitat, and protect against scour erosion within the floodplain. Establishment costs for riparian forest buffers are likely higher than other riparian measures to intercept runoff.

e) *Management of highly erosive crop land.* A variety of more intensive measures can be targeted specifically for crop land that is eroding at high rates. One possibility is to retire such crop land: take it out of production and establish a permanent vegetative cover on it. Retirement, conservation crop rotations, contour strip cropping, terracing and other measures will substantially reduce losses of soil and agricultural chemicals. In estimating the costs of this practice, we will assume that all crop land eroding at greater than 15 tons/acre/year (as estimated in NRI) will need one of these more intensive measures. Again, in order to be conservative in costing, we will estimate costs as if the selected measure is to retire the land and establish permanent vegetative cover on it.

For most crop land-related water quality problems, the combination of all these selected practices will be more than enough to mitigate the contribution of crop land to impairment. TMDLs requiring reductions of sediment or nutrients from agricultural land have typically required reductions in the range of 20 - 70 %.[66] EPA cites the following rough estimates of the effectiveness of some of the practice groups we are assuming will be applied:[67]

Exhibit I-1
Relative Gross Effectiveness of Sediment Control Measures (% reduction)

Practice Category	Total Phosphorus	Total Nitrogen	Sediment
Reduced tillage systems (e.g., conservation tillage)	45	55	75
Diversion systems (e.g., grassed waterways)	30	10	35
Terrace systems	70	20	85
Filter strips (vegetative control measures)	75	70	65

These effectiveness figures are for each of the practices applied individually. We assume, however, that several of these practices will be applied simultaneously (conservation tillage plus in/edge-of-field measures plus riparian measures), as well as additional measures not among those shown in the table (nutrient management planning plus management of highly erosive crop land). In most circumstances, the entire package of practices that we assume and then estimate costs for will be more than enough to achieve the desired reduction in load from crop land. This fits with our aim to be generally conservative in costing. In some instances, however, the water quality problem caused by crop land may not be addressed by the group of practices we assume. For example, water quality problems relating to use of agricultural herbicides may require application of BMPs other than these (e.g., integrated pest management). We have also not considered any of the specific measures that might apply particularly to

66 We will update this range when we complete the review we plan to do of additional completed TMDLs for "ground-truthing" purposes.

67 U.S. EPA. *National Management Measures to Control Nonpoint Source Pollution from Agriculture.* Page 101. (http://www.epa.gov/owow/nps/agmm/chapter_4)

irrigated agriculture.[68] Note, though, that even in these instances where our set of practices might not be sufficient (e.g., pesticides, irrigation), the set of practices that we do simulate will at least contribute substantially to diminution of the water quality problem. For example, the practices we simulate that reduce sediment losses and transport will also sharply reduce direct runoff of pesticides and transport of pesticides adsorbed to soil particles.

In assuming the application of this full set of practices in our cost analysis, we do not mean to imply that all these particular practices should necessarily or always be chosen by farmers to meet the load reduction requirements of TMDLs. Conservation tillage, for example, is obviously not appropriate for crops that do not involve tillage. The choice of appropriate practices will be highly site-specific, depending on both the nature of the agricultural operation and the nature and severity of the water quality problem. We intend this chosen set of practices as a reasonably comprehensive set of measures that will be more than sufficient to address the great majority of water quality problems from crop land. We might attempt to be more specific about additional tailored practices that could be appropriate in particular circumstances (e.g., for irrigated land, for tile–drained land, for different sorts of crops), but we judged that our current level of detail is reasonable for a nationwide analysis that involves broad uncertainties in virtually all the other steps in developing cost estimates.

In estimating the costs of applying this group of practices to crop lands that contribute to water quality impairment, we have further assumed particular BMPs that we use to represent the cost of each practice group. Each practice group includes a range of possible BMPs (e.g., in-field or edge-of-field measures to reduce sediment transport can include many different contouring, buffer and runoff management measures). For costing purposes, though, we have chosen a single, relatively expensive BMP to represent what it might cost to implement whatever specific BMP among the practice group is appropriate in each individual circumstance. The specific BMPs we selected for costing purposes are as follows:

Exhibit I-2
Specific BMPs Selected to Represent Practice Groups for Costing Purposes

Practice Group	BMP Selected for Costing
Conservation tillage	Mix of no-till/ridge till/mulch till
Nutrient management	Nutrient management planning: plans, soil testing
Practices to reduce sediment transport within or at the edge of the field	Vegetative barriers (discrete)
Practices to protect and restore riparian areas	Riparian forest buffers
Management of highly erosive crop land	Retirement of land and establishment of permanent cover

68 The great majority of States do not identify sources of agricultural impairment with sufficient specificity to indicate whether the crop land is irrigated or whether irrigation somehow contributes to the problem. Even if we wanted to simulate the application of a set of practices specifically for irrigated crop land, we would have difficulty determining where these practices might need to be applied and where they would not.

These specific BMPs will be described further in the next section. We have selected these specific BMPs only for the purpose of estimating costs. We do not mean to imply that these particular BMPs should or must be applied by farmers in order to mitigate water quality problems. Again, the selection of appropriate BMPs in practice should be site-specific. One or more of our particular selected BMPs may be poor choices in many circumstances. Riparian forest buffers are not reasonable for areas where trees are very difficult to plant and grow. Vegetative barriers are a relatively new and somewhat experimental (but very promising) measure, and alternative in-field measures should also be considered. We have not selected these particular BMPs with the intention of being prescriptive. Instead, we believe these particular BMPs are reasonably broadly applicable and they are among the more expensive BMPs included within each of the practice groups, and they therefore provide a relatively conservative indication of what the costs of abating loads from crop lands might be.

3. Unit costs for These BMPs

For each BMP in each of our 710 counties, we (1) determined the number of crop land acres to which the BMP would need to be applied; (2) estimated the cost per acre required to implement the BMP; and (3) estimated the proportion of acreage that is assumed already to have the BMP in place. Further detail on these procedures for each of the five crop land BMPs is provided below.

Exhibit I-3
Retirement

Extent BMP is Needed	Unit Cost for BMP	Degree Already Implemented
For all cropped crop land eroding at > 15 tons/acre/yr in every county with at least one crop-impaired water body. These data were obtained from NRI.	Assume that Conservation Reserve Program (CRP) rental payments for retired crop land equal the actual social cost of this BMP. Annual rental costs were estimated at $52.76/acre/yr (the avg. rate for latest CRP signup). Establishment cost for cover estimated at $67.20/acre (low, for non-native grasses) to $98.86/acre (high, for native grasses).[69] Annual maintenance cost assumed as zero (low est.) to $5/acre (high est. based on MD CREP data).	Much highly erosive land is already enrolled in CRP and retired. Such land is not counted as crop land in NRI. Thus, none of the additional crop land we calculate as needing to be retired (based on NRI figures) has yet been retired.

69 USDA, comments provided to EPA upon review of draft version of this report, June/July, 2001.

Exhibit I-4
Riparian Forest Buffer

Extent BMP is Needed	Unit Cost for BMP	Degree Already Implemented
75-foot wide corridor on each side of every crop-impaired water body. (NRCS conservation practice standard is for minimum of 55 feet plus)	For low est., assume that CRP rental rate ($52.76/acre/yr for latest signup) accurately represents social cost of having land in this use rather than crop production. For high est, assume that USDA CREP rental payments needed to attract small tracts represent the social cost ($130/acre).[70] Add to this the cost of establishing trees (assume $300/acre for poplar[71]) plus annual maintenance cost (assumed at $5/acre/yr based on MD CREP)	About 2.2 of the needed 4.2 - 5.0 million acres of all sorts of buffers are currently in place. However, more than 90 % of the buffer acreage in place is grass waterways and shelterbelts.[72] For low cost estimate we assume 25% of the needed riparian forest buffer is already in place, for high estimate we assume zero.

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70 USDA. Ibid.

71 See Turhollow, A. July 2000. *Costs of Producing Biomass from Riparian Buffer Strips.* Oak Ridge National Laboratory, Energy Division.

72 See TetraTech. July 2000. *Draft Nonpoint Source Gap Analysis.*

Exhibit I-5
Vegetative Barrier

Extent BMP is Needed	Unit Cost for BMP	Degree Already Implemented
Barrier 4 feet wide constructed for every 5 feet of elevation difference in crop field.[73] Applied to all crop land in every county with at least one crop-impaired water body. The acreage that would be needed for continuous barriers in each county is calculated from crop acreage and slope data in NRI, then scaled by 5/14 to represent the lesser acreage that would be needed for discrete barriers.[74]	Similar reasoning as for riparian forest buffer. Costs = CRP rental rate or CREP payment rate for small plots + establishment cost ($100/acre for switchgrass[75]) + annual maintenance cost. (Note: establishment cost might be higher for very small plots as would be in barriers than the figure in the reference.) Annual maintenance costs were assumed to range from $5/acre (lower estimate, as above) to $10/acre (higher estimate; SEDLAB suggests vegetative barriers could need more costly maintenance than other sorts of vegetated strips)	No data. Given the newness of this BMP, we presume that very little is already in place. We have assumed that none is in place.

73 Based on SEDLAB briefing. See USDA. *Vegetative Barriers: A New Upland Buffer Tool*. National Sedimentation Laboratory. Upland Erosion Processes Research Unit. (http://www.sedlab.olemiss.edu/uep_unit/projects/Dab_veg/index.htm)

74 Ibid. The SEDLAB briefing simulates both continuous (following the complete field contour line) and discrete (placed strategically on only those portions of the field contour line where gully erosion is most likely) barriers.

75 See Turhollow, A. July 2000. *Costs of Producing Biomass from Riparian Buffer Strips*. Oak Ridge National Laboratory, Energy Division.

Exhibit I-6
Conservation Tillage

Extent BMP is Needed	Unit Cost for BMP	Degree Already Implemented
For all annually planted crop land (that does not go into retirement, buffer or barrier) in every county with at least one crop-impaired water body	Low estimate: $12.43/acre in capital costs and $8.66/acre savings in annual costs.[76] (Note: these figures represent an average for the corn/wheat/soybean acreage where CT is already being used. One might expect that the cost savings from CT would be much less if it were applied to the acreage where it currently isn't being used. Pending further research, we will assume $8.66 as an upper estimate of savings and $0 as a lower estimate.) High estimate is based on figures from EQIP for ridge-till ($13.30/acre), mulch till ($10.60/acre) and no-till/strip-till ($23.70/acre), assumed to be annual costs.[77] These figures were weighted by the percentage of conservation tillage land in each of these three practices (3.2%, 53%, 43.8%) from CTIC, 1998, to derive an average cost per acre of $16.43.	37.2% of all planted acres nationally in 1998.[78]

76 See TetraTech. July 2000. *Draft Nonpoint Source Gap Analysis.*

77 USDA, 2001, op cit.

78 CTIC. 1998. *1998 Crop Residue Management Survey Report, 1998 United States Summary*. Conservation Technology Information Center, West Lafayette, Indiana.

Exhibit I-7
Nutrient Management Planning

Extent BMP is Needed	Unit Cost for BMP	Degree Already Implemented
For all crop land (that does not go into retirement, barrier or buffer) in every county with at least one crop-impaired water body.	USEPA estimates $5 - $15/acre/yr for nutrient management plan and soil testing.[79] NPS Gap analysis assumes $12/acre initial cost plus $7/acre for soil test every three years.[80] We assumed initial cost (for plan) of $7 - $15/acre and annual costs (testing) of $2.33 - $4/acre. Annual savings from NMP (at $.15 - $.25/lb of N) may range from virtually nothing to $30/acre. A median figure assuming farmers will save only through reduced use of commercial N is $10/acre/yr.[81] We use this as an upper estimate for cost savings, and zero as a lower estimate. (Note: These savings calculations could use more work.)	6 % of cultivated crop land is managed under CCA NMPs (NPS Gap analysis). Other surveys suggest more extensive use of NMP techniques: IL/IA/IN/WI – 30 - 37 %,[82] PA – 36 %.[83] We assumed 35% (upper estimate) or 17.5% (lower estimate) of total acreage already had nutrient management plans in place.

