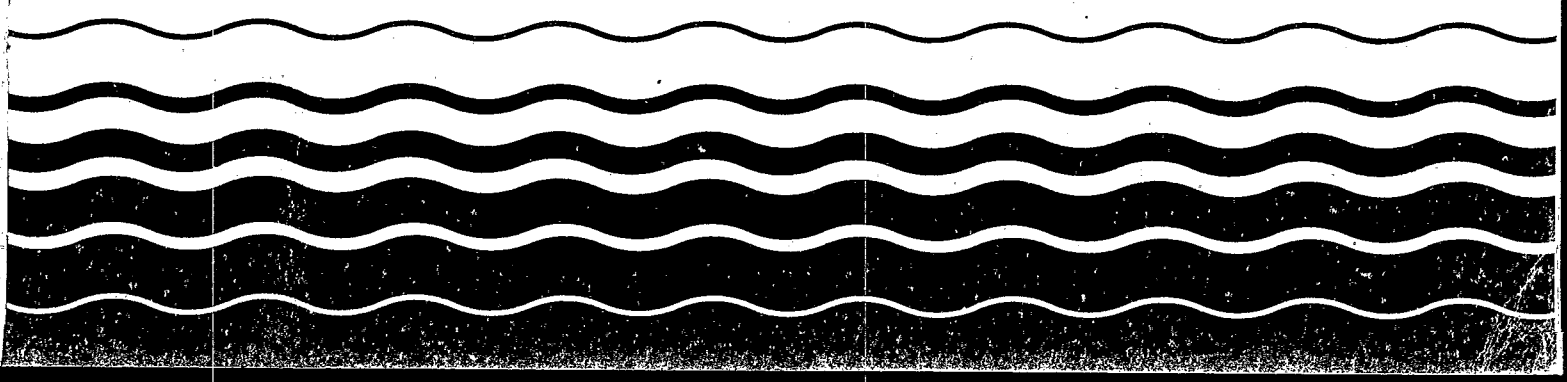
United States
Environmental Protection
Agency

Office Of Water
(4204)

EPA 833-R-99-002
October 1999

Economic Analysis Of The Final Phase II Storm Water Rule



ECONOMIC ANALYSIS
OF THE
FINAL PHASE II STORM WATER RULE

Final Report

October 1999

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EPA Contract No. 68-C4-0034; Work Assignment No. IM-5-4(P)
SAIC Project No. 01-0833-08-2995-XXX

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In addition, this document includes a discussion of the National Water Pollution Control Assessment Model (NWPCAM) developed by Research Triangle Institute (RTI). EPA has incorporated findings from the assessment model into Chapter 6. The NWPCAM report is included in its entirety in Appendix E.

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EXECUTIVE SUMMARY

This document provides EPA's Economic Analysis of the Phase II Storm Water Rule, a regulatory action which requires small municipalities and construction sites to implement best management practices to control storm water discharges. This analysis updates the benefit-cost analysis prepared for the proposed rule. The analysis is based on the final rule. Revisions have been made in response to internal agency review and comments received during the public comment period.

ES.1 Environmental Concerns Addressed by the Rule

Storm water discharges have emerged as one of the leading causes of impairment of the Nation's surface waters (US EPA, 1998a). Several studies reveal that storm water runoff from urban areas and construction sites can include a variety of pollutants, such as sediment, bacteria, organic nutrients, hydrocarbons, zinc, copper, cadmium, mercury, iron, nickel, oil, and grease (Barret et al., 1996). In addition, the National Water Quality Inventory, 1996 Report to Congress, which summarizes state §305(b) reports, provides documentation of water quality impairment resulting from storm water discharges. The report shows that urban runoff/storm sewer discharges affect 13% of impaired rivers, 21% of impaired lakes, and 45% of impaired estuaries. Impaired waters are those waters not meeting water quality standards or designated beneficial uses such as drinking water supply, primary contact recreation, and aquatic life support. The report also documents impairment to rivers, lakes, and wetlands resulting from construction (e.g., land development, road construction).

Many studies provide documentation of the impacts of storm water discharges on humans, aquatic life, and other wildlife, including impacts to small streams. The potential impacts of these discharges include increased bacterial contamination, increased turbidity, increased toxic sediments, decreased dissolved oxygen concentrations, and alterations in stream channel morphology and habitat. In turn, these in-stream conditions can have a considerable impact on human health and the abundance and diversity of aquatic species. The level of impact is site-specific and depends on site imperviousness, the type of receiving waters, acreage of land disturbance, topography, soil type, and resource sensitivity. The nature of the impact also varies temporally throughout the land development process, with significant differences observed between the site clearing phase, construction phase and post development conditions.

ES.2 Statutory Background for the Rule

In the 1987 amendments to the Clean Water Act (CWA), Congress established a tiered approach for addressing certain industrial, municipal, and other storm water discharges. These amendments provided for a phased program to address the most significant contributors first (Phase I), and identify an appropriate second tier of sources at a later date. EPA published Phase I application requirements for categories of storm water discharges recognized as the most damaging to the environment in 1990 (55 Federal Register (FR) 47990, November 16, 1990). Generally, Phase I sources include storm water discharges associated with certain industrial activities, medium and large municipal separate storm sewer systems (MS4s), and large construction sites (greater than five acres).

Phase II storm water sources were to be identified based on EPA's findings as presented in its Report to Congress (US EPA, 1995a). Based on this report, EPA published a direct final Phase II storm water rule in 1995 (60 FR 40229, August 7, 1995). EPA published this rule in part to protect Phase II dischargers from CWA citizen suit liability. However, it was recognized that the Phase II regulatory program would undergo further development. The 1999 final rule, when promulgated, will replace the August 1995 direct final rule.

ES.3 Description of the Rule

The Phase II rule will require storm water discharges from small MS4s and small construction sites to be covered under a National Pollutant Discharge Elimination System (NPDES) permit. Small MS4s include incorporated places, counties, and other places under the jurisdiction of a governmental entity (including Tribal and Territorial governments) that are located in an urbanized area but are not included in Phase I. Phase I addresses larger and medium-sized MS4s serving populations of 100,000 and more. Phase II generally pertains to systems serving less than 100,000 people. Indian reservations located within urbanized areas and with a population of less than 1,000 persons are excluded. And, the permitting authority can waive MS4s that serve a population of less than 1,000 under certain conditions. Owners or operators of small MS4s would be required to develop and implement a storm water management program designed to reduce the discharge of pollutants to the maximum extent practicable and protect water quality. The storm water management program would need to include a requirement for post-construction runoff controls from new development and re-development.

Phase II small construction sites that will be designated by the rule are those that disturb between one and five acres of land. In addition, sites disturbing less than one acre would be subject to regulation if they are part of a larger common plan of development or sale. However, the NPDES permitting authority could waive permitting requirements under certain conditions. Small construction site owners or operators would be required to plan and implement appropriate erosion and sediment control best management practices (BMPs) to control storm water discharges.

ES.4 Baseline for the Analysis

Analysis of the incremental benefits and costs of the Phase II rule requires that EPA establish a baseline for similar storm water programs, population, construction starts, and water quality. EPA defined the universe of potentially affected municipalities as those located in urbanized areas and construction sites by excluding corresponding construction sites in states that have instituted erosion and sediment control programs in response to CZARA or other state ordinance. Population estimates are based on 1998 US Census Bureau estimates of population, households, urban population, and sewered population. To develop estimates of Phase II construction and land development activities, EPA used construction start data gathered in 14 municipalities across the country and 1994 US Census Bureau estimates of the number of building permits issued nationwide.

Finally, EPA characterized existing water quality and the relative impact of Phase II sources on water quality using the National Water Quality Inventory Report to Congress (US EPA, 1998_a),

also referred to as "305(b) data". However, the 305(b) data characterize waters based on impairment of surveyed waterbodies. Therefore, to establish a baseline representing all waters impaired by urban runoff/storm sewers, construction, and land use, EPA assumed that the 305(b) survey data characterize 100% of all US waters. EPA approximated the proportion of impairment specifically attributable to Phase II sources by multiplying the percentage impairment by the percentage of the municipal population and construction activities (starts) regulated under the rule.

ES.5 Potential Costs for Municipalities

EPA estimated annual per household program costs for automatically designated municipalities using data from a 1998 survey conducted by the National Association of Flood and Stormwater Management agencies which sought to identify current storm water spending levels in Phase II municipalities (see Section 4.2.1). EPA also estimated an average annual per household administrative cost for municipalities to address application, record keeping, and reporting requirements of the final rule. The average per household cost of the rule is expected to be $9.16.

To determine potential national level costs for municipalities, EPA multiplied the number of households (32.5 million) by the per household compliance cost ($9.16)[1]. The annual estimated national Phase II municipal cost is approximately $297.3 million.

ES.6 Potential Costs for Construction Operators

EPA developed a national level cost estimate for implementing erosion and sediment controls on sites that disturb between one and 5 acres. EPA estimated a per site compliance cost for sites of one, three, and five acres and multiplied the cost by the total number of Phase II construction starts expected to incur incremental cost in these size categories to obtain a national cost estimate. EPA used construction start data from fourteen municipalities and 1994 Census Bureau construction permit data to estimate the number of construction starts disturbing between one and five acres of land. Of the estimated 129,675 construction starts likely to incur incremental costs, EPA expects that 110,223 (85%) will require erosion and sediment controls to comply with the regulation.

EPA used standard cost estimates from R.S. Means (R.S. Means, 1997a and 1997b) and the WEF database to estimate construction BMP costs for 27 model sites of typical site conditions in the United States. The model sites included three different site sizes (one, three, and five acres), three slope variations (3%, 7%, and 12%), and three soil erosivity conditions (low, medium, and high). EPA used the WEF database to determine BMP combinations appropriate to the model site conditions. For example, sites with shallow slopes and a low erosivity require few BMPs, while larger, steeper, and more erosive sites required more BMPs. Detailed site plans, assumptions, and BMPs that could be used are presented in Appendices B–2 and B–3. Based on the assumption that any combination of site factors is equally likely to occur on a given site, EPA

[1]Per household cost can be converted to per capita cost using the national average of 2.6246 persons per household.

averaged the matrix of estimated costs to develop an average cost for one-, three-, and five-acre starts for all soil erodibilities and slopes.

EPA then estimated administrative costs per construction site for the following elements required under the Phase II rule: submittal of a notice of intent (application) for permit coverage; notification to municipalities; development of a storm water pollution prevention plan (SWPPP); record retention; and submittal of a notice of termination. The average total administrative cost per site is estimated to be $937.

Summing the average BMP costs and the administrative costs yields a total compliance cost of $2,143 for sites disturbing between one and two acres of land, $5,535 for sites disturbing between two and four acres of land, and $9,646 for sites disturbing between four and five acres of land. To estimate national level incremental annual costs for Phase II construction starts, EPA multiplied the total costs of compliance for one to two acre, two to four acre, and four to five acre sites by the total number of Phase II construction starts within each of those size categories. This yielded an estimated annual compliance cost of approximately $499.8 million (based on 110,223 construction starts in 1998).