4. Total national annual BMP costs for crop land

To estimate the number of acres that will need each BMP, we used the following data from NRI for each of the 710 counties: (1) acres of crop land in the county; (2) the average slope of these crop acres; (3) the number of crop acres eroding at greater than 15 tons/acre/year. From these data, we estimated the nationwide acres needing BMPs as follows:

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79 See USEPA. *National Management Measures to Control Nonpoint Source Pollution from Agriculture.* Chapter 4A, page 63. (http://www.epa.gov/owow/nps/agmm/index.html)

80 TetraTech, July 2000, op cit.

81 U.S. EPA. *National Management Measures to Control Nonpoint Source Pollution from Agriculture.* Op cit. This document cites the change in N and P application rates observed for 19 USDA Demonstration and Hydrologic Unit Area Projects where nutrient management planning was implemented. (Source: Meals, Sutton and Griggs. 1996. Assessment of Progress of Selected Water Quality Projects of USDA and State Cooperators. USDA-NRCS. 1996) The median change in N use across 15 N-oriented projects was a reduction of 43 lb/acre. The median P reduction across 14 P-oriented projects was 21 lb/acre. We valued reduced N application at $.23/lb and reduced P application (conservatively) at $0/lb. $.23/lb x 43 lb/acre = roughly $10/acre. The source does not report whether changes in crop yields, costs for nutrient application, or other factors were observed in the projects. The absence of such data on other potential impacts of nutrient management planning means that our assessment of potential savings from nutrient management planning are incomplete.

82 See Khanna et al., 2000. Site Specific Crop Management: Adoption Patterns and Incentives. *Review of Agricultural Economics*. 21: 455-472.

83 See Shortle et al. 1993. *Economic and Environmental Potential of the Pre-sidedressing Soil Nitrate Test.* Draft final report on the USEPA Contract No. CR-817379-01-0, Department of Agricultural Economics and Rural Sociology. The Pennsylvania State University.

a. Retirement acres

In each of the 710 counties, the acreage to be retired was assumed to be all acres that are eroding at a rate greater than 15 tons/acre/year. We then summed over all counties to find the total acres to be retired in the 23 States, and multiplied this sum by the scaling factor of 1.56 to obtain the national estimate. In the 710 counties, there are 3,118,400 acres of crop land eroding at greater than 15 tons/acre/year. Nationally, we estimate 4,864,704 acres of crop land to be retired.

b. Riparian forest buffer acres

The number of acres requiring riparian buffers in each county depends on the length of the banks of the impaired waters in the county and the width of the buffer that is assumed necessary. For each crop land-impaired water body, we obtained information from the 303(d) data base on its size -- its length (for rivers and coastal shorelines) or area (for lakes and estuaries). A 75 foot buffer[84] was assumed to be necessary on each side of the rivers, around the perimeter of lakes and estuaries, and along the length of coastal shoreline. We calculated the total number of bank-feet needing buffers as follows:

- *For rivers.* We assumed that buffers would be required on each side of a river. The number of bank-feet needing buffers is thus double the length of all the impaired river segments.

- *For lakes.* We assumed that all lakes were circular in shape, and thus estimated each lake's circumference from its area. A buffer was assumed to be required around the lake's perimeter. The number of bank-feet needing buffers is therefore the circumference of the lake.

- *For estuaries.* Similarly as for lakes, we assumed that estuaries are roughly circular and calculated their circumference given their area. Estuaries are partly but not fully enclosed by land.; we assumed that the average estuary is enclosed by land around only two-thirds of its circumference. The number of bank-feet needing buffers is therefore the circumference multiplied by two-thirds.

- *For coastal shoreline.* A buffer is required on only the landward side, and the number of bank-feet needing buffers is thus equal to the length of crop-impaired shoreline.

We summed bank-feet across the crop-impaired water bodies in a county, and then estimated the number of acres to be put into riparian buffers in the county through the following equation:

Number of acres needing riparian buffer = total number of bank-feet x 75 feet x .000022957 acres/sq ft

We summed over all 710 counties and multiplied by 1.56 to scale up to the nation.

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84 The NRCS conservation practice standard for a riparian forest buffer requires a Zone 1 of at least 15 feet immediately adjacent to the stream and a Zone 2 of at least 20 feet adjoining Zone 1. The total should be 100 feet or 30 % of the flood plain, whichever is less, but at least 35 feet. In addition, when the riparian forest buffer is to be next to cropland or other sparsely vegetated or highly eroded areas, NRCS recommends an additional filter strip (Zone 3) of at least 20 feet. For cropland riparian buffers, we have assumed an average width of 75 feet, comprising Zones 1,2 and 3.

Calculating the number of bank-feet for each type of impaired water body as described above, we estimate 469,364,293 bank-feet needing buffers for the 2,228 crop-impaired water bodies in the 710 counties. Applying a buffer depth of 75 feet, converting to acres and scaling to the entire nation, we estimate 1,260,698 acres of riparian forest buffer needed. We assume that all this buffer will be land that was formerly crop land.

c. Vegetative barrier acres

We developed assumptions based on a briefing describing this BMP by the USDA National Sedimentation Laboratory (SEDLAB).[85] SEDLAB considers the use of two types of vegetative barriers: continuous contour barriers, and discrete barriers. Continuous vegetative barriers on contours across the full width of a field would prevent both sheet and rill and concentrated erosion, whereas properly located discrete barriers would be sufficient to prevent concentrated erosion alone. A SEDLAB simulation suggests that discrete barriers might require only 5/14 the acreage that continuous barriers would require. We assumed that conservation tillage would satisfactorily reduce sheet and rill erosion, and hence simulated the implementation of discrete vegetative barriers to address concentrated erosion specifically. We simulated discrete buffers by first estimating the acreage of continuous barriers that would be needed and then by scaling this acreage down by the 5/14 factor.

Consistent with SEDLAB guidance, we assumed a 4-feet wide continuous vegetative barrier for every 5 feet of field elevation change. We estimated the acreage of continuous barriers that would be needed in counties with crop impairments for all crop land that will neither be retired nor put in riparian forest buffers. The proportion of crop land acres in each county that will need to go into barriers is given by the following equation:

$$\textit{Fraction of acreage needed in barrier strips} = 0.8 * [1/\mathrm{sqrt}(1+1/(\textit{average slope})^2)]$$

We estimated the number of acres needing vegetative barriers by multiplying this fraction by the total crop land acres in each county. We then scaled down this acreage estimate in each county for continuous barriers by multiplying by 5/14. To calculate the national estimated acres required for vegetative barriers, we summed over all counties and multiplied this sum by the scaling factor of 1.56.

In the 710 counties, assuming that the highly erosive crop land is retired and using the information on average slope, we calculate 2,524,753 acres as needed if continuous vegetative barrier strips were to be implemented. Scaling down by 5/14 to represent discrete barriers rather than continuous ones and scaling up by 1.56 to obtain a national estimate, we project 1,406,648 acres needed for discrete vegetative barriers.

d. Conservation tillage and nutrient management plan acres

To estimate the number of acres needing conservation tillage and nutrient management plans in the 710 counties, we subtracted from the total area of crop land in these counties the acreage that is to be retired, devoted to vegetative barriers, and devoted to riparian buffers to determine the acres of crop land remaining. It was assumed that both conservation tillage and nutrient management would be applied to these lands. We then scaled this estimate by 1.56 to extrapolate to the nation as a whole.

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85 SEDLAB, op cit.

In the 710 counties, there are:

128,138,800 acres	of crop land
- 3,118,400 acres	to be retired (eroding at > 15 tons/acre/year)
- 901,698 acres	needed for discrete vegetative barriers
- 808,140 acres	needed for riparian forest buffers
123,310,562 acres	needing conservation tillage and nutrient management

After scaling to the nation, we estimate 192,364,478 crop land acres potentially needing conservation tillage and nutrient management planning. However, not all of this acreage of crop land is planted in annual crops for which conservation tillage could be appropriate. Some is orchards, perennial crops, vegetables, potatoes, etc.. NRI, from which we draw our information on crop land in each county, estimates 375 million acres of crop land in the U.S. CTIC estimates only 293 million acres of annually planted crop land.[86] Thus 21.9% of all crop land ([375-293]/375) is inappropriate for conservation tillage. We scale down the estimated 123,310,562 acres potentially needing conservation tillage by a factor of .781 to account for the lesser acreage for which conservation tillage might by appropriate.

e. Total annualized national costs and savings from BMPs for crop land

To estimate the nationwide costs for each BMP, we multiply the total number of acres needing each BMP by the estimated costs per acre and by the percent of acreage needing BMPs. Summing across all 5 BMP costs, we estimate the total annual costs for crop land BMPs at roughly $1.3 billion/year (lower estimate) or $3.9 billion/year (higher estimate). Applying two further scaling factors (0.4484 to reflect the pace/lag scale factor and 1.13 to reflect unknown/not classified source information), we estimate the total annualized national cost at **$645 million/year** (lower estimate) and **$1.956 billion/year** (higher estimate).

For conservation tillage and nutrient management plans, we estimate the unscaled annual potential savings at up to $0.8 million and $1.6 billion, respectively. Applying the two further scaling factors (0.4484 to reflect the pace/lag scale factor and 1.13 to reflect unknown/not classified source information), we estimate the annualized national potential savings at up to **$414 million** for conservation tillage and up to **$804 million** for nutrient management plans. The lower estimate for potential annual savings for both of these practices is zero.

A spread sheet following the discussion of pasture land and range land provides detail on these calculations for crop land.

B. PASTURE AND RANGE LAND

We found 1,454 water bodies on States' 303(d) lists that States have identified as impaired by pasture and/or range land (either directly in their 303(d) submission or cited as impaired in their 305(b) submissions and corresponding with a 303(d)-listed water body).[87] These water bodies are in 511 counties

86 Conservation Tillage Information Center, 1998, op cit.

87 Sometimes States reported in a manner that identified whether the impairment was due specifically to pasture land or to range land or to both. In other instances, though, a State reported source information in a manner that did not allow us to determine whether pasture or range was responsible -- citing "animal damage to riparian zone", for example. Because we were unable to distinguish pasture from range impairments, we decided to estimate the amount of BMPs that are necessary to respond to both source

in 25 States. We assume conservatively that the remaining States may have pasture or range land-impaired water-bodies, but either did not report sources of impairment at all or reported them in a manner that was insufficiently specific to identify pasture or range land as a source of impairment. The 25 States reporting pasture or range land-impaired 303(d) waters contain 70.596 million acres of pasture land. In the Nation as a whole, there are 119.573 million acres. We assume that the degree to which pasture land impairs waters in the 25 "reporting" States is replicated in the remaining States. The scale factor to extrapolate from whatever pasture land costs we estimate for the 25 States to the entire nation is thus 1.69 (119.573 million divided by 70.596 million).

Similarly, in the 25 States there are 387.143 million acres of range land.[88] In the nation as a whole, there are 555.278 million acres. The scale factor for range land is thus 1.43.

1.Extent of nonpoint source activity requiring BMPs

Using NRI data, we determined that there are 25,628,300 acres of pasture land and 137,703,200 acres of private range land in these 511 counties. The pasture land in these counties constitutes 36.3% of all the pasture land in the 25 States (70.596 million acres). The private range land in these counties constitutes 45.9% of the private range land in the 25 States (299.986 million acres). We assume that in these counties there is also 45.9% of all the Federally owned grazing land in the 25 States (87.157 million acres), or 40.005 million acres of Federal grazing land. In total, then, there are 177.708 million acres of range land in the 511 counties.

Applying the scale factors of 1.69 and 1.43 to extrapolate from the 25 States to the entire nation, we estimate that 43.31 million acres of pasture land and 254.1 million acres of range land will need to implement BMPs in the Least Flexible TMDL Program scenario.

2. Description of the BMPs required where controls are needed

We assumed that owners of pasture land identified as contributing to impairment of a 303(d) water will achieve the load reductions required by TMDLs by implementing the following groups of BMPs:

1. *Prescribed grazing practices.* Planting, field management and livestock use are planned and coordinated such that grazing needs are met and healthy vegetative cover is maintained to minimize soil erosion. Also, grazing is managed in a manner to distribute the manure to

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types simultaneously, and then to split this total amount of BMPs required into portions attributable to each of pasture and range separately.

88 This calculation is complicated by the fact that the NRI data on range acreage by county covers private land only. In many States, though, there is substantial additional non-private land (e.g., Federal, State, Tribal) that is used for range grazing. This non-private range land, in additional to the private range land, will need BMPs if range-related impairments are to be remedied. We are unable to find complete data on non-private range land acreage. GSA provides figures (by State, not county) on Federal land leased for grazing purposes, which is likely the large majority of non-private range land. (Federal land leased for grazing amounts to roughly 38 % as much land as NRI reports for private range acreage.) We have added the amount of Federally leased range land to the private range land totals from NRI in estimating the extent of range land in each of the 25 "reporting" States and in the nation as a whole. Source of Federal range information: General Services Administration. *Summary Tables of Real Property Owned by the U.S. Throughout the World.* Table 12.

increase its rate of decomposition and nutrient cycling. In estimating the costs of such practices when applied to pasture land, we have assumed intensive rotational stocking as a specific practice. Intensive rotational stocking is defined as the rotation of grazing animals among several small pasture subunits (paddocks) rather than continuously grazing one large pasture. Each paddock is grazed quickly and then allowed to regrow for a period ungrazed until is it ready for another grazing. The practice both maximizes forage and eliminates denuded areas.

2. *Practices to protect and restore riparian areas.* As for crop land, we will assume riparian forest buffers as a relatively higher cost measure within this general category.

For range land, we assumed that conservation practices applied in riparian areas would be sufficient to address most range land-related impairments, and that measures addressing the range acreage itself would not be necessary. For costing purposes we assumed two alternative riparian measures that will establish two different cost estimates:

1. *Use exclusion.* Grazing animals are prevented from accessing the riparian zone, commonly by fencing it off. The exclusion may be permanent, or only when streambanks are most vulnerable to damage (via fences with gates). This will allow riparian vegetation to re-establish itself, and will prevent livestock from degrading a stream's banks and channel.

2. *Stream protection and/or bank stabilization*. These practices can include a variety of measures to protect and/or restore riparian areas, including livestock exclusion, alternate livestock watering facilities, tree planting, bank stabilization, filter strips, critical area plantings, channel vegetation, mulching, stock trails and walkways, and more.

Again, these various practices for pasture and range are selected for costing purposes. We do not mean to suggest that any of these specific practices must be chosen. Selection of specific BMPs should reflect the particular characteristics of the water quality problem and the pasture or range grazing operation that needs to be managed.

3. Unit costs for these BMPs

For these BMPs in each of the 511 counties with pasture and/or range-impaired waters, we (1) determined the number of acres to which the BMP would need to be applied; (2) estimated the cost per acre required to implement the BMP ; and (3) estimated the proportion of acreage that is assumed already to have the BMP in place. Further detail on unit costs for each BMP is provided below.

Exhibit I-7
Intensive Rotational Stocking (Pasture)

Extent BMP is Needed	Unit Cost for BMP	Degree Already Implemented
For all pasture land in every county with at least one pasture-impaired water body. These data were obtained from NRI.	Zero net costs. Several studies considering net farm profit find that intensive rotational stocking (IRS) is profitable relative to alternative approaches. IRS was found more profitable than continuous pasture, hay, or corn silage for dairy operations in PA.[89] IRS was found to increase net returns by 2 - 8 % relative to open access grazing for TX dairy farms.[90] Because of uncertainty in extrapolating these savings to all pasture operations, we have assumed zero savings as well as zero costs.	15 % in PA. Unknown elsewhere. The degree to which this practice is already implemented makes no difference, however, when we assume that it entails zero net costs.

Exhibit I-8
Riparian Forest Buffer (Pasture)

Extent BMP is Needed	Unit Cost for BMP	Degree Already Implemented
50-foot wide corridor on each side of every pasture-impaired water body. (NRCS conservation practice standard is for minimum of 35 feet plus). Note that this is different from the assumption for buffers adjoining crop land, which require an additional zone of 20 feet on each side.	Same approach as for riparian forest buffer for crop land. The average CRP rental rate for pasture land is $43.29, and for the low estimate we assumed that this represents the social cost of having land in this use rather than pasture. For the high estimate, we assumed $130/acre the average cost incurred by CREP to enroll small tracts, as discussed for crop land buffers. The cost of establishing trees ($300/acre) and annual maintenance cost ($5/acre) are assumed to be the same as for crop land buffers.	As cited previously, about 2.2 of the needed 4.2 - 5.0 million acres of all sorts of buffers are currently in place. However, more than 90 % of the buffer acreage in place is grass waterways and shelterbelts. We assume that no riparian forest buffer has been implemented for pasture land.

89 USDA, Grazing Lands Technology Institute. Dairy Farmer Profitability Using Intensive Rotational Stocking. September, 1996. Www.ftw.nrcs.usda.gov/pdf/Dairy.pdf

90 Jan McNitt, et al. *Livestock and the Environment: Precedents for Runoff Policy. Policy Options – CEEOT-LP*. Prepared for the U.S. EPA's Office of Policy Development, contract No. CR 820374-02. October, 1999.

Exhibit I-9
Use Exclusion (Range)

Extent BMP is Needed	Unit Cost for BMP	Degree Already Implemented
Along both banks for the entire length of every range-impaired water body. 9 acres are enclosed by fence (lost to grazing) per bank-mile (18 acres per stream mile), making the exclusion zone equivalent to roughly 75 feet in depth on each bank..[91]	Low estimate is based on costs from BLM/SCS studies.[92] Fencing installation costs $5261 per stream mile (1978 $), or $3,006 per bank-mile in current dollars. Annual O&M cost = 1 % of capital cost. Average annual rental rate for grazing land = $8/acre/yr or $9.14/acre/yr in today's $. Assume that riparian land lost to grazing is worth twice the average, or $18.28/acre/year. Assume 25 year useful life for fencing. High estimate. Fencing costs $19,000 per stream mile ($9500 per bank-mile).[93] Annual O&M cost = 5% of capital cost.[94] Value of lost grazing in exclusion zone calculated identically as for low estimate.	Assumed not to be implemented at all yet.

91 As summarized in RCG/Hagler, Bailly, Inc. *Controlling Nonpoint Source Loadings from Federal Lands: an Analysis in support of Clean Water Act Reauthorization.* July 1, 1992.

92 Ibid.

93 Robert Edwards and Travis Stoe, Susquehanna River Basin Commission. *Nutrient Reduction Cost Effectiveness Analysis, 1996 Update*. Publication No. 195, March, 1998.

94 RCG/Hagler Bailly, Inc. Op cit.

Exhibit I-10
Stream Protection and/or Streambank Stabilization

Extent BMP is Needed	Unit Cost for BMP	Degree Already Implemented
Along both banks for the entire length of every range-impaired water body. Assume that these practices are applied to a riparian zone of 100 feet in depth on each bank.[95]	Capital cost is estimated from NRCS data for 1997 on cost share payments per acre for installation of WP2 (stream protection) and SP10 (streambank stabilization) (avg. $47.88/acre, applied to the riparian zone calculated as the number of bank-feet of impaired water multiplied by the assumed 100 foot depth). This cost share amount is assumed to represent 40% (upper estimate) to 75% of total practice cost.[96] WP2 and SP10 useful life are assumed to be 15 years. Annual O&M costs are calculated similarly as for use exclusion – 1 % of capital cost for low estimate, 5 % for high estimate. 50 % (low estimate) to 100 % (high estimate) of the 100 foot depth riparian zone is assumed lost to grazing use, and the acreage lost is valued at $18.28/acre, as for use exclusion.	Assumed not to be implemented at all yet.

Note again that these two sets of practices -- use exclusion and stream protection and/or streambank stabilization -- are regarded as alternatives for protecting and restoring range-impaired riparian areas. The costs estimated for the two sets of practices represent alternative cost estimates. We do not presume that both sets of practices need to be applied, and the cost estimates are not to be added.

4. Total national annual BMP costs for pasture and range land

Because we have assumed that the unit costs of implementing intensive rotational stocking are zero, we estimate that there will be no cost to implement this practice on all the pasture land in the 511 counties with pasture-impaired waters in the 25 States. The cost after scaling to the nation is similarly zero.

Our procedure for estimating costs for pasture land-related riparian forest buffers is similar to that for crop-land related buffers. However, we believe there should be no costs for buffers for the pasture land-impaired waters that are also crop land-impaired. Many pasture-impaired water bodies are also crop-

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95 U.S. EPA, Agriculture Policy Branch, Office of Policy, Planning and Evaluation. *Economic Achievability Analysis: Agricultural Management Measures.* December 18, 1992.

96 Tony Esser, NRCS. Personal communication, March, 2000.

impaired, and 75-foot buffers have already been costed for them in the crop land section. Adding further buffer costs due to pasture land would constitute double-counting.

We make a similar assumption regarding use exclusion or stream protection/streambank stabilization for range-impaired water bodies. For any water body that is also impaired by crop land and has had riparian forest buffers already costed for it, we assume that use exclusion or stream protection/streambank stabilization is unnecessary.[97]

Among the 1454 water bodies in the 25 States that are cited as pasture and/or rangeland impaired, 773 water bodies are also cropland-impaired and have already had buffers costed for them. The remaining 681 pasture and/or rangeland-only water bodies are in 22 States. For three States (ME, NC, NE), all pasture and/or rangeland-impaired water bodies are also impaired by crop land. No additional bank-feet of buffer, use exclusion or stream protection are needed in these three States due to pasture and/or range land.

For the 681 waterbodies (impaired by pasture and/or rangeland, but not by cropland) in 22 States, there are 150,473,159 bank-feet of control measures needed. However, four of these 22 States reported pasture/range impaired waterbodies but did not report on crop impairments (NV, RI, VA, WI). These latter four States pose some difficulty in our analysis. In the crop land analysis, we assumed that these "non-reporting" States for crop land may in fact have crop land-related impairments, and we scaled to these States in estimating the need for crop land-related buffers, as well as the other crop land-related BMPs. Thus, for four of the 19 States that report pasture or range land-related impairments, crop land-related buffers have already been projected, but we do not know which (presumed) crop land-related water bodies these buffers apply to. We apply a scaling procedure to address this issue. Some of the pasture/range impaired water bodies in these four States are also likely crop-impaired, and these water bodies have already been scaled to in the crop land buffer analysis.

- 147,714,887 bank-feet are in the 18 states that report for rangeland and/or pastureland but not for cropland. These bank-feet are completely incremental to the bank-feet needed for crop land in these 18 States.

- 150,473,159 - 147,714,887 = 2,758,272 bank-feet are associated with pasture and/or rangeland water bodies in the four States that did not report on crop impairments. Some of these bank-feet are already scaled to in the crop land analysis; thus not all of these bank-feet are incrementally due to pasture and range.

- In the 21 States that report for both crop and pasture/range, there are 353,066,997 bank-feet associated with pasture and/or rangeland-impaired water bodies. 147,714,887 of these bank-feet are associated with waterbodies that are impaired only by pasture and/or range land, and not by crop land. The portion of the total that is due exclusively to pasture and/or range is thus 41.83% (147,714,887/353,066,997 = .4183).

- We apply this percentage to the total pasture/range-impaired bank-feet in the 4 States that do not report for crop land: 2,758,272*41.83% = 1,153,996. Thus 1,153,996 bank-feet are needed for exclusively crop/pasture-impaired water bodies in the 4 States.

97 Note that the cost per acre for a crop land riparian buffer is higher than the cost per acre for either use exclusion or stream protection/streambank stabilization.

- The total number of incremental bank-feet attributable solely to pasture/range in the 25 States is thus1,153,996 +147,714,887 = 148,868,883.

We split this total amount of pasture/range bank-feet needed among pasture and range in each State according to the fractions of pasture vs. range land in each State. The result for the 25 States is 66.548 million bank-feet needed for pasture lands, and 82.321 million bank-feet needed for range lands.

The scale factor for pasture land is 1.69. Therefore, the national number of bank-feet of riparian buffers needed for water bodies impaired by pasture only is 1.69*66.548 = 112.466 million bank-feet.

The scale factor for range land is 1.43. Therefore, the national number of bank-feet of use exclusion or stream protection/streambank stabilization needed for water bodies impaired by range only is 1.43*82.321 = 117.719 million bank-feet.

We convert these estimates of bank-feet needing BMPs to acreage and then to costs by applying the factors shown previously in the unit cost tables. We also scale the costs to reflect the pace of TMDL development/compliance time lag (factor of 0.4484) and to reflect unknown/not classified source information (factor of 1.13).

We estimate the costs for pasture land-related BMPs at **$5.0 - $10.7 million/year**. These costs are for buffers, as intensive rotational stocking is assumed to be costless.

We estimate the total annual costs for range land BMPs at:

- For use exclusion: $5.1 - $16.4 million/year. OR

- For stream protection and/or streambank stabilization: $2.3 - $5.1 million/year.

Regarding these two sets of practices as alternative ways of estimating costs and taking the low and high estimates, we project the costs for range land BMPs at **$2.3 million to $16.4 million per year**.

C. SUMMARY COSTS FOR AGRICULTURAL LAND

Exhibits I-10 through I-12 summarize the estimated costs for Scenario 1 (Least Flexible TMDL Program) for crop, pasture and range land.