EPA anticipates that 19,452 (15%) of the estimated Phase II incremental construction universe will qualify for a waiver from program requirements by meeting one of two conditions. Construction sites can be waived if they are either located in areas with low rainfall potential or if water quality analyses show that there is no need for regulation. EPA estimates the incremental administrative cost associated with preparing and submitting a waiver to be approximately $665,000 (1998). Total costs (national compliance and waiver costs) resulting from implementation of the Phase II erosion and sediment control provision are estimated to be $500.4 million.

EPA also estimated incremental costs attributable to the post-construction runoff control measure. The Phase II municipal program requires municipalities to develop, implement, and enforce a program that addresses storm water runoff from new development and redevelopment sites on which land disturbance is greater than one acre and that discharge into a regulated MS4. To develop a cost estimate associated with this measure, EPA estimated a per site BMP cost, including operation and maintenance, for 12 model sites of varying size (1, 3, 5, and 7 acres) and imperviousness (35%, 65%, and 85%). The per site BMP cost was then multiplied by the total number of multi-family, institutional, and commercial construction starts that are located in Phase II urbanized areas to obtain a national cost estimate. Using this total of 13,364 post-construction starts, EPA estimated a range of national costs associated with this measure from $44.6 to $178.3 million (see Appendix B–4).

EPA estimates total annual costs to construction operators, including implementation of erosion and sediment controls and post-construction controls, to be between $545.0 – $678.7 million.

ES.7 Potential Costs for Federal and State Program Administrators

EPA estimated incremental costs associated with program administration for states that possess NPDES permitting authority and for EPA within non-NPDES authorized states and territories.

The storm water permitting authority must review and manage the application, certification, reporting and notice requirements for municipalities and construction sites. The estimated annual incremental Federal and State administrative costs are estimated to be $5.3 million.
The permitting authority must also develop municipal designation criteria and use the criteria to determine whether municipalities that are not automatically designated should be regulated by the Phase II rule. The costs associated with developing and applying these criteria are not included in the annual administrative cost estimates because they are considered a one-time-only start up cost. However, these costs and other administrative start-up costs are considered in the sensitivity analysis, referred to as Scenario Six, in Section 4.6 of Chapter 4.

ES.8 Summary of Potential Costs

A summary of the potential costs from implementing the Phase II municipal measures and construction site erosion and sediment controls is presented in Exhibit ES–1. Once the Phase II storm water rule is fully implemented, EPA expects the total range of annual costs for implementing the rule to be $848 to $981 million.

Exhibit ES–1. Potential Annual Costs for Phase II Storm Water Regulation

Phase II Element	Universe	Estimated Total National Annual Costs (millions of 1998 dollars)
Municipal	32,458,000 Households	$297,318,623
Construction	129,675 Erosion & Sediment Control Starts and 13,364 Post-Construction Starts *	$545,000,539 – $678,692,291
Federal/State Administration	53 States and Territories	$5,318,668
Total		$847,637,830 – $981,329,582

* The total number of construction starts potentially affected by the Phase II construction program is not the sum of 129, 675 and 13, 364. This is because the E&S provision affects all 1–5 acres starts nationwide, while the PCRC provision affects starts under 10 acres in Phase II municipalities only.

ES.9 Pollutant Loading Reductions from Municipalities

EPA developed estimates of municipal pollutant loading reductions for the final Phase II rulemaking using estimates of national municipal loading reductions for total suspended solids (TSS) based on the National Urban Runoff Program (NURP) study (US EPA, 1997c). Although these estimates for TSS do not capture the full extent of potential loading reductions that result from implementing municipal storm water controls, they provide a minimum estimate of the reductions that may result from the Phase II rule. EPA also anticipates that the rule will result in reductions in oil and grease, nitrogen, phosphorus, pathogens, lead, copper, zinc, and other metals.

Partial TSS loadings reductions may range from 639,115 tons/year (assuming 20% BMP efficiency) to 4.1 million tons/year (assuming 80% BMP efficiency). EPA anticipates that municipalities will strive to achieve 80% effectiveness when implementing their storm water programs.

ES.10 Reduced Sediment Delivery from Phase II Construction Starts

To estimate reduced sediment delivery from Phase II construction starts, the US ACE developed a model based on EPA's 27 model sites to estimate sediment loads from construction starts with and without Phase II controls (US ACE, 1998). The US ACE model uses the construction site version of the Revised Universal Soil Loss Equation (RUSLE) to generate sediment delivery estimates for 15 climatic regions with each of the following variations: three site sizes (one, three, and five acres), three soil erodibility levels (low, medium, and high), three slopes (3%, 7%, and 12%), and the BMP combinations from EPA's 27 model sites. The 15 climatic regions represent the various rainfall and temperature conditions throughout the United States. Sediment delivery represents the quantity of sediment that BMPs placed at the base of the hill slope are unable to capture. EPA estimated that the average reduction in soil loss from the model sites implementing BMPs would be 89.6 tons per site.

ES.11 Cost Effectiveness

Cost effectiveness is typically defined as the incremental annualized cost of a pollution control option per incremental pound of pollutant removed annually by the control option. Cost-effectiveness analysis can thus be used to compare pollutant removal costs across regulatory alternatives and across different industries. This type of analysis is limited for the Phase II rule because EPA was only able to quantify potential reductions in TSS loadings (the reduced sediment delivery from construction starts would contribute to the reduced loadings from municipalities). EPA also anticipates that the rule will result in reductions of other pollutants.

Based on the total cost of the rule and the estimated reduction in TSS from Phase II municipalities, EPA estimates that Phase II municipalities may experience costs of between $0.04 (80% BMP efficiency; high end reduction) and $0.18 (20% BMP efficiency; low end reduction) per pound of TSS removed.[2] While EPA anticipates 80% effectiveness at reducing pollutant loading following program implementation, both low and high end reduction costs are very low compared to the $0.70 (1998 dollars) established for POTWs to remove BOD and TSS; thus, the requirements of the final Phase II rule may be cost effective.[3] This is particularly true since EPA's analysis of cost-effectiveness is based solely on removal of one of many pollutants believed present in storm water discharges.

ES.12 Anticipated Benefits of the Phase II Rule

Storm water runoff from construction sites and urban areas can adversely affect aquatic systems. Runoff from these areas can include litter, chemicals, metals, nutrients, pesticides, organics, bacteria, and sediment. These pollutants can have a variety of detrimental effects on humans, aquatic ecosystems, and wildlife. For example, bacterial contamination of waters used for swimming can threaten the health of swimmers. Sediment related pollution can degrade and

[2]Cost effectiveness is based on the total cost of the rule because the municipal component includes construction activity within the watershed.

[3]The technologies used for secondary treatment at POTWs removes both BOD and TSS at the same time. Therefore, estimating the tons of TSS removed from secondary treatment is not possible.

destroy benthic habitat and organisms, decrease photosynthetic activity, and reduce the viability of aquatic biota. Sediment can particularly detrimental to smaller streams, altering channel morphology and threatening critical aquatic habitat as well as human safety and property. Other pollutants such as metals, organics, pesticides, and nutrients can have chronic or acute effects on aquatic organisms and lead to bioaccumulation or eutrophication.

Estimation of Benefits

In the economic analysis for the proposed rule, a top-down approach was used to estimate economic benefits. Under this approach, the combined economic benefits for all wet weather programs were estimated first, and then were divided among various water programs on the basis of expert opinion. The use of an expert opinion in this manner rendered the benefits estimates for an individual program uncertain. In addition, the approach was inconsistent with the bottom-up approach used to estimate the cost of the proposed storm water rule, which aggregated costs across municipalities and construction starts. Researchers normally prefer to base cost and benefits analysis on a similar structure. Therefore, EPA decided to change the benefits analysis for the Phase II rule. To adequately reflect the quantifiable benefits of the rule, EPA used two different approaches, one that relied on a national water quality model and another that relied on the 305(b) national water quality assessment. Both approaches estimate benefits based on expected water quality improvements of the Phase II rule. Despite the difference in the estimates, both approaches show that benefits potentially exceed costs.

National Water Quality Model Approach

To estimate the benefits of the Phase II municipal and construction site controls, EPA used the National Water Pollution Control Assessment Model (NWPCAM). This model estimates water quality and associated use support for the 632,000 miles of rivers and streams in the EPA Reach File Version 1 (RF1), which covers the continental United States. The model analyzes water quality by stream reach based on point source and nonpoint source pollution loadings and geographic and hydrologic conditions. The water quality parameters modeled in the NWPCAM are biological oxygen demand (BOD), total suspended solids (TSS), dissolved oxygen (DO), and fecal coliforms (FC). The model simulates the impact of loadings on water quality immediately below a point source in the down stream segment of a reach.

The model projects improvements in water quality by comparing the simulation results of a baseline loadings scenario with results for a scenario based on Phase II municipal and construction site controls. These improvements are characterized as changes in modeled water quality classifications between four water quality use support categories: no support, boatable, fishable, and swimmable. To calculate the economic benefits of change in water quality, the model overlays the water quality changes with estimates of households in the proximity of the affected stream reach. The household estimates are based on the 1990 Census of Populated Places and Minor Civil Divisions, and updated 1998 population levels. Economic benefits are calculated multiplying number of households by household willingness-to-pay (WTP) values for water quality improvements. The WTP values are based on a national valuation survey (Carson and Mitchell, 1993). The benefits are separately estimated for local and nonlocal waters on the basis of WTP values.

Definition of Baseline Conditions

To estimate economic benefits, NWPCAM compares given baseline pollution loadings conditions to compliance with the Phase II program. The baseline conditions are described below.

- All combined sewer overflows (CSOs) are controlled by detention basins and assume 85% capture of the runoff (the 85% capture is based on NEEDS Survey assumptions)
- Detention basin controls are at each of the 1,723 individual NWPCAM Phase I urban sites and assume 85% capture of the runoff
- Construction start BMPs are in place based on existing state programs
- Construction start BMPs are in place at sites greater than five acres.

Definition of Scenario Conditions—Phase II Controls in Place

The Phase II conditions include the baseline conditions and are assumed to further impose:

- Detention basin controls at each of the 5,038 individual NWPCAM Phase II urban sites that assume 85% capture of the runoff[4]
- Construction starts BMPs are in place at sites between one and five acres.

The model normally requires an engineering surrogate for treatment of specific pollutants contained in discharges, whereas the Phase II program includes both structural and nonstructural controls. The model uses detention basins as a proxy to represent the impact of the municipal program.

EPA applied Carson and Mitchell's (1993) estimates of household WTP for incremental water quality improvements to the improvements simulated using NWPCAM. Carson and Mitchell estimate the WTP for three minimum levels of fresh water quality: boatable, fishable, and swimmable. EPA adjusted the WTP amounts to account for inflation, growth in real per capita income, and increased attitudes towards pollution control. The adjusted WTP amounts for improvements in fresh water quality are $210 for boatable, $158 for fishable, and $177 for swimmable.