Exhibit I-10
Implementation Costs for Crop Land ($ in millions/yr)

Number of States analyzed	23
Number of counties in these States with crop-impaired waters	710
Fraction of crop acreage in these States that is in impairment counties	.53
Scale factor from these States to the nation	1.56
National total annualized implementation costs (millions of 2000 dollars/yr):	
Conservation tillage	85 - 785
Nutrient management planning	317 - 781
Riparian measures	41 - 104
In-field or edge-of-field measures	49 - 108
Management of highly erosive crop land	154 - 177
Total costs	645 - 1956
National total potential savings from implementing these BMPs (millions of 2000 dollars/yr):	
Conservation tillage	0 - 414
Nutrient management planning	0 - 804
Total potential savings	0 - 1218

Exhibit I-11
Implementation Costs for Pasture Land ($ in millions/yr)

Number of States analyzed	25
Number of counties with pasture and/or rangeland-impaired waters in these States	511
Fraction of pasture acreage in these States that is in impairment counties	.363
Scale factor from these States to the nation	1.69
National total annualized implementation costs (millions of 2000 dollars/yr):	
Riparian measures	5.0 - 10.7
Intensive rotational stocking	0
Total costs	5.0 - 10.7

Exhibit I-12
Implementation Costs for Range Land ($ in millions/yr)

Number of States analyzed	25
Number of counties with pasture and/or rangeland-impaired waters in these States	511
Fraction of rangeland acreage in these States that is in impairment counties	.459
Scale factor from these States to the nation	1.43
National total annualized implementation costs (millions of 2000 dollars/yr):	
Riparian measures:	
Use exclusion (fencing); OR	5.1 - 16.4
Stream protection/bank stabilization	2.3 - 5.1
Total costs	2.3 - 16.4

On the following page is a spread sheet showing the derivation of these estimates for crop, pasture and range land.

Scenario 1 -- Summary Costs for Nonpoint Sources; Detail on Agriculture and AFO BMPs ($/yr)

BMP	Acres* Needing BMP	Capital Cost/ Acre* -- Low	Capital Cost/ Acre*-- High	Useful Life (Years)	Annual O&M Cost/Acre* -- Low	Annual O&M Cost/Acre* -- High	Annualized Cost/Acre* -- Low	Annualized Cost/Acre* -- High	Degree Not Needed/ Already Implemented - High	Degree Not Needed/ Already Implemented - Low	Estimated Annualized Cost -- Low	Estimated Annualized Cost -- High	Annualized Cost w/ Scale Factors -- Low	Annualized Cost w/ Scale Factors -- High
Crop Land														
Conservation tillage	150,236,657	$12.43	$0.00	10	$0.00	$16.43	$1.77	$16.43	37.20%	37.20%	$166,973,694	$1,550,147,840	$84,604,235	$785,447,509
Potential CT savings	150,236,657	$0.00	$0.00	10	($8.66)	$0.00	($8.66)	$0.00	37.20%	37.20%	($817,059,056)	$0	($413,997,287)	$0
Nutrient mgt plan	192,364,478	$7.00	$15.00	3	$2.33	$4.00	$5.00	$9.72	35.00%	17.50%	$624,854,664	$1,541,900,236	$316,608,859	$781,268,515
Potential NMP savings	192,364,478	$0.00	$0.00	3	($10.00)	$0.00	($10.00)	$0.00	35.00%	17.50%	($1,587,006,944)	$0	($804,123,722)	$0
Riparian forest buffer	1,260,698	$300.00	$300.00	20	$57.76	$135.00	$86.08	$163.32	25.00%	0.00%	$81,388,652	$205,894,512	$41,238,979	$104,325,102
Vegetative barrier	1,406,648	$100.00	$100.00	15	$57.76	$140.00	$68.74	$150.98	0.00%	0.00%	$96,692,234	$212,374,974	$48,993,182	$107,608,700
Retirement	4,864,704	$67.20	$98.86	10	$52.76	$57.76	$62.33	$71.84	0.00%	0.00%	$303,206,143	$349,458,152	$153,632,127	$177,067,650
											Subtotal of costs:		$645,077,382	$1,955,717,476
											Subtotal of potential savings:		($1,218,121,009)	$0
Pasture Land														
Riparian forest buffer	129,094	$300.00	$300.00	20	$48.29	$135.00	$76.61	$163.32	0.00%	0.00%	$9,889,635	$21,083,397	$5,010,999	$10,682,788
Rotational stocking	43,180,906						$0.00	$0.00	0.00%	0.00%	$0	$0	$0	$0
Range Land														
Riparian fencing only*; or	*22,295*	*$3,005.50*	*$9,500.00*	25	*$194.58*	*$639.52*	*$452.48*	*$1,454.72*	0.00%	0.00%	$10,088,131	$32,433,374	$5,111,575	$16,433,731
Stream protection/bank stabilization	270,248	$63.84	$119.70	15	$9.78	$24.27	$16.79	$37.41	0.00%	0.00%	$4,536,832	$10,109,264	$2,298,777	$5,122,283

** for range riparian fencing, units are miles rather than acres*

II. ANIMAL FEEDING OPERATIONS (AFOs)

We found 750 water bodies on States' 303(d) lists that States have identified as impaired by AFOs. These water bodies were either cited directly in a State's 303(d) submission as impaired by AFOs, or they were cited as impaired by AFOs in a State's 305(b) submission and corresponded to a 303(d)-listed water body. These water bodies are in 451 counties in 32 states. We assume conservatively that the remaining 18 states may have AFO-impaired water bodies, but either did not report sources of impairment at all or reported them in a manner that was insufficiently specific to identify AFOs as a source of impairment. The 32 States reporting AFO-impaired waters have 44,790,402 animal units confined in AFOs. In the nation as a whole, there are 69,312,402 animal units confined in AFOs.[98] We assume that the degree to which AFOs impair waters in the 32 "reporting" States is replicated in the remaining States. The scale factor to extrapolate from whatever AFO costs we estimate for the 32 States to the entire nation is thus 1.55 (69,312,402 divided by 44,790,224).

A. EXTENT OF AFO ACTIVITY REQUIRING CONTROLS

To determine the amount of AFO activity occurring in these 451 counties, located in 32 States, we used data from the 1997 Census of Agriculture on the number of farms in each county and their animal inventories.

1. Types of animals covered in the analysis

The types of animals covered in the analysis include:

- Beef cows[99]
- Milk cows
- Layers 3 weeks old and older
- Broilers and other meat-type chickens
- Swine.

The Census of Agriculture also provides some, but not complete, information on other animal species: turkeys, sheep, goats, horses, ducks, mink, etc.. For a variety of reasons, including incomplete county-level inventory information, limited information on manure management costs for farms raising these species, and a desire to keep the amount of data collection and analysis to a manageable level, we decided to analyze in this study only AFOs raising beef and dairy cows, swine, layers and broilers. This set of animals that we analyzed accounts for nearly 95 % of the volume of confined animal manure produced

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98 Source: Data on confined animals of various sorts in each State, obtained from the 1997 Census of Agriculture, multiplied by the number of animal units (EPA definition) per head for each sort of animal. U.S. Department of Agriculture. 1997 Census of Agriculture. Www.nass.usda.gov/census.

99 We assume that AFOs where beef cattle are raised in confinement are represented by the Census category "Cattle and calves fattened on grain and concentrates for slaughter". This category should generally include beef feedlots and exclude pasture and range operations in which the cattle are not confined.

annually at U.S. livestock and poultry farms.[100] We believe that omitting the numerous animal types other than the five we have analyzed results in only a very small underestimate of the likely costs for AFOs to achieve TMDL-mandated load reductions.

For broilers as well as beef fattened on grain and concentrates, the Census provides information on the number of animals sold over the course of the year rather than on the inventory on hand at the end of the year. We converted the sales information to approximate inventory by dividing sales by the number of production cycles assumed to take place at a typical farm in a year (for broilers, 6.0 and for confined beef, 2.5).

2. Size of AFOs covered in the analysis

We assumed that very small AFOs would be unlikely to be addressed in TMDLs. USDA estimated that in 1997 AFOs with less than 50 animal units represented roughly 40 % of all farms, but less than 5 % of all animal units.[101] For this analysis, we assume that AFOs with less than approximately 20 animal units will not face TMDL requirements. This cutoff level defining a *de minimis* AFO is the same as EPA used for its economic analyses of both coastal zone management measures for CAFOs and national nonpoint source management measures for CAFOs. More specifically, AFOs with fewer than the following numbers of animals were assumed to be unlikely targets for the TMDL requirements:

- 50 beef cattle sold (equivalent to 20 beef cattle inventory, or 20 animal units);
- 20 dairy cows (28 animal units; the Census provides data on dairies using a 20 cow break point, and provides no data on farms corresponding with 20 animal units or approximately 14 dairy cows);
- 50 swine (20 animal units);
- 3,200 layers (the equivalent of 32 animal units, the closest of the Census break points to 20 animal units for layers); and
- 60,000 broilers produced (10,000 broilers inventory, the equivalent of 100 animal units, but roughly the size of the smallest broiler house in common use).

In the cost analysis, we also make some distinctions involving AFOs that are sufficiently large to be CAFOs. We defined CAFOs with reference only to their size and not to their "method of discharge".[102] In this analysis, CAFOs include all farms with more than the following numbers of animals:

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100 Source: U.S. EPA. *Preliminary Study of the Livestock and Poultry Industry: Section 2, Economics*. September 30, 1998.

101 U.S. Department of Agriculture, Economic Research Service. "Confined Animal Production Poses Manure Management Problems." *Agricultural Outlook*. September, 2000. Pages 12-18.

102 Existing regulations also define some farms of smaller size as CAFOs because they discharge pollutants in specified undesirable ways.

- 1,000 beef cattle (equivalent to 2,500 cattle sold);
- 700 dairy cows;
- 2,500 swine;
- 30,000 layers or broilers (equivalent to180,000 annual production of broilers) at an AFO with a liquid manure system. We assume that 10 % of layer farms use liquid manure systems, and no broiler farms use such systems.[103]

Using data from the Census of Agriculture, we calculated the total number of animal units in the 451 AFO-impaired counties as 13,830,056. This number represents 31% of the total number of animal units in the 32 States.

B. Relationship between the AFO cost analysis and EPA's proposed CAFO regulations

EPA has recently proposed substantially revised effluent guidelines for feedlots. The AFO cost analysis in this report does not account for these proposed revisions. We assume that the existing feedlots effluent guideline is part of the baseline for the cost analysis (as we assume for other promulgated technology-based standards also), and that the new proposed-but-not-yet-finalized effluent guideline is not part of the baseline. Any not-yet-incurred costs for CAFOs (as defined under the existing regulations) to meet existing requirements are part of the baseline, not attributable to the TMDL program. To the extent that TMDLs will likely require load reductions of AFOs or CAFOs that exceed what is required by the existing effluent guideline, we attribute the ensuing costs to the TMDL program. In fact, if the revised feedlot effluent guideline is promulgated in roughly the same form as it has been proposed, much of these costs that we now attribute to the TMDL program will instead be required by the new effluent guideline. Nevertheless, for this analysis, we do not anticipate the promulgation of the revised effluent guideline, and we instead count as attributable to the TMDL program all costs for AFOs beyond the requirements of the existing guideline.

In support of the proposed effluent guideline, EPA has conducted extensive research and analysis on potential management measures for AFOs and their costs.[104] Most of the work for the TMDL cost analysis was completed before this effluent guideline AFO costing work was performed. In many respects, this TMDL cost analysis for AFOs does not reflect the newer and generally better data developed for the effluent guideline. However, EPA's feedlot effluent guideline cost studies are currently being revised, and we did not believe that we should make the substantial effort to change our TMDL costing to conform to the effluent guidelines work while this work is still in flux. We plan soon (likely during the period while the draft TMDL cost analysis is undergoing public review) to revise the TMDL cost analysis for AFOs to conform our estimates to the effluent guideline cost analysis information.

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103 Source: USDA. "USDA Review of EPA's TMDL Cost Assessment" June 29, 2001.

104 U.S. EPA, Office of Water, Office of Science and Technology. *Final Cost Methodology Report for Beef and Dairy AFOs. Final Cost Methodology Report for Swine and Poultry Sectors.* January, 2001.

C. DESCRIPTION OF BMPS REQUIRED WHERE CONTROLS ARE NEEDED

We assumed four sets of measures would be necessary for AFOs that contribute to impairment of waters that States have identified as AFO-impaired:

- *Upgrades to AFO facilities as necessary to collect, store and spread manure on nearby fields.* Necessary facilities and equipment include those to:1) Collect and store manure/process wastewater and runoff that comes in contact with manure; 2) Manage the manure by spreading it on nearby agricultural land; 3) Compost dead animals; and 4) Prevent pollutant movement to ground water.

- *Additional manure hauling and/or composting.* Manure should be used consistent with agronomic needs rather than simply spread nearby. In areas where the amount of manure generated exceeds crop needs, excess manure will need to be transported either to nutrient-deficient areas or to alternative end uses such as composting. We assume that manure application rates should not exceed phosphorus-based limits.[105]

- *Nutrient management planning.* For AFOs, this will include: (1) Developing a nutrient management plan; 2) Manure and soil testing; 3) Training and certification of personnel who apply manure; and 4) Keeping records regarding manure generation and disposition.

- *Practices to protect and restore AFO-impaired riparian areas.* As for crop and pasture land, for costing purposes we will assume riparian forest buffers will be implemented. Again, riparian forest buffers will tend to be more expensive than alternatives such as grass buffers, use exclusion, stream protection, etc..

We estimate the costs for these four practice groups for all AFOs of greater than de minimis size in counties within which there are AFO-impaired water bodies. These practices are likely to generate some savings that will offset the costs in part or in whole:

- As AFOs improve their manure management facilities, they will collect and manage a greater percentage of their manure. The additional manure collected and available for spreading may have some value.

- Manure increases in value when it is hauled to where its nutrient content can be more fully used rather than always being spread near the farm where it is generated.

- Nutrient management planning and careful use of manure nutrients may allow a farmer to reduce his purchases of commercial fertilizers.

We will also estimate the amount of these potential savings.

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105 In general, P-based limits allow less manure to be spread than will N-based limits. P-based limits will thus require manure to be transported a greater distance in order to find a sufficient quantity of agricultural land on whcih the manure can be used. EPA's proposed feedlots effluent guideline would require application of manure consistent with phosphorus needs.

D. CALCULATING THE COSTS TO UPGRADE AFO FACILITIES

In estimating the costs of upgrading manure management facilities at AFOs, we used a set of unit cost estimates developed by DPRA for EPA in connection with the Agency's "Management Measures Guidance for Coastal Zone Nonpoint Source Pollution" required by the Coastal Zone Management Act Reauthorization Amendments of 1990. Until the recent feedlots effluent guideline work, the set of CZARA measures promulgated for AFOs and the accompanying cost analyses represented EPA's most comprehensive review of AFO facilities needs. The 1995 Economic Impact Analysis supporting the CZARA management measures describes the measures recommended for AFOs and their costs in more detail:[106]

> Management measures considered in this analysis focus on (1) facility runoff controls, (2) nutrient management practices with respect to the disposal of manure on agricultural land and (3) dead animal composting for poultry. Facility runoff is controlled primarily through diversions (diking) for eliminating run-on and channeling on-site effluents to the ultimate control mechanisms... [The measures also] included lined retention ponds and irrigation for ultimate disposal of effluents...
>
> Variable rainfall patterns were also considered in estimating management measures for controlling run-on and runoff. For example, retention ponds were designed to hold runoff from a 25-year, 24-hour rainfall event, plus allowances for additional freeboard, process water, and storage for periods when water cannot be disposed. Because a storm of this magnitude is variable, control designs varied to provide capacity for 4-, 6-, 8- and 10-inch rainfall events. Ultimately, facilities in different states were required to have management measure controls designed appropriately for the expected rainfall event (e.g., Louisiana facilities were designed on the basis of a 10-inch 25-year/24-hour storm, Michigan facilities for a 4-inch storm).
>
> Investment costs for effluent control mechanisms vary by size of facility and expected intensity of storm events. The ranges of total investment costs are ... [from $900 for a small swine operation to $60,500 for a large dairy]... (Effluent control costs for poultry operations, which are presumed to be entirely enclosed, are not significant and were not estimated.) ... Annual operating costs for these facilities, including farmer provided labor, range from a low of approximately four percent to a high of eight percent of total investment costs.
>
> Manure management includes provisions for disposing of manure on agricultural land. Manure management consisted of spreading manure so that application of the nitrogen and phosphorus constituents do not exceed 60 and 20 pounds per acre, respectively. This requirement increased manure land application costs by requiring operators to apply manure over larger areas, consequently increasing transportation costs. Transport distances were estimated to increase up to five (5) miles (one-way) for the largest model facilities considered. Manure management cost estimates ranged from approximately $100 per year for small swine feedlots to over $12,000 per year for large dairies.
>
> Dead animal disposal was considered only for poultry (layers and broilers). The disposal method considered was composting dead birds with poultry litter. Composting facility investment costs ranged from approximately $400 for small 5,000-bird facilities, to more than $6,700 for 80,000-bird facilities. (Source: DPRA, 1995. op cit., pp 7-8.)

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106 DPRA Incorporated. *Economic Impact Analysis of Coastal Zone Management Measures Affecting Confined Animal Facilities*. October 7, 1992. Also, DPRA Incorporated. *Economic Impact Analysis of National Nonpoint Source Management Measures Affecting Confined Animal Facilities.* May 17, 1995.

DPRA estimated the costs for such facilities for model AFOs of different sizes for each animal type that we address (confined beef, dairy, swine, layers, broilers). We made several adjustments in using DPRA's unit costs for AFOs for this study. First, we deleted a cost reduction of $3,500 per farm assumed by DPRA to be provided in environmental cost sharing funds by Federal and State agricultural agencies. Our analysis aims to estimate the total implementation costs of TMDLs. Cost sharing funds reduce costs to farmers, but for our analysis they represent transfer payments from governments rather than any reduction in total implementation costs. Second, we extend DPRA's cost estimates to several new model AFOs that were sized smaller or larger than the range that DPRA had dealt with in its analysis. We did this by developing regression equations giving DPRA's estimated costs as a function of AFO size, and using these estimated equations to extrapolate costs for model AFO sizes outside of DPRA's range. Third, we inflate DPRA's costs to March, 2000 dollars, using the index of producer prices.

There are both pros and cons in our using the DPRA costs to estimate the unit costs for AFOs that will need to improve their environmental performance to meet the requirements of TMDLs:

- Pro: The DPRA costs cover a broad set of minimum management measures that are typical of the least that a representative AFO will need to do. The costs reflect the effluent guideline requirement of no discharge except for a 25-year/24-hour storm, and add some modest manure spreading requirements.

- Pro: The DPRA costs represent the most comprehensive set of costs for AFO water quality management that EPA had developed until recently, and they have been widely used by the Agency and others.

- Con: DPRA presents the costs as a package that is very difficult to break into component pieces and component costs. One result is that it is difficult to adjust the DPRA costs to reflect the fact that the various different items are currently in place at AFOs to varying degrees. DPRA costed out construction of waste lagoons, retention basins, liquid waste irrigation equipment, dead animal composting facilities, manure hauling equipment, etc., assuming that no portion of any of these facilities or equipment was yet in place. Some of these items are currently in place at the great majority of AFOs (virtually all AFOs have some equipment for collecting and disposing of their manure), but other items are much less commonly in place (e.g., many AFOs already have waste lagoons, but many of the lagoons are not lined).

- Con: DPRA does not assume that poultry farms need manure storage structures. In fact, virtually all poultry farms should have such structures (perhaps only half of them now have them) in order to store dry litter appropriately after it is removed from the poultry house until it can be spread on fields.

- Con: DPRA's assumptions seem generally low regarding the typical distance from an AFO that manure will need to be transported before it can be spread consistent with agronomic needs. DPRA assumes transport distances of 0 - 5 miles. In many areas of the country, however, there are large excesses of confined animal manure relative to local crop needs and manure will need to be shipped much greater distances. We are able to estimate the amount of manure needing to be shipped out of the county of origin and the resulting costs for inter-county shipping (see below), but there may also be a substantial quantity of manure that needs to be shipped some distance intermediate between DPRA's 0 - 5 miles and entirely out of the county (typically 15 miles or more). We likely miss the costs when such intermediate shipping is needed.

- Con: Embedded within the DPRA estimate of annualized costs is an assumed 10 % discount rate. We would prefer to use a 7 % discount rate consistent with the remainder of this analysis. However, it would be very difficult to disentangle DPRA's annualized costs into capital and annual O&M costs and then substitute our preferred discount rate. We have chosen to retain DPRA's annualized costs despite their 10 % discount rate assumption. Annualized compliance costs with a 10 % discount rate may be, by our rough estimate, about 0 - 5 % higher than they would be if we were to recalculate them with a 7 % discount rate. This error is small compared with other likely uncertainties in our estimates.

In sum, the DPRA cost estimates have some important shortcomings relative to our desires, but they are the best available to us pending completion of the feedlots effluent guideline cost estimates. We will convert this analysis to use the effluent guideline cost estimates as soon as possible.

We applied DPRA's unit costs to the numbers of farms of each animal type and size in each of the counties with AFO-impaired waters. We also reflected the degree to which each type/size farm currently has these facilities in place.

CAFOs were presumed already to have all the needed facilities in place due to requirements of the existing CAFO effluent guideline. Costs for facilities upgrades were presumed to be zero for all CAFOs. We assumed that CAFOs included all farms with more than 1,000 AU (EPA definition) of a single animal type, with the exception of broiler farms (all were assumed to use dry manure management techniques, and hence none are CAFOs by reason of size) and 90 % of layer farms with more than 30,000 inventory (10% of such large layer farms were assumed to use liquid manure systems and hence subject to CAFO status).

Treatment-in-place estimates for AFOs having fewer than 300 animal units were developed from EPA's Nonpoint Source Gap Analysis data. We assumed that the following percentage of AFOs containing fewer than 300 AU already had the desired facilities in place:

Exhibit I-6
Percentage of AFOs < 300 Animal Units With Facilities in Place

Animal Type	Storm Water Diversion, Management
Beef	90
Dairy	90
Swine	50
Layer	73
Broiler	11

Source: TetraTech, Inc. Nonpoint Source Gap Analysis. Op cit.

For AFOs containing 300 to 1000 AU, we assumed that the percentage needing facilities was half of that for AFOs containing fewer than 300 AU, such that:

Exhibit I-7
Percentage of AFOs 300-1000 Animal Units With Facilities in Place

Animal Type	Storm Water Diversion, Management
Beef	95
Dairy	95
Swine	75
Layer	87
Broiler	56

Note that the information on facilities in place from EPA's Nonpoint Source Gap analysis covers only some of the sorts of facilities presumed to be necessary at AFOs in EPA's CZARA analysis. We assume that the fraction of farms with storm water diversion and management facilities in place is representative of the fraction of farms with all of the osther sorts of facilities in place also (e.g., dead animal composting, lined lagoons). This assumption is likely inaccurate, and better information on facilities in place will be obtained before this analysis is finalized.

To estimate the costs for AFOs to upgrade manure management facilities, we multiply the number of farms in each of the 451 counties of each animal type/size clas by the appropriate DPRA cost for that sort of farm by the proportion of that sort of farm that is presumed not yet to have the needed facilities in place. Exhibit I-8 shows the resulting estimated costs for AFOs to upgrade their facilities. These costs include the various scaling factors to extrapolate from the States that "report" regarding AFO impairments and to reflect the incomplete coverage of the nonpoint source analysis and the TMDL pace/lag factor.

Exhibit I-8
National Facilities Costs by Animal Type (in millions of 2000 dollars/yr)

Animal Type	Facilities Costs
Broilers	$19.707
Swine	$3.916
Beef	$0.997
Layers	$0.498
Milk Cows	$3.197
Total	***$28.316***

Our final estimate of the nationwide incremental cost of upgrading facilities at AFOs is **$28.3 million/yr** for Scenario 1.

E. POTENTIAL COST SAVINGS FROM ADDITIONAL MANURE MANAGEMENT FACILITIES

As some AFOs improve their facilities for collecting and managing manure, more manure will become available for use. Depending on the local relationship between the amount of nutrients available through already-collected manure and crop needs, this additional collected manure may or may not have economic value for local use. We estimate this potential value of the additional collected manure assuming, for this step in the analysis, that it is not shipped. We assume that the additional collected manure has value (without hauling) if local crop nutrient needs exceed local manure availability of nutrients through manure.

We estimate the volume of additional manure collected as a result of the AFO facilities upgrades, the amount of nutrients recovered and available to crops if such manure were spread locally, and the value of these nutrients as a function of the local balance between nutrient needs and availability. These calculations involve the following data:

- Data from the 1997 Census of Agriculture on the number of confined animals in each county within which an AFO is located;
- Estimates from DPRA of the tons of manure generated per animal per year;
- Data from Lander et al[107] on:
  - The proportion of generated manure from each animal type that is typically recovered and then available for use (the "recoverable manure factor"),
  - The pounds of nutrients (phosphorus, nitrogen, and potassium) available per ton of recoverable manure generated by each animal type; and
  - The ratio of the amount of nutrients that will be available to plants after the manure is spread to the total amount of nutrients in recovered manure.

For each county and animal type, the total tons of manure generated and then recovered as a result of upgraded facilities at AFOs are calculated by multiplying the number of animals at upgraded facility farms by DPRA's estimated number of tons of manure generated per animal. The total tons of recoverable manure is calculated by multiplying the total tons of manure generated by the "recoverable manure factor". For phosphorus and potassium, the total pounds of nutrients available to crops in the additional manure are calculated by multiplying the total tons of recoveraed manure by the pounds of nutrients per ton of

107 Lander et al. February 1998. *Nutrients Available from Livestock Manure Relative to Crop Growth Requirements.*

recoverable manure. For nitrogen, based on Lander, it is assumed that 30 percent of nitrogen in recovered manure is lost and unavailable to crops due to volatilization of ammonia.[108]

The application of manure to crop land can have economic value if it allows for decreased expenditures on commercial fertilizer. Exhibit I-9 shows the average potential value per pound that we assumed for the nutrients contained in the additional manure. This value will be realized if all the manure nutrients displace on a one-for-one basis an equivalent amount of purchased nutrients in commercial fertilizer.