The NWPCAM valuation analysis assumes that households place a higher value on local water quality improvements than on nonlocal water quality improvements. Thus, if improvement occurs in waters that are not close to population centers, the economic value is lower. Benefits are estimated for local and nonlocal waters, separately by apportioning the WTP between local and nonlocal waters. Mitchell and Carson (1986) asked respondents to apportion each of their

[4]The benefits analysis used 5,038 municipalities instead of 5,040 used for the cost analysis.

stated WTP values between achieving the water quality goals in their own state and achieving those goals in the nation as a whole. On average, respondents allocated 67% of their values to achieving in-state water quality goals and the remainder to the nation as a whole. Mitchell and Carson argue that for valuing local (substate) water quality changes 67% of the WTP value is a reasonable upper bound for the local multiplier and 33% of the value is for nonlocal water quality changes. For the purposes of this analysis, the locality is defined as urban sites and associated populations linked into the NWPCAM framework Using this methodology, the total benefits of Phase II controls are estimated to be $1.63 billion per year. The summary of the local and nonlocal benefits due to Phase II controls are presented in ES–2.

Exhibit ES–2. Annual Local and Nonlocal Benefits Estimates Due to Phase II Controls

Use Support	Local Benefits ($million)	Nonlocal Benefits[1] ($million)	Total Benefits ($million)
Swimming, Fishing, and Boating	306.2	60.6	366.8
Fishing and Boating	395.1	51.9	447.0
Boating	700.1	114.6	814.7
Total	1401.4	227.1	1628.5

[1] To estimate nonlocal willingness to pay per household, the 33% of WTP is multiplied by the fraction of previously impaired national waters (in each use category) that attain the beneficial use as a result of the Phase II rule. To estimate the aggregate nonlocal benefits, nonlocal WTP is multiplied with the total number of households in the United States.

Sensitivity Analysis

The benefit estimates are derived using conservative assumptions of the pollution control effectiveness of the municipal component of the Phase II rule. The Phase I and Phase II urban runoff controls used in this analysis employ pollutant removals that would be characteristic of detention basins. To determine the impact of the alternative assumptions a sensitivity analysis is conducted. Alternative analysis assumes different levels of control, such as 60% or 80% pollutant removals in the storm water run off from municipal sources. Supplemental sensitivity analysis in conjunction with the controls in the 60% to 80% range shows that the economic benefits in NWPCAM increase by $200 million to $300 million from the estimate of $1.63 billion, respectively.

The benefit estimates can be considered quite robust because model sensitivity analyses have consistently shown that the estimates are stable, even under assumptions of large changes in model input values. As an example, a sensitivity analysis was conducted assuming that the construction starts loads are 25% higher and lower. The local economic benefits estimates change by only +/– 5%. Moreover, a statistical groundtruthing of the model to storage and retrieval ambient water quality data indicates that the NWPCAM produces reliable baseline estimate can be considered as a reasonable predictor of the actual use support for 1990s.

National Water Quality Assessment

This approach to estimating the benefits of the Phase II rule estimated benefits separately for the municipal minimum measure and the soil erosion control provisions. Furthermore, it estimated partial benefits associated with marine water quality improvements. Each component is described separately below and aggregate benefits are reported at the end of this section.

Potential Value of the Benefits of Municipal Measures—Fresh Waters

Runoff from Phase II municipalities contribute loadings of nutrients, metals, oil and grease, and litter that result in impairment of the nation's rivers and streams, lakes, reservoirs, Great Lakes, estuaries, and oceans. The benefits of implementation of the Phase II municipal minimum measures to remove impairment depend on a number of factors, including the number, intensity, and duration of wet weather events; the success of the municipal programs; the site-specific water quality and physical conditions; the current and potential uses of the receiving waters; and the existence of nearby "substitute" sites of unimpaired waters. Because all these factors will vary substantially from municipality to municipality, data and information are not available with which to develop estimates of benefits measure by measure and water body by water body.

EPA applied Carson and Mitchell's (1993) estimates of the household WTP for incremental water quality improvements to estimates of waters impaired by urban storm water discharges as reported by states in their 305(b) reports. Carson and Mitchell's 1993 study reports the results of their 1983 national survey of WTP for incremental improvements in fresh water quality. Carson and Mitchell estimate the WTP for three minimum levels of fresh water quality: boatable, fishable, and swimmable. EPA adjusted the WTP amounts to account for inflation, growth in real per capita income, and increased attitudes towards pollution control. The adjusted WTP amounts for improvements in fresh water quality are $210 for boatable, $158 for fishable, and $177 for swimmable.

To develop estimates for the potential value of the municipal measures (except storm water runoff controls for construction sites), EPA apportioned the WTP estimates for the different water quality levels based on the baseline level of water quality impairment potentially associated with Phase II municipalities. However, although the Carson and Mitchell estimates apply to all fresh water, it is not clear how these values would be apportioned among rivers, lakes, and Great Lakes. The 305(b) data indicate that lakes are the most impaired by urban runoff/storm sewers, followed closely by Great Lakes, and then rivers. Therefore, EPA applied the WTP values to the categories separately and assumed that the higher resulting value for lakes represents the high end of the range (i.e., assuming that lake impairment is more indicative of national fresh water impairment) and that the lower resulting value for impaired rivers represents the low end of a value range for all fresh waters (i.e., assuming that river impairment is more indicative of national fresh water impairment).

Summing the benefits across the water quality levels yields a low estimate of benefits ranging from approximately $120.2 million to $145.2 million per year and a high estimate of benefits ranging from approximately $270.1 million to $372.8 million per year, assuming 80% program effectiveness. The fresh water benefit analysis does not include the prospective benefits that are expected to accrue from the post-construction runoff control provision of the Phase II Storm

Water rule. This is because the benefit analysis was based on current water quality impairment levels in the 305(b) report. The post-construction runoff control provision will mitigate future impairment to water bodies by controlling contaminated storm water runoff from sites that are developed or redeveloped in the future. This would happen because development increases the amount of impervious surface. Such increases in imperviousness alter runoff patterns and reduces the effectiveness of natural water quality improvement mechanisms, such as groundwater infiltration and wetlands filtration. Furthermore, development introduces new sources of contamination to a watershed. Without this provision, national water quality impairment from Phase II would increase relative to the impairment levels currently reported in the 305(b). EPA estimated that annual benefits of avoided water quality impacts would range from $1.7 million to $5.4 million. This analysis is based on projections of current impairment levels reported in the 305(b) that use disturbed area estimates for the affected construction starts as a proxy for potential long-term future water quality impacts.

Potential Value of the Benefits of Municipal Measures—Marine Waters

The Phase II rule will impact all types of waters, fresh waters as well as marine. In addition to the fresh water benefits captured by the Carson and Mitchell study, EPA anticipates benefits as a result of improvements to marine waters. Sufficient methods have not been developed to quantify benefits for commercial or recreation fishing. EPA used beach closure data and visitation estimates from its Beach Watch Program to estimate potential reductions in marine swimming visits due to storm water runoff contamination events in 1997. The estimated 86,100 trips that did not occur because of beach closures in coastal Phase II communities is a lower bound because it represents only those beaches that report both closures and visitation data. Using average consumer surplus value of $30 per day per trip (in 1998 dollars) from applicable studies, which were summarized in two meta-analyses (Walsh et al., 1990 and Freeman, 1993), EPA estimated potential swimming benefits for the rule as $2.6 million. Assuming 80% program effectiveness, the benefit estimate is $2.1 million.

EPA developed an analysis of potential benefits associated with avoided health impacts from exposure to contaminants in storm sewer effluent. Based on a study of incremental illnesses found among people who swam within one yard of storm drains in Santa Monica Bay, EPA estimated a range of incremental illnesses (Haile et al., 1996). The Santa Monica Bay study reported attributable illnesses for several health symptoms. The attributable illnesses characterized incremental cases of illness found among those swimming close to the storm drains compared to a control group swimming at least 400 yards away from the drains. The benefits analysis applied values to two of the symptom categories. A WTP estimate of $24 per case was multiplied by the additional cases of significant respiratory disease (SRD) (US EPA, 1997d), in 1998 dollars. Assuming that each case was accompanied by one mild restricted activity day, and additional $47 was multiplied by each case (US EPA, 1997d), in 1998 dollars. Cases of highly credible gastroenteritis two were valued using a cost of illness value of $244, which was estimated by Mauskopf and French (1991), in 1998 dollars for mild cases of salmonellosis—an illness with symptoms similar to those in the Santa Monica Bay study. Depending on assumptions made about number of exposures to contaminants and contaminant concentrations, benefits ranged from $8.7 million to $37.4 million. Assuming 80% program effectiveness, the benefit range is $7.0 million to $29.9 million.

Potential Value of the Benefits of Construction Site Controls

Development activities increase the amount and types of contaminants that degrade water quality. During construction, soil erosion from disturbed areas increases sediment loads in water bodies, which leads to a variety of habitat impairments, increases flooding risks, and adds to dredging costs. In addition to sediment, construction activities also yield pollutants such as pesticides, petroleum products, and solvents. The national benefits of construction site storm water runoff controls will depend on a number of factors, including the number, intensity, and duration of wet weather events; the effectiveness of the selected construction site BMPs; the site-specific water quality and physical conditions of receiving waters; the current and potential uses of receiving waters; and the existence of nearby "substitute" sites of unimpaired waters. Again, because these factors will vary substantially from site to site, data are not available with which to develop estimates of benefits for each site.

Nonetheless, a survey of North Carolina residents (Paterson et al., 1993) indicated that households are willing to pay for erosion and sediment controls similar to those contained in the Phase II program. Paterson et al.'s (1993) analysis of the survey results indicated a mean WTP of $25 per year (in 1998 dollars). This study provides one way to develop national-level benefits estimates of the rule and, therefore, EPA chose to use benefit transfer methodology to apply the study results. Paterson et al's. (1993) study is applicable to the construction component of the Phase II rule not only because North Carolina's program requires similar controls, but also because the median income of North Carolina residents is just below the median income for the United States. The similarity of the median incomes indicates that the WTP estimates developed by Paterson et al. (1993) may be appropriate for transfer to residents elsewhere in the United States.

The impact of Phase II construction sites on overall construction soil erosion damages to water quality is uncertain. EPA developed a benefit range based on high and low impact assumptions. For the high impact assumption, EPA multiplied the updated mean WTP of $25 by the percentage of Phase II construction sites and the number of households in each state. For the low impact assumption, EPA used the percentage of total construction site perimeter affected by the Phase II rule rather than the percentage of total sites. Summing the low and high estimates across all states indicates that the WTP for the erosion and sediment controls of the Phase II rule may be approximately $487.7 million to $622.4 million per year. This range reflects the potential benefits of erosion and sediment control programs that protect all lakes, rivers, and streams. However, because construction can be especially harmful to small stream habitat, EPA is interested in the benefits that may be attributable to improvements in small stream ecology. Based on inventory data reported in state 305(b) reports and the distribution of streams by stream order (Leeden, 1990), approximately 2% of all water bodies are first order streams. This suggests that approximately $9.8 to $12.4 million of the total annual benefits from erosion and sediment controls may reflect a desire to protect small streams.