Exhibit I-9
Maximum Value Per Pound for Manure Nutrients

Nutrient (oxide form)	Value per lb.	Nutrient	Value per lb.[109]
N	$0.23	N	$0.23
P_2O_5	$0.237	P	$0.543
K_2O	$0.154	K	$0.186

The spreadsheet "sum of nutrients all animals" contains the final estimates of the total value of nutrients in each county. Those counties located in Great Plains states are assigned no value for Potassium because......EXPLAIN....The number of pounds of P, N, and K are summed up over all animal types to give the total pounds of nutrients contained within each county.

To determine whether nutrients in the additional manure collected due to upgraded AFO facilities has value at these maximum levels, or at some lower level, or has no value at all, we conducted a county-by-county analysis. For each of the 451 counties, we used data from Lander et al. to compare the amount of nutrients available in all manure generated in the county to the amount of nutrients that is needed for non-legume, harvested crop land, hay land, and pasture land in the county. We assumed the following:

- Nitrogen. Manure nitrogen has full value if it is generated in a county where total manure nitrogen amounts to 25% or less of total county crop and pasture nitrogen needs. It has half of full value if it is generated in a county where total manure nitrogen amounts to 25 - 50% of crop/pasture needs. It has 25% of full value ... THE AFO DISCUSSION IN THIS APPENDIX IS NOT WRITTEN/EDITED BEYOND THIS POINT

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108 Lander et al. Op cit.

109 Sources for value per pound and factors for converting from oxide form. Jacobs, L.W. February 12, 1997. *Resource Value of Dairy Manure.* Crop and Soil Science Department. Michigan State University. http://ww.canr.msu.edu/fldcrp/manure2.htm. Zublena, J.P. et al. March 1996. *Swine Manure as a Fertilizer Source*. North Carolina Cooperative Extension Service. Publication Number AG-439-4. Hart, J. et al. August 1997. *Dairy Manure as a Fertilizer Source*. Oregon State University Extension Service. http://eesc.orst.edu. Bennett, M., Fulhage, C., and Osburn, D. October 1993. *Waste Management Systems for Dairy Herds*. Department of Agricultural Economics, University of Missouri-Columbia.

b. Nutrient management planning costs (for both AFOs and CAFOs)

AFO nutrient management planning costs include the following:

- Capital costs associated with training
- Costs to develop and periodically update nutrient management plans
- Annual soil testing
- Annual manure testing
- Annual record-keeping

Due to the lack of nutrient management plan requirements in the existing effluent guidelines for CAFOs, we calculated costs for both AFOs and CAFOs. For some AFOs and CAFOs, we assumed that nutrient management planning was current practice, and hence did not require them to incur any incremental costs. Exhibit I-9 indicates the percentage of AFOs and CAFOs that are assumed currently to conduct these nutrient management activities.

Exhibit I-9
Percentage of AFOs and CAFOs
Currently Conducting Nutrient Management Activities

Animal Type	Training	NMP	Soil Test	Manure Test
Beef	0	100	100	100
Dairy	0	100	100	100
Swine	0	13	90	40
Layer	0	72	42	73
Broiler	0	19	20	20

Source: Tetra Tech GAP Analysis

We assumed that AFOs and CAFOs would have the same performance, regardless of size. However, CAFOs and larger AFOs were assumed to incur greater nutrient management planning costs than smaller AFOs (that is, those with fewer than 300 animal units). Exhibits I-10 and I-11 illustrate the assumed cost per AFO for AFOs with fewer than 300 animal units, and the additional assumptions used for CAFOs and larger AFOs, respectively.

Exhibit I-10
Nutrient Management Cost per AFO--Fewer than 300 Animal Units

Animal Type	Training[110] (capital)	NMP (yearly)	Soil Test (yearly)	Manure Test (yearly)	Record Keeping[111] (yearly)
Beef	$117	$11	$12	$50	$20
Dairy	$117	$50	$25	$50	$20
Swine	$117	$26	$17	$50	$20
Layer	$117	$9	$11	$50	$20
Broiler	$117	$28	$18	$50	$20

Exhibit I-11
Nutrient Management Cost per AFO and CAFO (Relative to AFO with Fewer than 300 AU)

	Training	NMP	Soil Test	Manure Test	Record Keeping
Costs per AFO <300 AU	A	B	C	D	E
Costs per AFO 300 - 1,000 AU	A	4B	4C	2D	4E
Costs per CAFO	A	8B	8C	4D	8E

With these assumptions, we estimated the national nutrient management costs as follows:

- We obtain Census of Agriculture data for each county on the number of farms for each animal type and farm size category (1)
- We multiply (1) by the proportion of farms assumed to be currently conducting nutrient management plans by the estimated cost per farm. We sum each management activity for all counties and determine a total nutrient management plan cost for the 32 states.
- To obtain an estimate for the entire nation, we multiply by the scaling factor of 1.55 and obtain a national estimate of $ 5.9 million/yr.

We next apply two further scaling factors (.4484 to reflect the pace of TMDL development at a 7 % discount rate, and 1.13 to reflect unknown/not classified source information). Our final estimate of the nationwide incremental cost of nutrient management plans for AFOs is **$ 3.0 million/yr**.

110 We assumed a 5-year useful life for the turnover of the $117 capital investment in training and certifying the assumed one employee per farm who is to supervise manure testing and application.

111 We assumed that record-keeping was required as an element of nutrient management planning. Record keeping entails keeping records of how the manure the AFO or CAFO generates is used and disposed of. We estimated this cost at $20/year (2 hours at $10/hour) for an AFO < 300 AU.

c. Savings due to nutrient management plans

d. Additional manure hauling and/or composting costs (only for AFOs and CAFOs in nutrient access counties)

Some 303(d) water impaired counties were considered "manure-excess counties," because the nutrient content in the manure produced from concentrated animals exceeded plant uptake. We assumed that both AFOs and CAFOs in these counties would need to transport their manure some extra distance (over the minimal distance presumed in the DPRA facility costs) in order to find land on which it could be agronomically applied. We used 1997 data from a USDA/Lander et al study[112] on nutrient balance in every US county to identify which of the 451 303 (d) counties needed extra shipping. The USDA/Lander et al study provides data on confined animal manure P and N production and crop P and N needs. We assumed manure would need to be hauled a sufficient distance to permit its application consistent with phosphorus needs for crop and pasture land.

In order to estimate the costs for additional manure hauling, we calculated the following:

4. *Tons of manure needing shipping*. The tons of manure needing shipping were calculated for each animal type using several data sources: Agricultural Census data on the number of confined animals per farm, DPRA data on the tons of manure produced per head per day, and USDA/Lander et al data on the percentage of recoverable manure in each state.

5. *Extra shipping distance*. In order to decide whether an extra shipping distance was required and how far the manure should be shipped, we used the following criteria:

   - *If the county crop nutrient needs exceeded recoverable manure nutrient availability*. No additional shipping distance was assigned and the minimal manure hauling included in the facilities costs is presumed sufficient.

   - *If the recoverable manure P exceeds the crop P needs.*
      a. A quantity of manure sufficient to meet crop P needs can stay in-county, incurring no additional shipping cost; and
      b. The remainder of the manure was assumed to need to be shipped into another county.

   The shipping distance depended upon several factors:

   - The size of the county. Each county was assumed to be circular in shape, and the distance to the perimeter was assumed to be the radius taken from its known area[113].

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112 Lander et al. *Manure Nutrients Relative to the Capacity of Cropland and Pastureland to Assimilate Nutrients: Spatial and Temporal Trends for the United States.* USDA. Publication No. ps00-0579. 2000.

113 County areas (in square miles) taken from U.S. Census Bureau. *Land Area, Population, and Density for States and Counties: 1990.* Www.census.gov/population/censusdata/90den_stco.txt

- *Proportion of the county surrounded by other counties with excess P*. If the county was surrounded by another excess county, it was assumed that manure would need to be shipped some distance beyond that county.
- *Proportion of the county where transport was impossible or uncertain*. If a portion of the county was surrounded by a large lake or ocean, it was assumed that manure must be shipped elsewhere..In addition, if the county was surrounded by a state that is not included in our AFO analysis, hauling manure into that county was considered uncertain.

3. *Hauling cost per mile*. In general, hauling costs per ton-mile vary widely, depending upon the assumed capacity of the transport vehicle and the nature of the waste. For the average cost per ton-mile, we used a range recommended by TetraTech, set at $.10 to $.25 per ton mile. To calculate these upper and lower hauling costs estimates, we multiplied the tons recoverable manure by the assigned shipping distance by the average $.10 and $.25 per ton mile.

With these assumptions in place, we estimated the national nutrient management costs as follows:

- To calculate the tons of manure needing shipping in each of the 451 counties, we collected data on (1) the number of animals for each animal type in each farm size category; (2) tons of manure produced per animal for each animal type; and (3) the proportion of manure generated that is recoverable, and multiply (1) by (2) by (3) and summed across all animal types for each county.
- To calculate the excess shipping distance, we collected data on (1) the radius of each of the 451 counties, (2) the proportion of the county that is surrounded by other excess counties; (3) the proportion of the county that is surrounded by an ocean or large lake; and (4) the proportion of the county where transport is uncertain. We then multiplied:
 (1) x [1+[(2)+ (3)]/[1-(4)]] We capped the total cost estimated for excess shipping at some figure corresponding to an assumed cost for a large regional composting facility. We assumed the cost of a central composting facility to be $5.33/ton, based on Pratt, Jones and Jones (TIAER, 1997).[114] We assumed that such a central composting facility becomes economically feasible only if the volume of recoverable manure to be managed exceeds 150,000 tons/year within an assumed 20-mile radius catchment area.[115]
- We then multiplied the tons of manure needing shipping by the excess shipping distance by the $.10 (lower estimate) and $.25 (higher estimate) cost per ton mile estimates for each county and estimated the total national manure hauling costs in 32 states. To obtain an

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114 Pratt et al. Estimate that using a large central composting facility at 20 miles distance would cost a dairy farm $73/cow/year (sum of hauling cost and tipping fee). At 100 lb manure generated/head/day for a dairy cow (DPRA), about 75% of which is recoverable (Lander), the $73 would pay for disposal of 75 lbs/day*365 days/yr=13.7 tons/yr of manure. The composting cost would thus be $5.33/ton of manure managed.

115 Again based on Pratt, Jones and Jones. The large central composting facility they evaluate serves approximately 12,000 dairy cows. At 13.7 tons/yr of recoverable manure per dairy cow, the composting facility processes 164,400 tons of manure per year. We assumed that the composting facility becomes economical at a slightly lower figure of 150,000 tons of recoverable manure per year.

estimate for the entire nation, we multiply by the scaling factor of 1.55 and obtain a national estimate of **$ 81.0 - 134.7 million/yr**.

We next apply two further scaling factors (.4484 to reflect the pace of TMDL development at a 7 % discount rate, and 1.13 to reflect unknown/not classified source information). Our final estimate of the nationwide incremental cost of hauling additional manure for AFOs is **$41.0 - 68.2 million/yr**.

e. Increased economic value of the shipped/composted manure

The increased value of manure when it is shipped may offset part of the shipping cost. Manure can have economic value because its use on crops can reduce the amount of chemical fertilizer that needs to be used. The value of manure depends on its nutrient content (N, P and K), and the effective value of each nutrient in the location to which the manure has been shipped (e.g., whether the manure nutrients serve to displace purchased chemical nutrients).

To estimate the increased value of the shipped manure, we first estimated the tons of recoverable manure generated by multiplying the number of confined animals per animal type[116] by the tons manure per head per year by the percentage of recoverable manure for each animal type. We then multiplied the tons of recoverable manure by the percentage content of N, P and K for each variety of manure.3.62 pounds P[117] to calculate the P content of the manure.

$7.5 - $18.2 million /year.

f. Costs for buffers for AFO-impaired water bodies

We estimated costs for a 75 foot buffer width on both sides of an impaired river, and that the buffer would take crop land out of production. We estimated buffer needs only for those AFO-impaired water bodies that have not yet had buffers costed because of crop, pasture or range impairments.

$4.0 - $10.2 million/year.

116 For broilers and beef fattened off of grains and concentrates, the county data pertained to sales instead of inventories. To calculate the number of confined animals by inventory, we divided the number of animals sold by the production cycle (for broilers :6, for beef :2.5). For broilers and layers, county-level data was only provided for the number of farms. To estimate the number of animals, we assumed that each county had the same average number of animals per farm as the state. We calculated the average number of animals per farm for each state in each farm size category and multiplied it by the number of farms in each farm size county for each county. In cases where state data was lacking, we referred to national-level data. For the rest of the animal groups, there were instances where the data on the number of animals was not provided. In these cases, we used the mean number of animals in each farm size category as an approximation of the number of animals.