Summary of Monetized Benefits: National Water Quality Assessment

A summary of the potential benefits resulting from implementation of the Phase II municipal measures and erosion and sediment controls for construction sites is presented in Exhibit ES–3.

Total benefits from municipal measures and construction site controls are expected to be $671.5 million to $1,096.2 million per year (assuming 80% effectiveness of municipal programs), including benefits of approximately $10.8 million to $13.7 million per year associated with small stream improvements. The largest portion of benefits are associated with erosion and sediment controls for construction sites.

As shown in the exhibit, some categories of benefits are not included in the WTP estimates from the research used. In particular, benefits for improving marine water quality such as fishing and passive use benefits are not included in the values used to estimate the potential benefits of the municipal minimum measures (excluding construction sites controls), and they are not estimated separately.

Exhibit ES–3. Potential Annual Benefits of the Phase II Storm Water Rule (Millions of 1998 dollars)

Benefit Category	Annual WTP
Municipal Minimum Measures[1]	
Fresh Water Use and Passive Use[2]	$121.9 – $378.2
Marine Recreational Swimming	$2.1
Human Health (Marine Waters)	$7.0 – $29.9
Other Marine Use and Passive Use	+
Erosion and Sediment Controls for Construction Sites	
Fresh Water and Marine Use and Passive Use[3]	$540.5 – $686.0
Total Phase II Program	
Total Use and Passive Use (Fresh Water and Marine)	>$671.5 – >$1,096.2

+ = positive benefits expected but not monetized

[1] Includes water quality benefit of municipal programs, based on 80% effectiveness of municipal programs.

[2] Based on research by Carson and Mitchell (1993). Fresh water value only. Does not include commercial fishery, navigation, or diversionary (e.g.,municipal drinking water cost savings or risk reductions) benefits. May not fully capture human health risk reduction or ecologic values.

[3] Based on research by Paterson et al. (1993). Although the survey's description of the benefits of reducing soil erosion from construction sites included reduced dredging, avoided flooding, and water storage capacity benefits, these benefit categories may not be fully incorporated in the WTP values. Small streams may account for over 2% of total benefits.

ES.13 Benefits Estimation Comparison

The two approaches to estimating the potential benefits of the rule generate a wide range of benefits. The NWPCAM approach obtained a higher overall benefit estimate of $1.6 billion compared to the range for the national water quality assessment approach ($671.5 million to $1.1 billion). Both approaches are based on expected water quality improvements of the rule and both show that the benefits are likely to exceed costs.

ES.14 Comparison of Benefits and Costs

Exhibit ES–4 provides an annual comparison of benefits and costs for a representative year in which the rule is implemented, one in which benefits from the minimum measures and construction controls are accruing. Because there is not an initial outlay of capital costs with benefits accruing in the future (i.e., benefits and costs are almost immediately at a steady state), it is not necessary to discount costs in order to account for a time differential. In addition, EPA did not vary the factors that comprise the benefits and costs to account for market changes over time. Therefore, the benefits and costs presented in Exhibit ES–4 reflect a constant and steady stream of annual benefits and costs.

Exhibit ES–4. Comparison of Annual Benefits to Costs for the Phase II Storm Water Rule

Monetized Benefits[1]	**Millions of 1998 dollars[2]**
National Water Quality Model **Total Annual Benefits**	**$1,628.5**
National Water Quality Assessment	
Municipal Minimum Measures	$131.0 – $410.2
Controls for Construction Sites[3]	$540.5 – $686.0
Total Annual Benefits	**$671.5 – $1096.2**
Costs	**Millions of 1998 dollars[2]**
Municipal Minimum Measures	$297.3
Controls for Construction Sites[3]	$545.0 – $678.7
Federal/State Administrative Costs	$5.3
Total Annual Costs	**$847.6 – $981.3**

[1]National level benefits are not inclusive of all categories of benefits that can be expected to result from the regulation.

[2]Detail may not add to total due to independent rounding.

[3] Controls evaluated include both erosion and sediment and post-construction controls.

ES.15 Impact on Small Entities

Because EPA revised its cost analysis, it reviewed the economic impact analyses for small entities in its initial screening analysis. The small entities affected by the rule include almost 4,500 municipalities with populations below 50,000 and potentially more than 180,000 building construction businesses with revenues below $17 million. EPA revised its revenue test for small municipalities using the updated municipal cost estimates, and concluded that its original finding that the rule would not have a significant impact on a substantial number of small entities was consistent with the analysis.

EPA also updated its proxy for a sales test for small construction companies by comparing its revised per home compliance cost estimates for single family detached to the median and mean

cost of a new home. Compliance costs of approximately $400 to $650 per home equaled 0.22% to 0.43% of the price of a new home, and EPA concluded that it was unlikely that such costs would have a significant impact on a substantial number of small construction companies.

Finally, EPA added similar analyses of costs for multi-family residential developments and commercial developments to evaluate the potential impacts of indirect costs such as those estimated for the post-construction runoff control element of the municipal program provision. For multi-family developments, the per-site compliance costs was compared with the estimated revenues from constructing condominiums or apartments on the site. The revenue estimates were determined by multiplying the estimated number of units per site by the median condominium price and mean apartment price, respectively. Compliance costs equaled 0.17% to 0.91% of anticipated sales revenues. For commercial sites, the per-site compliance costs were compared to the estimated revenue from a commercial office development. Compliance costs ranged from 0.38% to 0.47% of sales. Based on the results from these three screening analyses, EPA concluded that typical construction firms, which build and sell residential or commercial sites, are unlikely to incur compliance costs which exceed 1% of expected sales.

ES.16 No Exposure

The Storm Water Phase II rule includes a conditional exclusion for no exposure for all categories of industrial activity covered by the Phase I program that can certify a condition of no exposure, except for discharges from construction and individually designated sources. "No exposure" means all industrial materials or activities are protected by a storm resistant shelter so that the materials or are not exposed to rain, snow, snowmelt, or runoff. EPA estimates that approximately 181,885 facilities are eligible to take advantage of the no exposure provision. Potential cost savings are provided to these facilities in the form of avoided costs. These forgone costs include the development and implementation of storm water pollution prevention plans that range from $3,661 to $24,147 annually, visual and analytical monitoring costs that vary, notice of intent costs of $3.25 annually, notification of municipalities cost of $3.25 annually, and record keeping costs of $91 annually. An annual no exposure certification cost of approximately $1.2 million is expected for the 181,885 facilities. After this certification cost is subtracted from total industrial avoided costs, the resulting net cost savings range from $317.6 million to $1.86 billion annually.

1.0 INTRODUCTION

In January 1998, the US Environmental Protection Agency (EPA, or the Agency) proposed a Phase II storm water rule that contained provisions for controlling pollutants in storm water discharges associated with certain municipalities and construction sites. EPA's proposal was accompanied by an economic analysis of the potential economic effects of the rule in compliance with Executive Order 12866 and other statutory and legal authorities such as the Small Business Regulatory Enforcement Fairness Act (SBREFA). EPA is currently under court order to finalize the Phase II storm water rule by October 31, 1999.

1.1 Statutory Background

The final rule has changed from the proposal in response to public comment and internal agency review. This document updates the benefit-cost analysis prepared for the proposed rule.

In the 1987 amendments to the Clean Water Act (CWA), Congress established a tiered approach for addressing certain industrial, municipal, and other storm water discharges. These amendments provided for a phased program to address the "worst offenders" first (Phase I), and identify an appropriate second tier of sources at a later date. EPA published Phase I application requirements for categories of storm water discharges recognized as the most damaging to the environment in 1990 (55 Federal Register (FR) 47990, November 16, 1990). Generally, Phase I sources include storm water discharges associated with certain industrial activities, medium and large municipal separate storm sewer systems (MS4s), and large construction sites (greater than five acres).

Phase II storm water sources were to be identified based on EPA's findings as presented in its Report to Congress (US EPA, 1995a). Based on this report, EPA published a direct final Phase II storm water rule in 1995 (60 FR 40229, August 7, 1995). EPA published this rule in part to protect Phase II dischargers from CWA citizen suit liability. However, it was recognized that the Phase II regulatory program would undergo further development. Indeed, the 1999 final rule, when promulgated, will replace the August 1995 direct final rule.

1.2 Description of the Rule

The final Phase II rule requires storm water discharges from small MS4s and small construction sites to be covered under a National Pollutant Discharge Elimination System (NPDES) permit. Small MS4s include incorporated places, counties, and other places under the jurisdiction of a governmental entity (including Tribal and Territorial governments) that are located in an urbanized area but are not included in Phase I. Phase I addresses larger and medium-sized MS4s serving populations of 100,000 and more. Phase II generally pertains to systems serving less than 100,000 people. However, the permitting authority could waive permitting requirements for systems serving less than 1,000 people. Indian reservations located within urbanized areas and with a population of less than 1,000 persons are excluded.
Phase II small construction sites are those that disturb between one and five acres of land. In addition, sites disturbing less than one acre would be subject to regulation if they are part of a

larger common plan of development or sale. However, the NPDES permitting authority could waive permitting requirements under certain conditions.

The Phase II rule does not include any additional regulatory requirements for industrial establishments nor will it expand the universe of industrial establishments.

Owners or operators of small MS4s would be required to develop and implement a storm water management program designed to reduce the discharge of pollutants to the maximum extent practicable and protect water quality. These programs would be required to include, at a minimum, control measures to address requirements for:

- Public education and outreach
- Public involvement and participation
- Illicit discharge detection and elimination
- Construction site storm water runoff control
- Post-construction storm water management in new development and redevelopment
- Pollution prevention/good housekeeping for municipal operations.

Construction site owners or operators would be required to plan and implement appropriate erosion and sediment control best management practices (BMPs) to control storm water discharges from small sites.

1.3 Economic Analysis of the Rule

The analysis presented here updates the benefit-cost analysis prepared for the proposed rule. Revisions have been made primarily in response to internal Agency review and comments received during the public comment period.

A number of issues were raised in the public comments regarding the economic analysis (EA) that accompanied the proposed rulemaking. One was the belief that the analysis was biased toward understating benefits because several of the benefits categories, such as reduced flood damage, were not reflected in the monetized benefits estimate. Another was the belief that the universe of affected municipalities and construction sites would be larger than estimated, resulting in an underestimation of costs. In contrast, commenters also suggested that reducing storm water pollutants would not be sufficient to restore waters (i.e., benefits were overstated) and that costs were overstated. Impacts on smaller municipalities and construction site operators were also discussed, as well as the use of data collected from Phase I municipalities.

Internal EPA review of the analysis resulted in questions relating to the accuracy and completeness of the data underlying the analysis, including data used to estimate the cost of municipal minimum measures (e.g., data on start-up costs and changing costs over time), the number of construction sites between one and five acres, the impairment of water bodies, the number of waivers expected, the amount and cost of monitoring, and the cost and extent of dredging. Another issue identified by EPA related to implementation of the Coastal Zone Act Reauthorization Act Amendments of 1993 (CZARA) and whether both costs and benefits associated with controls in these areas should be considered.

To address the issues raised in the public comments and during internal review, EPA gathered additional data and information to refine the analysis of potential benefits and costs. These data and analyses are described in detail in the chapters that follow. A large part of the effort was directed to refining the estimates of the number of regulated MS4s and construction sites and better characterizing potential costs based on information from the Phase I storm water program. Efforts were also directed towards more fully capturing the potential benefits associated with the municipal and construction site components of the rule.

1.4 Structure of the Report

This report consists of the following chapters:

- **Chapter 2, Environmental Concerns Addressed by the Rule**, discusses the nature of the environmental problems caused by storm water discharges regulated by the rule.
- **Chapter 3, Baseline for Estimating Benefits and Costs**, describes the data and issues related to developing a baseline against which benefits and costs can be measured.
- **Chapter 4, Potential Costs, Pollutant Load Reductions, and Cost-Effectiveness**, provides revised estimates of the potential costs of compliance with the final rule, the anticipated reductions in pollutants loadings anticipated, and the anticipated cost per pound of pollutant removed.
- **Chapter 5, Qualitative Assessment of Benefits**, provides a qualitative discussion of the benefits that are expected to result from the final rule.
- **Chapter 6, Quantitative Assessment of Benefits**, provides estimates of the potential magnitude of benefits, where feasible.
- **Chapter 7, Comparison of Potential Benefits and Costs**, presents a comparison of the estimated benefits and costs, and discusses uncertainties associated with the analyses.
- **Chapter 8, Revised Analysis for Small Business Regulatory Enforcement Fairness Act, Environmental Justice, and Unfunded Mandates,** provides an update to the screening analysis developed for the proposed rule.
- **Chapter 9, No Exposure,** provides estimates of the net cost savings that will result from implementation of the Phase I no exposure provision.
- **Chapter 10** provides references.

In addition, several appendices provide supporting materials and references.

2.0 ENVIRONMENTAL CONCERNS ADDRESSED BY THE RULE

Storm water discharges have emerged as one of the leading causes of impairment of the Nation's surface waters (US EPA, 1998a). This chapter takes a more detailed look at the environmental problems resulting from storm water discharges that result in a need for the Phase II regulation. Specifically, Section 2.1 provides an overview of storm water discharges from construction sites and urban areas and Section 2.2 describes the potential adverse impacts of these discharges on humans, aquatic ecosystems, and wildlife.

2.1 Storm Water Discharges from Urban Areas and Construction Sites

Several studies reveal that storm water runoff from urban areas and construction sites can include a variety of pollutants, such as sediment, bacteria, organic nutrients, hydrocarbons, zinc, copper, cadmium, mercury, iron, nickel, oil, and grease (Barret et al., 1996). In addition, the *National Water Quality Inventory, 1996 Report to Congress*, a summary of state §305(b) reports, documents water quality impairment resulting from storm water discharges. The reports found urban runoff/storm sewer discharges to affect 13% of impaired rivers, 21% of impaired lakes, and 45% of impaired estuaries. "Impaired" waters are those not meeting water quality standards or designated beneficial uses such as drinking water supply, primary contact recreation, and aquatic life support. The reports also found construction activities (e.g., land development, road construction) to have a significant impact on rivers, lakes, and wetlands. The pollutants associated with urban area and construction site discharges are discussed in more detail below.

2.1.1 Urban Area Storm Water Discharges

Urbanization has been shown to affect both the quantity and quality of storm water runoff. In heavily populated areas, water quality impairment has been linked to human activity. Often, individuals in residential communities improperly dispose of used oil, household toxic materials, radiator fluids, and litter (e.g., disposable cups, cans, and fast food packaging) directly into storm sewer systems or in open areas where the materials can be picked up and carried by storm water runoff. Additional pollutants in runoff can include herbicides and pesticides, toxic heavy metals, organic pollutants, fecal coliform bacteria and pathogens, sediment, and air pollutants (Field and Pitt, 1990; Marsh, 1993). Sediment is a primary pollutant from construction activity, as discussed below, but it can also be contributed by urban areas as a result of road maintenance activities such as street cleaning, road resurfacing, and deicing efforts (Rhoads, 1995). Some additional pollutants such as sanitary waste and sewer main construction materials (e.g., asbestos cement, brick, cast iron, vitrified clay) are due to wastes and wastewater from non-storm water sources, commonly referred to as illicit discharges. These discharges are "illicit" because the storm water systems are not designed to accept and discharge, or to process, such wastes.

Areas associated with urban development, such as commercial and residential districts, parking lots, and roads, are mostly paved so that storm water may not infiltrate into the ground. Such surfaces are referred to as "impervious" surfaces. These areas speed runoff flows and pollutants to receiving waters. In addition, urban areas are specifically designed to efficiently carry storm water away from the community to reduce flooding and into receiving waters, further increasing the rate at which waters receive runoff. The increase in flow and frequency of high flows can lead to changes in stream channel morphology such as the widening of banks and undercutting of

stream beds. Indeed, Schueler (1995) notes that urban stream channels become unstable when 10% of a watershed is impervious.

A number of studies have determined that watershed development leads to increases in peak storm water runoff, as well as to decreases in the time required for the peak to be reached. Based on a compilation of studies, Hollis (1975) estimated that the frequency of small floods could increase 10 times as a result of imperviousness covering 20% of a watershed. Small floods are described as those with a return period, or recurrence interval, of one year. For larger floods (i.e., those with a return period of 100 years), the author estimated a possible doubling in size due to imperviousness covering 30% of a watershed. Barringer et al. (1994) also observed increases in flow and flow variability in two streams in New Jersey as development occurred, although the authors could not statistically link the changes to specific causes. Yorke and Herb (1978) were able to attribute observed increases in peak flow to urbanization in the Washington, D.C., area. In summary, the relative impact of development on storm water flows decreases as the recurrence interval of the flow (i.e., the flood size) increases (Hollis, 1975).

2.1.2 Construction Site Storm Water Discharges

Construction fundamentally alters natural landscapes (Toy and Hadley, 1987). During construction, earth is compacted, excavated and displaced, and vegetation is removed. These activities increase runoff and erosion, thus increasing sediments transported to receiving waters. Although erosion and sedimentation are natural processes, when land is disturbed by construction activities, surface erosion increases 10 fold on sites formerly used for crop agriculture, 200 times on sites formerly under pasture, and 2,000 times on sites formerly forested (Toy and Hadley, 1987). In addition to sediment, construction activities also yield pollutants such as pesticides, petroleum products, construction chemicals, solvents, asphalts, and acids that can contaminate storm water runoff (Marsh, 1993).

Numerous studies have examined the increases in sediment loads resulting from storm water runoff. For example, Daniel et al. (1979) monitored three residential construction sites in southeastern Wisconsin and determined that annual sediment yields were more than 19 times greater than yields from agricultural areas. Yorke and Herb (1978) studied nine sub-basins in the Maryland portion of the Anacostia watershed for more than a decade to determine the impacts of changing land use and land cover on runoff and sediment. Average annual suspended sediment yields from construction sites ranged from seven to 100 tons per acre, as compared to cultivated land and forest/grassland, which yielded 0.65 to 4.3 tons per acre and 0.07 to 0.45 tons per acre, respectively. A 1970 study conducted by the National Association of Counties Research Foundation found the potential impacts of urban and suburban development to be even more dramatic. The Foundation concluded that sediment yields from construction areas could be as much as 500 times the levels detected in rural areas.

2.2 Potential Adverse Effects of Storm Water Discharges to Humans, Aquatic Life, and Wildlife

The impacts of storm water runoff from developed and developing areas on humans, aquatic ecosystems, and wildlife can be explored within the context of the hydrologic cycle. When it rains, water is intercepted by vegetation and consequently, is absorbed by the soil. The water then infiltrates into soil pores, subsurface flows, and groundwater aquifers. When soils become

saturated, the water runs off land areas and into surface waters. As development of a watershed occurs, soils are compacted and covered with impervious surfaces such as roads, parking lots, and buildings. The vegetative cover that intercepts the initial portion of rainfall and enhances filtration is reduced. Together, the development activities reduce the filtration rates of soils, and subsequent rainfall onto these impervious areas is converted into runoff.

Many studies provide documentation of the impacts of storm water discharges on humans, aquatic life, and other wildlife, including impacts to small streams. The potential impacts of these discharges include increased bacterial contamination, increased turbidity, increased toxic sediments, decreased dissolved oxygen concentrations, and alterations in stream channel morphology and habitat. In turn, these in-stream conditions can have a considerable impact on the abundance and diversity of aquatic species. The level of impact is site-specific and depends on site imperviousness, the type of receiving waters, acreage of land disturbance, topography, soil type, and resource sensitivity. The nature of the impact also varies temporally throughout the land development process, with significant differences observed between the site clearing phase and post development conditions. Exhibit 2–1 summarizes environmental concerns and impacts associated with urban storm water runoff, as compiled by Horner et al. (1994) and selected impacts are discussed in detail below.

2.2.1 Human Health Impacts

Bacterial contamination of waters used for swimming can threaten the health of swimmers. A recent epidemiological study of Santa Monica Bay examined the incidence of disease among swimmers near storm drain outfalls and swimmers 400 yards away from the outfalls (Haile, et al., 1996). The results indicated that those who swam near storm drain outfalls experienced significant increases in the incidence of gastrointestinal and respiratory diseases, as well as related symptoms. The study found human pathogens to be the cause of the illnesses and related symptoms. The study also indicated that illegal connections, leaking sewer lines, malfunctioning septic systems, illegal dumping from recreational vehicles, or direct human sources such as campers or transients are possible sources of pathogen contamination into storm drain systems.

Nationally, beach closings and swimming advisories are typically based on elevated levels of bacteria indicative of human pathogens that can cause illness. These wastes can enter the water via storm sewer systems, sewage treatment plants, and polluted storm water runoff. In 1996, approximately 83% of beach closings and advisories were due to bacteria levels that exceeded beach water quality standards (NRDC, 1997). An estimated 14% of beach closings were in response to a known pollution event, and 4% were precautionary beach closures due to rain that carried pollution into coastal waters. Furthermore, 414 closings and advisories in 1996 were prompted by urban storm water runoff.[1] Five of these closings lasted more than 12 weeks.

[1]A closing may be due to one or more sources; therefore, the total number of closings in 1996 independent of source may be less.