117 According to XXX source, there are 3.62 pounds of P produced for every ton of recoverable manure.

g. Total costs and savings for AFOs

Summing over all estimated costs for AFOs, we estimate the total national implementation cost for AFOs at **$76.4 - $109.8 million/year**. The total potential savings are estimated at **$7.5 - $66.7** million/year.

III. SILVICULTURE

Silvicultural activities can contribute to water impairment through several means: erosion, siltation, bank destabilization, runoff of forest management chemicals, loss of vegetative cover, and an increase in water temperature. The level of water quality impairment caused by silviculture depends not only on the degree of site disturbance (given by the acres or volume of timber harvested), but also the terrain (whether an area is hilly or flat).

We found 646 water bodies on States' 303(d) lists that States have identified as impaired by silviculture (either directly in their 303(d) submission or cited as impaired in their 305(b) submissions and corresponding with a 303(d)-listed water body). These water bodies are in 294 counties in 30 States. We assume conservatively that the remaining States may have silviculture-impaired water bodies, but either did not report sources of impairment at all or reported them in a manner that was insufficiently specific to identify silviculture as a source of impairment. The 30 States reporting silviculture-impaired 303(d) waters harvest 10.9 million cubic feet (mcf) of timber per year. In the Nation as a whole 16.3 mcf are harvested per year. We assume that the degree to which silviculture impairs waters in the 30 "reporting" States is replicated in the remaining States. The scale factor to extrapolate from whatever silviculture costs we estimate for the 30 States to the entire nation is thus 1.498 (16.3 million divided by 10.9 million).

A. EXTENT OF NONPOINT SOURCE ACTIVITY REQUIRING BMPS

We determined the amount of silvicultural activity in these 294 counties, located in 30 states, using timber harvest volume data from the U.S. Forest Service's Timber Product Output Data Retrieval System (http://srsfia.usfs.msstate.edu/rpa/tpo/), developed in support of the 1997 Resources Planning Act Assessment. Timber harvest volume for 1996 is available by type of product at the regional, sub-regional, state and county level, and can be broken out into volumes harvested on National Forest land, other public land, forest industry land, and other private land.[118] The timber harvest volume estimates for 1996 are shown in the exhibit below.

118 Other private land is defined as private land owned by an entity that does not operate a wood-using facility.

Exhibit I- 12
National Timber Cut in 1996 (mcf)

From private lands	14,330,530
From National Forests	912,060
From other public lands	1,025,628
Total	16,268,218

Using this harvest data, we calculated the total volume of timber harvested in the 294 counties: 2.3 million cubic feet (mcf). This volume represents 21% of the total timber harvest in the 30 States for which we have data. [119] For our BMP unit costs, we used both mcf estimates and acreage estimates.

In order to convert the USFS timber harvest data into acreage information, The Timber Data Company developed for us regional estimates of the number of acres on which harvesting operations would occur in order to obtain 1 mcf of timber.[120] These estimates are as follows:

Exhibit I- 13
Timber volume per acre, by region

Region	***mcf/Acre***
Westside Oregon & Washington	3.0
California	2.0
Arizona & New Mexico	1.5
Inland & Rocky Mountain	1.5
Lake States	1.3
Midwest	0.6
Northeast	0.6
Westside Southeast	1.0
Eastside Southeast	1.0

119 In 1996, there were 10.9 mcf of timber in the 30 States for which we had data.

120 TDC estimated the acres harvested in order to produce a given log volume based on queries of Timber Data Company's database of USFS and selected State timber sale appraisal data for 1998 sales. TDC adjusted this data somewhat based on discussions with industry professionals regarding differences between public and private timberland management practices. Adjustments also were made for known regional differences in land growth potential and harvest methods.

B. Description of BMPs required where controls are needed

There exists a fairly typical set of BMPs that silviculture operations should employ to minimize their impacts on water quality. These practices, and the particular combination of practices used, will vary somewhat according to the type of silviculture operation and the conditions (e.g. region, climate, topography, soils) of the silviculture site. Examples of BMPs for silvicultural activities are available from numerous sources, including State forest practices laws and State forestry boards. The most important document in which EPA has indicated the Agency's judgment about the BMPs that are generally appropriate is EPA's 1993 *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters*. The Guidance specifies 10 management measures for use in coastal States (including the Great Lakes States) to protect waters from silvicultural sources of nonpoint pollution, and lists and describes management practices that can be applied successfully to achieve the management measures.

According to The Guidance, we assumed that the following BMPs would be required where controls are needed:

2. Preharvest planning
3. Streamside management areas
4. Road construction/reconstruction
5. Road management
6. Timber harvesting
7. Site preparation and forest regeneration
8. Fire management
9. Revegetation of disturbed areas
10. Chemical management
11. Wetlands forest management

Each BMP is described as follows:

12. *Preharvest planning* . Performing advance planning for forest harvesting to minimize negative water quality impacts. BMPs include laying out harvest units to minimize the number of stream crossings, systematically designing transportation systems to minimize total mileage; minimizing road and skid trail grades; and surfacing roads (with gravel, grass, crushed rocks, etc.) where grades increase the potential for surface erosion.

2. *Streamside Management Areas.* Establishing and maintaining a streamside management area (SMA) along surface waters, which is sufficiently wide and which includes a sufficient number of canopy species to buffer against detrimental changes in the temperature regime of the water body, to provide bank stability, and to withstand wind damage. BMPs include providing a minimum SMA width of 35 to 50 feet; avoiding operating skidders or other heavy machinery in the SMA; and applying harvesting restrictions in the SMA to maintain its integrity.

3. *Road Construction/Reconstruction.* Minimizing delivery of sediment to surface waters during road construction/reconstruction projects. BMPs include following the design developed during preharvest planning to minimize erosion by properly timing and limiting

ground disturbance operations; using straw bales, grass seeding, and other erosion control and revegetation techniques to complete the construction project; and installing surface drainage controls to remove storm water from the roadbed before the flow gains enough volume and velocity to erode the surface.

4. *Road Management*. Managing existing roads to maintain stability and utility and to minimize sedimentation and pollution from runoff-transported materials. BMPs include maintaining road surfaces by mowing, patching, or resurfacing as necessary; and revegetating to proving erosion control.

5. *Timber Harvesting*. Minimizing sedimentation resulting from the siting and operation of timber harvesting, and managing petroleum products properly. BMPs include felling trees away from watercourses; removing slash from the water body and placing it out of the SMA; minimizing the size of landings; skidding uphill to landings whenever possible; avoiding cable yarding in or across watercourses; and taking precautions to prevent fuel leakage and spills.

6. *Site Preparation and Forest Management.* Regenerating harvested forest lands. Examples of BMPs include avoiding mechanical site preparation on slopes greater than 30 percent or in SMAs; distributing seedlings evenly across the site; and hand planting highly erodible sites, steep slopes, and SMAs.

7. *Fire Management.* Minimizing potential NPS pollution and erosion resulting from prescribed fire for site preparation and from the methods used for wildfire control or suppression. BMPs include planning burning to achieve the desired results while minimizing impacts on water quality; avoiding intense prescribed fire or construction of firelines in SMAs; avoiding burning on steep slopes with high-erosion-hazard areas or highly erodible soils.

8. *Revegetation of Disturbed Areas.* Preventing sediment and pollutants from entering water bodies by revegetating disturbed soil. BMPs include using seed mixtures adapted to the site; using native woody plants planted in rows, cordons, or wattles on steep slopes; and seeding during optimum periods for establishment, preferably just prior to fall rains.

9. *Chemical Management.* Minimizing the water quality impact of the use of pesticides and fertilizers. BMPs include maintaining a buffer area around all water bodies for aerial spray applications; and applying pesticides and fertilizers during favorable atmospheric conditions, and during maximum plant uptake periods to minimize leaching.

10. *Wetlands Forest Management.* Taking special measures to protect beneficial wetlands functions and avoid water quality impacts in wetlands areas. BMPs include providing adequate cross drainage to maintain the natural surface and subsurface flow of the wetland; and establishing a SMA adjacent to natural perennial streams, lakes, ponds, and other standing water in the forested wetland.

C. Unit costs for BMPs

To cost out a typical set of BMPs that designated and permitted silvicultural operations might need to employ, we used the set of BMPs and costs provided in EPA's 1992 report, "Economic Analysis of Coastal Nonpoint Source Pollution Controls: Forestry", prepared by the Research Triangle Institute (RTI). The report analyzes the economic achievability of the management measures cited above and contained in the *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters*. RTI estimated the incremental costs of these management measures by: 1) Specifying a set of key BMPs that RTI judged the coastal states in each major forest region as likely to require in order to achieve each management measure; and 2) Estimating the incremental costs of these BMPs relative to the costs of following current silvicultural practices. In summarizing the results of the incremental cost analysis, RTI combined the BMPs for the ten management measures into groups:

- *Management measures for activities generally relating to harvesting.* RTI analyzed the incremental costs for seven management measures -- preharvest planning, streamside management areas, road construction/reconstruction, road management, timber harvesting, revegetation of disturbed areas, and wetlands forest management. Incremental costs for the management measures for these seven activities were added and then presented in two alternative ways -- as the summed incremental cost of these seven management measures per acre harvested, and as the summed incremental cost of these seven management measures per volume of timber harvested.[121]

- *Management measures for activities relating to artificial forest regeneration.* Costs for the remaining four management measures -- site preparation prior to planting, forest regeneration (tree planting or seeding), fire management (prescribed burns for clearing unwanted vegetation) and forest chemical management (herbicides, fertilizer) -- were dealt with by RTI in a very different manner than the harvesting-related costs.

The unit costs for harvesting-related activities in each of the 30 States and the unit costs for artificial forest regeneration in the north and south regions, are described in the exhibits below.

Exhibit I-14
Estimated Harvest-Related BMP Costs (2000 $)

	Flat %	Hilly %	BMP cost/acre for flat, wet forest land	BMP cost/acre for hilly, wet forest land	BMP cost/100 cu. ft for flat, wet forest land	BMP cost/100 cu. ft for hilly, wet forest land
Alabama	77.2%	22.8%	$24.72	$33.66	$1.16	$1.77
Alaska	25.3%	74.7%	$35.36	$35.36	$2.14	$2.14
Arizona	63.2%	36.8%	$24.72	$33.66	$1.16	$1.77
California	18%	82%	$35.36	$35.36	$2.14	$2.14
Florida	99%	1%	$24.72	$33.66	$1.16	$1.77
Illinois	95%	5%	$18.20	$18.20	$1.65	$1.65
Kentucky	70.8%	29.2%	$24.72	$33.66	$1.16	$1.77
Louisiana	96.1%	3.9%	$24.72	$33.66	$1.16	$1.77
Maine	85.5%	14.5%	$18.20	$18.20	$1.65	$1.65
Massachusetts	100%	0%	$18.20	$18.20	$1.65	$1.65
Minnesota	87.2%	12.8%	$18.20	$18.20	$1.65	$1.65
Mississippi	80%	20%	$24.72	$33.66	$1.16	$1.77
Montana**	25.3%	74.7%	$35.36	$35.36	$2.14	$2.14
New Mexico	38.9%	61.1%	$24.72	$33.66	$1.16	$1.77
North Carolina	78.8%	21.2%	$24.72	$33.66	$1.16	$1.77
North Dakota	92.9%	7.1%	$18.20	$18.20	$1.65	$1.65
Ohio	53.5%	46.5%	$18.20	$18.20	$1.65	$1.65
Oklahoma	68.7%	31.3%	$24.72	$33.66	$1.16	$1.77
Pennsylvania	54.5%	45.5%	$18.20	$18.20	$1.65	$1.65
Rhode Island	100%	0%	$18.20	$18.20	$1.65	$1.65
South Carolina	86.5%	13.5%	$24.72	$33.66	$1.16	$1.77
South Dakota	95.7%	4.3%	$18.20	$18.20	$1.65	$1.65
Tennessee	47.9%	52.1%	$24.72	$33.66	$1.16	$1.77
Vermont	39.8%	60.2%	$18.20	$18.20	$1.65	$1.65
Virginia	54.6%	45.4%	$24.72	$33.66	$1.16	$1.77
West Virginia	46.2%	53.8%	$24.72	$33.66	$1.16	$1.77
Wyoming**	26.4%	73.6%	$35.36	$35.36	$2.14	$2.14

Exhibit I-15
Incremental Costs for Management Measures Associated With Artificial Regeneration (2000 $)

Region	Costs
South - hilly	(\$.63 + \$15.05 x %S) x SH
South - flat	\$0.63 x SF
North - hilly	(\$.19 + \$3.50 x %S) x NH
North - flat	\$0.19 x NF
West	Assumed identical to North
SH = acreage harvested in South/hilly SF = acreage harvested in South/flat NH = acreage harvested in North/hilly NF = acreage harvested in North/flat %S = percentage of hilly acreage harvested in each State that has slope > 30%	

D. Total national annual BMP costs

To estimate total national annual BMP costs:

- We obtained data for each county on:(1) Total million cubic feet (mcf) of timber harvested on all lands; (2) The total number of acres harvested on all lands; (3) The percentage of all lands that have flat terrain; (4) The percentage of all lands that have hilly terrain; and (5) The percentage of hilly lands that have steep terrain (classified as having a greater than a 30% slope) The BMP costs per acre and costs per 100 cubic feet for each of the 30 States are listed in the exhibit below.