Exhibit 2–1. Adverse Impacts Associated with Urban Runoff

Resource/ Water Use	Concern	Potential Negative Impact on Resource/Water Use	Cause
Ground Water	Lower dry-season reserves	Lower dry-season base flow in water courses Lower drinking-water reserves	Increased impervious catchment surface area
Aquatic Habitat	Erosion	Physical destruction of habitat	Peak discharge, high runoff volume
	Fluctuating water levels and velocities	Altered thermal and mixing characteristics Reduced habitat diversity Erosion	High peak discharges and runoff volumes Low dry-season groundwater reserves
	Low dry-season base flow	Elimination of spawning beds Reduced habitat Reduced dilution capacity	Low dry-season groundwater reserves
	Sedimentation	Smothering of bottom communities and spawning beds Filling of storm water impoundments Transport of particulate-associated pollutants	Erosion Suspended solids
	Turbidity	Lower dissolved oxygen, reduced prey capture, clogging of fish gills	Suspended solids
	Low dissolved oxygen	Lethal and nonlethal stress to aquatic organisms	Biodegradable organic material
	Metals, organic contaminants, chlorides	Lethal and nonlethal stress to fish and other aquatic organisms in water column and bottom sediments	Urban pollution
	Increased water temperature	Lethal and nonlethal stress to sensitive cold water aquatic organisms	Biodegradable organic material
	Bacteria	Diseases of aquatic organisms Shellfish contamination	Fecal contamination
	Eutrophication	Algae blooms and nuisance aquatic plant growth Low dissolved oxygen Odors	Nutrient enrichment
Public Water Supply	Lower dry-season reserves	Reduced water supply	Lower dry season groundwater reserves
Wildlife Habitat	Flooding and erosion	Physical destruction of environment Dewatering and flooding of key habitat areas at critical times Reduction in streambank cover vegetation	High peak discharges and runoff volumes Sedimentation
Recreation and Aesthetics	Nature enjoyment	See Aquatic Habitat and Wildlife Habitat under the Resource/Water Use column	See Aquatic Habitat and Wildlife Habitat
Agricultural, Residential, and Industrial Land Use	Flooding and erosion	Public safety Damage to crops and farmland Damage to buildings and contents Reduction of useable land area	High peak discharges and runoff volumes Sedimentation

Source: Horner et al. (1994).

2.2.2 Aquatic Life and Wildlife Impacts

As noted earlier in this chapter, urban storm water runoff is a significant source of water quality impairment. As a result, pollutants carried in storm water or the impacts associated with increased flows are leading causes of impairment, as summarized in Exhibit 2–2. These pollutants and impacts in storm water can have a broad range of interrelated effects on aquatic habitats and organisms.

Exhibit 2–2. Five Leading Causes of Water Quality Impairment

Rank	Rivers	Lakes	Estuaries
1	Siltation	Nutrients	Nutrients
2	Nutrients	Metals	Pathogens
3	Pathogens	Siltation	Priority toxic organic chemicals
4	Oxygen-depleting substances	Oxygen-depleting substances	Oxygen-depleting substances
5	Pesticides	Noxious aquatic plants	Oil and grease

Source: US EPA (1998a).

Aquatic habitats and organisms can also suffer as a result of changing physical and ecological conditions in watersheds. Prior to development, physical and ecological conditions in watersheds are in a state of dynamic equilibrium. This means that the physical and ecological systems have adjusted to the rainfall patterns and the natural landscape changes occurring in the watershed that define natural flows. These flows determine the shape and slope of waterways. However, when watershed disturbances occur, such as those associated with development, flows are altered. Typically, peak flows increase. The increase in peak flow causes changes in the stream channel morphology and increases the amount of sediment and pollution transported to receiving waters. The effects of sedimentation, pollution, and excessive nutrients on habitat are discussed below.

Sedimentation

The National Water Quality Inventory 1996 Report to Congress identified sedimentation to be the leading pollutant or process affecting American rivers. It is the third leading pollutant or process impacting lakes, and the ninth leading pollutant impacting estuaries. Exhibit 2–3 summarizes the adverse impacts associated with sedimentation and sediment related pollutants as presented by Paterson et al. (1993). The following discussion presents additional studies that identify various environmental impacts of sediment related pollution.

Degradation and destruction of benthic habitat and organisms. When sediment falls out of suspension in the water column it accumulates on stream and riverbeds. Many benthic organisms depend on certain habitat conditions for survival, such as small crevices between rocks for protection of eggs and fry or hard substrates for attachment. When sediment covers streambeds, this critical habitat can be degraded or destroyed. Sedimentation can smother organisms such as fish eggs and fry, shellfish, and insects. In addition, many benthic organisms

Exhibit 2–3. Impacts Associated with Sediment and Sediment-Related Pollutants

Type of Impact	Comments
In-stream impacts Destruction or degradation of aquatic habitat and wildlife	Aquatic wildlife may be adversely affected in a variety of ways. Benthic communities may be directly damaged when sediments fall out and blanket the community. Benthic macrophytes may be destroyed, and the diversity and productivity of such communities may be reduced as a result (Crawford and Lenat, 1989). High concentrations of suspended sediments may abrade and damage fish gills, increasing their susceptibility to infection and disease (Abel, 1989). Survival rates for fish eggs may be reduced and spawning areas may be destroyed (West et al., 1982). High turbidity levels reduce both plankton and aquatic plant production. Nutrient and toxic enrichment of suspended sediments may adversely affect fish and other organisms directly and through secondary effects, including food chain disruptions, eutrophication, and toxic bioaccumulation/biomagnification effects (Simmons, 1987; Novotny and Chesters, 1989). In addition, a variety of additive, antagonistic, and synergistic effects are possible, depending on the types and amount of sediment delivered, the physical condition of the water body (e.g., depth, temperature, pH, and salinity), and the existing biological conditions (e.g., richness and diversity) (Mason, 1981).
Accelerated loss of storage in lakes and reservoirs	Accelerated deposition of sediment may reduce the effective life of water storage reservoirs by filling dead and active storage areas more rapidly than anticipated (Crowder, 1987). This problem tends to be most pronounced in smaller reservoirs and in regions with naturally high rates of erosion (Dendy, 1968).
Increased navigational obstruction and craft deterioration	Sedimentation of harbors and navigational channels reduces the shipping and boating capacity of those facilities, increases the likelihood of accidents, and requires expensive dredging to keep those facilities usable. In addition, suspended sediments may accelerate the wear and maintenance requirements for ship propellers and cooling systems of marine motors (Clark et al., 1985).
Diminished water recreational experiences	Sediment pollution may diminish, inhibit, or endanger water-related recreational activities. Excessive turbidity and sedimentation may contribute to boating, swimming, and diving accidents by obscuring submerged hazards or as a result of shoaling. In addition, sediment pollution may also decrease the quality of sport fishing by reducing fish populations, displacing more highly valued game fish with less desirable but more sediment-tolerant species, and turbidity may decrease the opportunities for making a catch (Clark et al., 1985).
Reduced aesthetic and preservation values	Aesthetic and preservation values are those that people gain through indirect use and the knowledge that uses are available for themselves, for future generations, or just existent (Walsh et al., 1984). Most water-related recreational activities involve people picnicking, walking, or playing near the water. Turbidity and sedimentation may diminish the indirect water recreational experience as a result (Clark et al., 1985). Likewise, people's preservation benefits are diminished when siltation and turbidity degrade valued water bodies.
Increased hydroelectric facility impairment	The major concerns for hydroelectric facilities are the loss of storage capacity, the blockage of inflow access for plant generation, and increased maintenance because of wearing of plant structures and machinery (e.g., the penstock and turbine runner). Additional concerns include downstream channel degradation and modification due to the interruption of natural bedload deposition (Fan and Springer, 1990).

Exhibit 2–3. Impacts Associated with Sediment and Sediment-Related Pollutants

Type of Impact	Comments
Accelerated stream bank erosion	Coarse sediment deposits in the form of channel bars often cause nearby bank erosion (Neill and Yaremko 1989). In addition, hydrogeologic alterations caused by urbanization and agricultural activities may increase streambank erosion in several ways, including: increasing downstream flood peaks; increasing the duration of flood peaks (as a result of detention systems); concentrating runoff at unprotected points along the bank; and creating obstruction to the flow channel.
Off-stream impacts Increased flood damages	Sediment pollution can increase flood damages in at least three ways. First, aggrading stream and lake beds may increase the frequency and magnitude of flood events. Second, the effectiveness of structural flood control devices maybe reduced due to loss of flood storage or siltation in structures. Third, sediment may directly damage agricultural and urban areas when it is deposited by flood waters in structures or on productive lands (Simmons 1987, Clark and others 1985).
Increased strormwater drainage system maintenance needs	Sedimentation in storm water drainage systems and irrigation canals may increase localized flooding problems and require more frequent maintenance of such facilities (e.g., hydro-flushing) (Porter 1976).
Reduced Infiltration	Suspended sediment in runoff and irrigation water sources can seal land surfaces, thereby reducing the infiltration rates. The surface sealant effect and reduced infiltration rates may have adverse impacts of surrounding vegetation by leaving the soil too dry, and increase the rate of runoff which in turn accelerates erosion potential, and reduces aquifer recharge (Guy 1972, Clark and others 1985).
Increased water-treatment costs	Water treatment costs for municipalities and certain industries may be significantly increased by higher concentrations of suspended sediments. Water treatment operations may require greater use of chemical coagulants, greater maintenance filters, and increased chlorination to purify the water (Mason 1981).
Sedimentation damage due to adjacent properties	Property owners downhill of locations undergoing extensive erosion may be adversely affected by the deposition of alluvium from runoff moving across their property. Such deposits may damage existing vegetation, soil characteristics, private drainage works, or structures (Guy 1972).

Source: Paterson et al. (1993). Reproduced with permission.

are filter feeders and sedimentation can interfere with their ability to feed. Lemly (1982) examined the effects of sedimentation on benthic insect communities in an Appalachian trout stream. Results of the study show that sediments covered insect body surfaces and respiratory structures, particularly affecting filter feeding species. Lemly also found a reduction in the range of the size of benthic matter. Further, Lemly found a decrease of available living space due to accumulation of sand and silt. Although not established as general water quality standards for estuaries, biologically based recommendations for maximum total suspended sediment levels have been made for the Chesapeake Bay (Chesapeake Bay Program, 1991). For example, the recommendation for the health of the eastern oyster is 250 mg/L.

Decrease in photosynthetic activity. Increases in turbidity levels not only cloud water, making it visibly unattractive, but turbidity also decreases light penetration, impairing photosynthesis. If photosynthesis is impaired, then the quantity of plankton, a primary food source, is reduced. In Oklahoma farm ponds, clear ponds (< 25 parts per million [ppm] of suspended sediment) produced eight times as much plankton as did ponds with intermediate suspended sediment

levels (25–100 ppm) and 12.8 times as much plankton as did ponds with high suspended sediment levels (>100 ppm) (Clark, et al., 1985). The recommended maximum total suspended sediment level to protect submerged aquatic vegetation in the Chesapeake Bay is 15 ppm (Chesapeake Bay Program, 1991).

Adverse effects on aquatic organisms. As part of an extensive literature review, Makepeace et al. (1995) found that turbid water can be detrimental to aquatic biota. The authors found that total suspended solid (TSS) concentration between 25 and 100 mg/L "could reduce a river's primary biological productivity by 13% to 50%. Turbidity has also been found to affect the ability of organisms dependent on vision to feed. For example, in a controlled experiment, Gardner (1981) found that increases in turbidity (60 to 150 nephelometric turbidity units [NTU]) reduced feeding rates of bluegills by 50%. The range in turbidity studied encompasses that typical of North Carolina waters. However, stream turbidity in disturbed watersheds could likely exceed these levels (Gardner, 1981). Organisms that rely on vision for courtship may also be affected (Clark, et al., 1985). Additionally, turbidity can be abrasive to fish and clog gills, affecting mortality (Marsh, 1993).

Pollutants

Storm water contains a multitude of pollutants including metals, organics, pesticides, inorganic pollutants, and oil and grease. These pollutants may have chronic or acute affects on aquatic organisms. Furthermore, these pollutants can be bound to sediment and accumulate on streambeds, leading to bioaccumulation. Field and Pitt (1990) reviewed a three-year monitoring study of a creek in San Jose, California and found that organics and heavy metals in the water column and sediments were likely responsible for the adverse biological conditions. For example, they found four to 60 times greater concentrations of sulfur, lead, and arsenic in urban sediments than in nonurban sediments. In addition, Field and Pitt found evidence of bioaccumulation of lead and zinc in many samples of algae, crayfish, and cattails. The biological conditions of the urban creek included a reduction in native fish species, decreased diversity and abundance of aquatic taxa, and an abundance of pollutant tolerant species of fish and benthic organisms. Finally, Field and Pitt indicate that the long term impacts of such pollutants may be more important than the short term impacts. They attribute the long term impacts to toxic sediments and the inability of organisms to tolerate repeated exposure to toxic contaminants and high flow rates.

Excessive Nutrients

Nutrients such as phosphorous and nitrogen are often used as fertilizer and can be contained in storm water runoff from urban areas and construction sites. When a water body receives an excessive amount of these nutrients, growth of algae and aquatic plants is stimulated. Like all plants, algae require oxygen and when abundant, can decrease the dissolved oxygen available for other organisms. In addition, when algae die they sink to the bottom of water bodies, where bacteria decompose the algae, depleting dissolved oxygen supplies (US EPA, 1995b). The overabundance of nutrients and resulting loss of oxygen, a condition known as eutrophication, leads to fish kills and mass mortality of benthic organisms (Water Environment Federation and the American Society of Civil Engineers, 1992).

2.2.3 Small Stream Impacts

Natural stream channel morphology is based largely on the quantity of water and sediment delivered to the streams (Toy and Hadley, 1987). Sediment loads can reduce stream depths, decreasing their retention and conveyance capacity, which can increase flooding (Water Environment Federation et al., 1992). Because these changes in morphology increase as development of a watershed increases, small streams are more susceptible to the adverse impacts of increased sediments. This is because a given amount of urbanization will affect a greater portion of small watersheds than large and thus have a greater impact.

Alterations in small stream channel morphology are of concern because they can pose significant threats to human health and safety, and can also threaten property (Toy and Hadley, 1987). Furthermore, the habitat provided by small streams can be critical to certain aquatic species. For example, small streams provide spawning and rearing habitats for several species of salmon (Sovern and Washington, 1997). Because of their size, small stream habitats are especially sensitive to excessive flows, sediment, and pollution resulting from construction activities and urban areas. Indeed, Sovern and Washington state that the destruction of small streams caused by urbanization is one significant reason for the decline in salmon populations.

2.3 Summary

The literature provides substantial evidence that storm water runoff from construction sites and urban areas can adversely affect aquatic systems. Runoff from these areas can include litter, chemicals, metals, nutrients, pesticides, bacteria, and sediment. In addition to contributing pollutants, construction sites and urban areas contribute to increased flows to receiving water bodies. The effects of pollutants and increased flows can be detrimental to aquatic organisms and habitat as well as to human health. The costs and benefits associated with controlling runoff from these areas are discussed in greater detail in Chapters 4 and 5, respectively. The resulting benefits are monetized in Chapter 6.

3.0 BASELINE FOR ESTIMATING BENEFITS AND COSTS

Analysis of the potential benefits and costs associated with implementation of the Phase II Storm Water Rule requires that a baseline be established. The baseline provides an initial starting point for measuring the incremental cost and benefit of regulatory compliance. This chapter describes the baseline EPA established for analyzing impacts to construction activities and municipalities regulated by the Phase II rule. It also discusses baseline water quality conditions, including water quality impairment potentially attributable to Phase II sources.

3.1 Existing Storm Water Programs

Analysis of the incremental costs and benefits requires that EPA identify regulatory programs that resemble the Phase II program at the federal, state, and local levels. Those programs with the greatest likelihood of overlap with the Phase II program requirements include the Phase I storm water program implemented under the National Pollutant Discharge Elimination System program implemented by certain authorized states; the Coastal Zone Authorization Reauthorization Act Amendments of 1990 program for the control of nonpoint source pollution; and state and local erosion and sediment control programs.

3.1.1 Phase I Storm Water Program

Some states that are authorized to regulate storm water discharges under the National Pollutant Discharge Elimination System (NPDES) program have chosen to implement more stringent requirements than those required by the Phase I rule (55 FR 47990, November 16, 1990). Specifically, a few states have expanded the Phase I storm water universe to include sources that would otherwise be regulated under the Phase II program. This includes lowering the five acre minimum size threshold for regulation of construction activity and designating certain "small" municipalities, thus mandating their participation in the Phase I storm water program. EPA does not include Phase I communities in the Phase II universe.

3.1.2 CZARA Program

The Coastal Zone Authorization Reauthorization Act Amendments of 1990 (CZARA) established requirements for states located in the coastal zone to implement controls that manage nonpoint source runoff. This includes the implementation of an enforceable erosion and sediment program for the control of runoff from construction sites disturbing less than five acres of land. The Phase II rule establishes similar requirements for owners and operators of construction sites that disturb between one and five acres. The overlap between the two programs is restricted to the implementation of erosion and sediment controls, or storm water BMPs. Additional requirements established by the Phase II program include the development of a storm water pollution prevention plan, inspections and regular maintenance of the controls, and the submittal of a notice of intent to be covered by the general permit and notice of termination.

In the analysis that accompanied the proposed rule, EPA included costs for sediment and erosion controls in coastal areas because programs developed under CZARA were not yet implemented. Since the proposed rule, states have more fully implemented sediment and erosion control programs recommended through CZARA. EPA assumed that where state programs are as

stringent as Phase II and applied as the primary enforcement tool for regulating construction site runoff the Phase II rule will not add incremental costs or benefits. Therefore, costs and benefits associated with implementing Phase II have not been analyzed for the coastal zones in ten states that have instituted such sediment and erosion control programs in response to CZARA: Delaware, Florida, Maryland, Massachusetts, Michigan, New Jersey, Pennsylvania, Rhode Island, South Carolina, and Virginia.

3.1.3 State and Local Erosion and Sediment Control Programs

A number of states (including the District of Columbia) and one territory require erosion and sediment controls, irrespective of CZARA, on construction sites that disturb less than five acres of land. For example, North Carolina's Erosion and Sediment Control Act of 1973 requires BMPs for all construction sites of one or more acres while West Virginia regulates sites that are three or more acres in size. States with established erosion and sediment control programs are shown in Exhibit 3–1. EPA accounted for these programs by not estimating benefits or costs associated with erosion and sediment controls for sites regulated by an equivalent program.

In addition to federal and state programs, some municipalities have developed local programs that require the owners or operators of construction sites disturbing less than five acres of land to implement erosion and sediment controls although the extent of these programs is unknown. A recent study by the Center for Watershed Protection (1997) reported survey responses from 113 locales with erosion and sediment control programs (a 52% response rate). This survey indicated that 27% of the responding locales required erosion and sediment controls on construction sites disturbing less than 0.5 acres of land and 43% required erosion and sediment controls at construction sites disturbing between one and five acres of land. However, EPA does not know the extent to which these local programs are similar to Phase II. Therefore, EPA chose to assume that there are no pre-existing local programs that duplicate Phase II requirements.

3.2 Population

To estimate the benefits of the Phase II rule, EPA used the most current estimate of the 1998 US population: 270 million residents with 2.62 persons per household (US Census Bureau, 1998a). These figures yield an estimate of 103 million households nationwide. However, to estimate the potential compliance costs of the Phase II rule, EPA needed to identify the sewered population. EPA used the most recent sewered population estimate from 1993 of 227.8 million persons (US Census Bureau, 1993) and assumed that this population represents the 1998 sewered population. In addition, EPA needed to estimate the population residing in automatically designated Phase II communities. To accomplish this, EPA used 1990 estimates of the urban population and US Census Bureau projections of the year 2000 population to arrive at 1998 estimates. The 1998 estimate is 85.2 million persons which is equivalent to 32.5 million households. Assuming that the automatically designated Phase II population is entirely sewered, EPA estimates that 37.4% of the total sewered population resides in these Phase II communities. The estimates of the population residing in Phase II communities excludes residents in communities with pre-existing equivalent municipal programs. Exhibit 3–2 presents a summary of the above estimates. The exhibit also reports the estimates for the potentially designated Phase II population which are households in unurbanized areas. These households represent an additional 5.2% of the US sewered households.

Exhibit 3–1. States and Territories Requiring Erosion and Sediment Controls at Construction Sites of Less than Five Acres

State or Territory	Minimum Construction Site Size Requiring Controls (Acres, Unless Specified)
Connecticut	0.5
Delaware*	5,000 (square feet)
District of Columbia	50 (square feet)
Florida*	0
Georgia	1.1
Maryland*	1
Massachusetts*	0.5
Michigan*	1
New Hampshire	50,000 or 100,000 (square feet)
New Jersey*	5,000 (square feet)
North Carolina	1
Pennsylvania*	0[1]
Puerto Rico	900 (square meters)
Rhode Island*	0
South Carolina*	0[2]
Virginia*	2,500 or 10,000 (square feet)
West Virginia	3
Wisconsin	1.5 acres for residential development 3 acres for commercial development

[1]All earth-moving activities.
[2]Any activity.
*denotes CZARA

Exhibit 3–2. Municipal Households Potentially Regulated Under the Phase II Rule

Community Type	Households	Percent of US Sewered Households
Urbanized Place, County, Minor Civil Division[1]	32,458,365[2]	37.4%
Unurbanized Place, County, Minor Civil Division[3]	4,539,440	5.2%
Total	37,062,643	37.4%–42.6%

[1]Automatically designated.
[2]Based on a population estimate of 85,189,912 and 2.6246 persons per household. EPA used this estimate of households in the cost analyses because it reflects those households which may bear the costs of implementing a municipal program.
[3]Potentially designated.
Source: US Census Bureau (1998a).