- In every county of our 30 States, we multiplied the number of acres in all lands by: (1) The per-unit harvest BMP costs (State-by-State per-acre and per-volume cost estimates, weighted according to the flat and hilly terrain percentages); and (2) The per-unit artificial regeneration BMP costs (per-acre cost estimates for Southern and Northern/Western States, weighted according to the flat, hilly, and steep terrain percentages). For each state, we then added (1) to (2) to estimate the higher estimate of the total BMP cost (based off of the BMP cost per mcf and the artificial regeneration BMP cost per acre) and the lower estimate of the total BMP cost per acre (based off of the BMP cost per acre and the artificial regeneration BMP cost per acre). Summing across all 30 states, we estimated the total annual cost for silviculture BMPs at $39.1 million (lower estimate) or $54.9 million (higher estimate).

- Applying two further scaling factors (.4484 to reflect the pace of TMDL development at 7 % discount rate, and 1.13 to reflect unknown/not classified source information), we estimated **$29.7 - 49.7 million/yr** as the annualized national BMP cost for silviculture.

IV. ON-SITE WASTEWATER TREATMENT SYSTEMS (OWTS)

On-site wastewater treatment systems (OWTS) may serve one or more homes or businesses, typically in rural areas where public sewers and a central wastewater treatment plant are not available. An OWTS typically includes a septic tank and a leach field, where partially treated wastewater from the septic tank percolates into the soil which provides further removal before the effluent leaches to ground water. OWTS can fail or perform poorly for a variety of reasons, including:

- Locations in inappropriate soils, or too close to surface water or ground water;
- Too many systems located in close proximity to each other;
- Hydraulic overloading;
- Insufficient maintenance (conventional septic tanks need to be pumped out every 3 - 5 years);
- Mechanical failure with age.

Approximately 23 % of the dwellings in the U.S. are served by OWTS. Their prevalence is particularly high among second homes and rural resort areas.

We found 596 water bodies on States' 303(d) lists that States have identified as impaired by OWTS (either directly in their 303(d) submission or cited as impaired in their 305(b) submissions and corresponding with a 303(d)-listed water body). These water bodies are in 318 counties in 24 States. We assume conservatively that the remaining States may have OWTS-impaired water bodies, but either did not report sources of impairment at all or reported them in a manner that was insufficiently specific to identify OWTS as a source of impairment. The 24 States reporting OWTS-impaired 303(d) waters include 14.2 million dwelling units served by OWTS. In the Nation as a whole, 24.7 million dwelling units are served by OWTS. We assume that the degree to which OWTS impair waters in the 24 "reporting" States is replicated in the remaining States. The scale factor to extrapolate from whatever OWTS costs we estimate for the 24 States to the entire nation is thus 1.732 (24.7 million divided by 14.2 million).

We assume that a TMDL addressing OWTS will require all OWTS within a riparian zone around the impaired water to be functioning properly. We further assume that "functioning properly" means that any OWTS that fails must promptly be repaired or replaced.

Estimates of the rate at which OWTS are currently failing vary across studies. Reasons for variation may include differences across studies in how "failing" is defined, and geographic differences in construction practices and environmental settings that result in actual differences in failure rates. EPA's Draft Nonpoint Source Gap Analysis[122] summarizes the estimates developed in many studies. One of the most broadly based estimates was developed by the National Small Flows Clearinghouse, which estimated

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122 Tetra Tech, Inc. *Draft Nonpoint Source Gap Analysis.* Prepared for U.S. EPA, Office of Water. February 7, 2001.

10.2 % of OWTS as failing during the mid-1990s.[123] A survey of State officials yielded failure estimates that ranged from as low as 0.5 percent (Arizona and Utah) to 50 - 70 percent in Minnesota.[124] In the Nonpoint Source Gap Analysis, Tetra Tech reviews these and other studies and assigns 24 States as having a "low" average failure rate (5 %), 19 States as having a "moderate" average failure rate (20 %), and 7 States as having a "high" failure rate (30 %). For this analysis, we will assume as a low estimate that 10 % of all OWTS are currently failing, and as a high estimate that 20 % of all OWTS are currently failing.

The cost of addressing a failed OWTS varies with the nature of the failure. In the Nonpoint Source Gap Analysis, Tetra Tech cites possible remedial responses ranging from pumping out an overloaded septic tank and installing a tank filter (cost about $300) to installing an entirely new advanced system with nitrogen removal and/or disinfection (cost about $12,000). The most common likely responses, according to Tetra Tech, are developing a new subsurface wastewater infiltration field (cost about $1,500) or installing a complete new conventional septic tank/leach field (cost about $3,000). Tetra Tech weights each remedial response by its likelihood and develops a weighted average cost of $3,040 per failed OWTS. We use this figure in this analysis.

A properly operated and maintained OWTS can last 20 - 35 years or more. Tetra Tech assumes that the average system will function for 25 years.

We thus estimate the cost to assure that the average OWTS is functioning correctly as $142.88 - $ 164.16 per year, as follows:

Exhibit I-16
Average Cost Per OWTS For Assuring Proper Performance

	Low Estimate	High Estimate
Cost to remediate the backlog of failed systems	0.1 (low est. of fraction of failed systems) x $3,040 = $304 capital cost, or, at 7% interest, $21.28 annualized cost	0.2 (high est. of fraction of failed systems) x $3,040 = $608 capital cost, or, at 7% interest, $42.56 annualized cost
Recurring cost to remediate the additional systems that will fail each year	0.04 (fraction of systems failing each year) x $3,040 per system = $121.60 per year	0.04 (fraction of systems failing each year) x $3,040 per system = $121.60 per year
Total	$142.88 per system per year	$164.16 per system per year

This estimated average cost will be applied to each OWTS that is assumed to be required by a TMDL to be functioning correctly.

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123 National Small Flows Clearinghouse. *Summary of On-Site Systems in the United States.* 1996.

124 Nelson, Dix and Shepard. *Advanced On-Site Wastewater Treatment and Management Scoping Study: Assessment of Shrot-Term Opprotunities and Long-Run Potential.* Prepared for the Electric Power Research Institute, the National Rural Electric Cooperative Association, and the Water Environment Research Federation. 1999.

We assume that the riparian zone within which TMDLs will require all OWTS to be functioning properly extends for 100 yards in all directions from an OWTS-impaired water. The 100 yard distance was based on the following information:

- We reviewed State recommendations or requirements regarding surface water setback distances – the minimum distance that an OWTS should be located away from a surface water body. We reasoned that the riparian zone within which all OWTS should be functioning correctly should be at least as large as these setback distances. The maximum State setback distance in any State, as cited in EPA's National Nonpoint Source Management Measures Guidance, was 100 feet.[125]

- We reviewed the management measures for OWTS recommended by the Buzzards Bay National Estuary Project, an effort rather like a TMDL and one of the best known investigations of extensive pollution from OWTS. The Project found that existing OWTS setback requirements, while adequate to deal with indicator bacteria, were inadequate to deal with viruses from OWTS that may reach ground water and then travel great distances. The Project recommended a setback distance of 250 feet for all new OWTS, and improvements to system design and application rate for existing OWTS within this zone.[126]

- We reviewed a study examining transport of pollutants from large failed septic systems. The study showed evidence of increased pollutant concentrations for different pollutants at various downgradient distances, the greatest of which was nearly 100 meters.[127]

Based on this information, we assume that a surface water is likely to be adequately protected from impairment by OWTS if all OWTS within 100 yards of the waters are properly sited (i.e., no inappropriate soils, no excessive OWTS density, no hydraulic overloading), operated and maintained.

To determine the area of the riparian zone around each OWTS-impaired water, we then multiplied the length of each impaired water body by the assumed 100-yard-deep zone, as adjusted for the type of water body:

- *Rivers.* In the 24 States, there were 5440 miles of OWTS-impaired rivers, multiplied by 300 feet on each of two sides. This results in 395,630 riparian acres needing OWTS controls.

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125 U.S. EPA. *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters*. Www.epa.gov/owowwtr!/NPS/MMGI/Chapter4/ch4-5a.

126 Buzzards Bay Project. *National Estuary Project Management Plan: Septic System Action Plan*. Www.buzzardsbay.org/ccmp/septicac.

127 W.D. Robertson and J. Harman. Phosphate Plume Persistence at Two Decommissioned Septic System Sites. Ground Water. Volume 37, No. 2, 1999, pp. 228 - 236

- *Lakes.* The 167 OWTS-impaired lakes average 5,103 acres per lake. Approximating the lakes' shape as circular, a 300-foot riparian ring around each lake results in an estimated 60,785 acres needing OWTS controls.

- *Estuaries.* The 47 OWTS-impaired estuaries average 7,064 acres each. Approximating their shape as circular and assuming that land occupies 2/3 of their circumference, a 300-foot ring around their landed perimeter results in an estimated 13,424 acres needing OWTS controls.

- *Coastal shorelines.* In the 24 States, there were 249 miles of OWTS-impaired coastal shorelines, multiplied by 300 feet on the land side of each. This results in 9,067 riparian acres needing OWTS controls.

Summing across all OWTS-impaired water bodies in the 24 States, we estimate there are 478,906 riparian acres within which OWTS controls are needed.

How many OWTS are there within this acreage? Absent a painstaking and impractical investigation to delineate these riparian zones, count the dwelling units within them, and estimate the fraction of the dwelling units that rely on OWTS, we cannot know the answer with any precision. Instead, we make a very rough simplifying assumption -- that the density of dwellings served by OWTS in any riparian zone is 10 times the density of dwellings served by OWTS in the county surrounding the impaired water. In essence, we assume that the riparian zone is much more intensively developed than is the county as a whole. This seems reasonable, as we would expect waterside home sites typically to be much more attractive than more undistinguished locations. If, for example, an entire county has an average of one OWTS-served dwelling unit per four acres of land area (e.g., as in Fairfield County, CT, one of the counties with the greatest number of OWTS-served homes), then we would assume in this county that there would be one dwelling per 0.4 acres specifically in the riparian zone around OWTS-impaired waters.[128]

With this final assumption that the density of OWTS in the riparian zones surrounding OWTS-impaired waters in a county is <u>10 times</u> the density of OWTS in the county as a whole, we are able to estimate the national costs for control of OWTS:

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128 This result seems at least plausible in this instance. Some of the OWTS-impaired waters in Fairfield County have shorelines fully developed with OWTS-served homes on lots averaging as little as 8,000 square feet per lot (density of roughly one dwelling per 0.2 acres). Others of the impaired waters in Fairfield County have typically larger lots in the developed shoreline areas, and some (limited) portions of the shorelines that are relatively undeveloped. The average density throughout the entire riparian zones for Fairfield County's ten OWTS-impaired waters could well be approximately one OWTS-served dwelling per 0.4 acres.

- We obtained data for each county on: (1) The riparian acreage needing OWTS controls, as described previously; (2) The total acreage in each county;[129] (3) The number of dwelling units served by OWTS.[130]

- [(1)/(2)] x 10 x (3) = # of dwelling units needing OWTS controls in each county.

- Summing across all 318 counties with OWTS-impaired waters in 24 States gives 191,921 dwellings needing OWTS controls

- Total annual cost for OWTS controls in the 24 States = 191,921 x $142.88 (lower estimate) or $164.16 (higher estimate) per system per year = $27.4 million/yr (lower estimate) or $31.5 million/yr (higher estimate).

- To obtain an estimate for the entire nation, we multiply by the scaling factor of 1.732. and obtain a national estimate of $47.5 - $54.6 million/yr.

We next apply two further scaling factors (.4484 to reflect the pace of TMDL development at a 7 % discount rate, and 1.13 to reflect unknown/not classified source information). Our final estimate of the nationwide incremental cost of TMDLs for OWTS is **$24.1 - $27.7 million/yr**.

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129 U.S. Census Bureau. *Land Area, Population, and Density for States and Counties: 1990.* Www.census.gov/population/censusdata/90den_stco.txt

130 U.S. Census Bureau. *American Housing Survey for the United States.* 1997. Www.census.gov/prod/99pubs/h150-97.pdf