3.3 Phase II Construction and Land Development Activities

To estimate the percent of construction and land development activities (see Section 3.4 below) that may be affected by the Phase II soil erosion control provisions, EPA first developed an estimate of the percentage of construction starts on one to five acres using data collected from fourteen areas of the country: Tucson, Arizona; Fort Collins, Colorado; New Britain, Connecticut; Tallahassee, Florida; South Bend, Indiana; Cary and Raleigh, North Carolina; Baltimore County and Prince Georges County, Maryland; Austin, Texas; Loudon County, Virginia; and Lacey and Olympia, Washington; and Waukesha, Wisconsin. EPA then multiplied this percentage by the number of building permits issued nationwide to determine the total number of construction starts occurring on one to five acres nationwide. Next, to isolate the number of construction and land development activities regulated by Phase II, EPA subtracted the number of activities regulated under equivalent programs. Exhibit 3–3 shows that approximately 110,000 sites may be affected by this provision by site size; this estimate excludes approximately 19,500 sites that EPA estimates will qualify for waivers. Dividing this number by the estimated total number of 521,000 construction starts nationwide for 1998 indicates that 21.1% of construction starts may be regulated under this provision of the Phase II rule. This methodology is presented in detail in Appendix B–2.

Exhibit 3–3 also shows the cumulative percentages for regulating all sites equal to or greater than each of the size categories shown. For example, if all sites regardless of size were regulated, then 100% of disturbed area and sites would be regulated. By lowering the compliance threshold from five acres to one acre of disturbed area, the Phase II rule effectively raises the share of regulated sites from 36% to 75%, and the share of total disturbed area from 78% to 98%.

Exhibit 3–3. Estimated Number of Total Construction Starts and Construction Starts Potentially Affected by the Phase II Soil Erosion Control Provision[1]

Area Acreage	Construction Starts (1998)			
	Total National Starts	Incremental Starts Potentially Affected by the Phase II Rule[2,3]	Total Percentage of National Disturbed Area Controlled by Regulating All Sites	Total Percentage of National Starts Regulated
Less than one acre	130,328	0	100%	100%
One to two acres	93,063	52,426	98%	75%
Two to four acres	79,322	41,389	92%	57%
Four to five acres	32,557	16,408	84%	42%
More than five acres	186,198	0	78%	36%
Total	521,467	110,223	na	na

Detail may not add to total due to independent rounding.

[1]The area acreage values reported in the table correspond to values established for the model sites described in Chapter 4, and represent the following acreage ranges: one acre, one- to two-acre starts; three acres, two- to four-acre starts; and five acres, four- to five-acre starts.

[2]Starts in States with equivalent Erosion and Sediment Control Programs have been removed.

[3]EPA estimates that of the approximately 129,675 Phase II construction starts estimated for 1998, 19,452 (15%) would qualify for a waiver from program requirements. The remaining 110,223 would require erosion and sediment controls.

3.4 Water Quality

Analysis of the incremental benefits of the rule required that EPA characterize existing water quality and the relative impact of Phase II sources on water quality. The National Water Quality Inventory Report to Congress (US EPA, 1998a) is the only national comprehensive source of data characterizing the extent and sources of impairment of the nation's waters. These data, often referred to as "305(b) data," are reported biennially by states, territories, and tribes as required under Section 305(b) of the CWA. The 1998 Report to Congress is based on water quality data from 1994–1995. For the purposes of this analysis, EPA assumed that current water quality is reflected in the current 1998 Report to Congress.

The 305(b) data identify the designated uses of the waterbodies surveyed by the states. Designated use categories include aquatic life support, fish consumption, primary contact (swimming), secondary contact (boating), drinking water supply, and agriculture. States then compare monitoring data with numeric criteria established for each designated use to classify these waters as fully supporting, threatened, or impaired. Threatened waters are defined as waters that support beneficial uses now but may not in the future unless action is taken. Impaired waters are the sum of waterbodies partially supporting or not supporting their designated use. Exhibit 3–4 presents a summary of the water quality data provided in the most recent 305(b) data. In addition to general water quality impairment, the National Water Quality Inventory provides the percentage of surveyed waters considered impaired by designated use. These data are presented in Exhibit 3–5.

3.4.1 Water Impaired by Urban Wet Weather Events

The 305(b) data also identify the sources of water quality impairment. As shown in Exhibit 3–6, urban storm water runoff ranks as the second leading source of impairment to estuaries, the third leading source of impairment to lakes, and the fifth leading source of impairment to rivers. In addition to this information, the 305(b) data also provide the *percentage* of all waters where various pollution sources cause major impairment. The sources of pollution that are relevant to the Phase II rule are urban runoff/storm sewers, construction and land development. The contribution of these sources to water quality impairment are summarized in Exhibit 3–7.

Exhibit 3–4. Summary of Assessed Waters

Waterbody Type	Number of Miles[1]		Assessment of Designated Use Attainment[2]		
	Total	Surveyed	Supporting	Threatened	Impaired
Rivers and Streams	3,600,000	693,905	56%	8%	36%
Lakes, Ponds, and Reservoirs	41,600,000	16,800,000	51%	10%	39%
Great Lakes	5,521	5,186	2%	1%	97%
Estuaries	39,839	28,818	58%	4%	38%

[1]Lakes, ponds, and reservoirs are measured in acres; Great Lakes are measured in shoreline miles; Estuaries are measured in square miles.
[2]Percent of surveyed miles.
Source: US EPA (1998a). Reflects monitoring from 1994 and 1995.

Exhibit 3–5. Summary of Assessed Waters by Designated Use

Waterbody	Designated Use	Miles/Acres Assessed	Percent of Miles/ Acres Impaired
Rivers	Aquatic Life Support	641,611	32%
	Fish Consumption	316,811	17%
	Primary Contact—Swimming	332,152	21%
	Secondary Contact—Boating	200,641	20%
Lakes, Ponds, and Reservoirs	Aquatic Life Support	14,200,153	31%
	Fish Consumption	10,896,449	35%
	Primary Contact—Swimming	15,369,354	25%
	Secondary Contact—Boating	8,306,333	25%
Great Lakes	Aquatic Life Support	5,186	72%
	Fish Consumption	5,186	98%
	Primary Contact—Swimming	5,186	4%
	Secondary Contact—Boating	4,844	4%
Estuaries	Aquatic Life Support	23,921	30%
	Fish Consumption	15,821	24%
	Shellfish Consumption	16,567	28%
	Primary Contact—Swimming	24,087	16%
	Secondary Contact—Boating	14,086	24%

Source: US EPA (1998a).

Exhibit 3–6. Leading Sources of Water Quality Impairment Related to Human Development

Rank	Rivers	Lakes	Estuaries
1	Agriculture	Agriculture	Industrial point sources
2	Municipal sewage treatment plants	Unspecified nonpoint sources	Urban runoff/storm sewers
3	Hydrologic/habitat modification	Urban runoff/storm sewers	Municipal sewage treatment plants
4	Resource extraction	Municipal sewage treatment plants	Agriculture
5	Urban runoff/storm sewers	Hydrologic/habitat modification	Combined sewer overflow

Source: US EPA (1998a).

Exhibit 3–7. Major Impairment by Pollution Source

Source of Impairment	Percentage of Miles/Acres Impaired			
	Rivers and Streams	Lakes, Reservoirs and Ponds	Great Lakes	Estuaries
Urban Runoff/Storm Sewers	3%	6%	1%	11%
Construction	1%	2%	1%	1%
Land Development	1%	0%	0%	0%

Source: US EPA (1998a).

3.4.2 Waters Impaired by Phase II Sources

To establish the baseline water quality impairment potentially attributable to Phase II sources, EPA first needed to determine the percentage of the nation's waters impaired by the three relevant sources of pollution. However, the 305(b) data characterize only the impairment of *surveyed* (assessed) waterbodies. Therefore, to establish a baseline representing all waters, EPA assumed that the 305(b) impairment data characterize all US waters. EPA then multiplied by the percent of waters that suffer impairment where the major cause of that impairment is due to urban runoff/storm sewers, construction, and land development as presented in Exhibit 3–7. As a result, the percent of aquatic life impairment in rivers and streams for which Phase II urban runoff/storm sewers are the major cause of impairment is as follows:

(% of waters impaired) × (% of waters impaired by urban runoff/storm sewers) or
(32%) × (3%) = 0.96%

The results of these equations are presented in Exhibit 3–8.

Exhibit 3–8. Percentages of Waters Impaired by Storm Water Sources by Designated Use

Designated Use	Urban Runoff/ Storm Sewers	Construction	Land Development
Rivers and Streams			
Aquatic Life Support	0.96%	0.32%	0.32%
Fish Consumption	0.51%	0.17%	0.17%
Primary Contact—Swimming	0.63%	0.21%	0.21%
Secondary Contact—Boating	0.60%	0.20%	0.20%
Lakes, Ponds, and Reservoirs			
Aquatic Life Support	1.86%	0.62%	N/A
Fish Consumption	2.10%	0.70%	N/A
Primary Contact—Swimming	1.50%	0.50%	N/A
Secondary Contact—Boating	1.50%	0.50%	N/A
Great Lakes Shoreline			
Aquatic Life Support	0.72%	0.72%	0.00%
Fish Consumption	0.98%	0.98%	0.00%
Primary Contact—Swimming	0.04%	0.04%	0.00%
Secondary Contact—Boating	0.04%	0.04%	0.00%
Estuaries			
Aquatic Life Support	3.30%	0.30%	N/A
Fish Consumption	2.64%	0.24%	N/A
Shellfish Consumption	3.08%	0.28%	N/A
Primary Contact—Swimming	1.76%	0.16%	N/A
Secondary Contact—Boating	2.64%	0.24%	N/A

Source: US EPA (1998a).
Note: N/A = Not Available

Using the percentages of impairment presented in Exhibit 3–8, EPA approximated the proportion of impairment specifically attributable to Phase II sources by examining the relevant municipal population and construction activity. Phase II municipal programs may be instrumental in improving waters impaired by urban runoff and storm sewers. As discussed in Section 3.2, 37.4% of the population resides in automatically designated Phase II municipalities. Multiplying the percent of waters impaired by urban runoff and storm sewers, shown in Exhibit 3–8, by 37.4% yields estimates of impairment caused by those Phase II municipalities.[1] The equation for

[1] To the extent that potentially designated municipalities do indeed become part of the Phase II municipal universe, the percentage of the population residing in Phase II municipalities will increase. This will increase the percentage of waters impaired by the Phase II municipalities as well as both the benefits and costs of the rule. Likewise, to the extent that Phase II municipalities with populations less than 1,000 are waived from the Phase II rule, the percentage of population residing in Phase II municipalities will decrease. This will decrease the percentage of water impaired by the Phase II rule as well as both the benefits and costs of the rule. EPA expects that the increases or decreases in the benefits and the costs will be proportional.

the impairment of aquatic life support in river and streams caused by Phase II urban runoff/storm sewers is:

(% impairment caused by urban runoff/storm sewers) × (% of population residing in Phase II municipalities) or

$$(0.96\%) \times (37.4\%) = 0.36\%$$

The results are presented in Exhibit 3–9.

Similarly, Phase II construction site controls may be instrumental in improving waters impaired by construction and land development activities. Multiplying the percent of waters impaired by construction and land development shown in Exhibit 3–8 by 24.9% (the percentage of Phase II construction starts, see Section 3.3) results in estimates of impairment caused by Phase II land disturbing activities. For example, the calculation for the impairment of aquatic life support in river and streams caused by Phase II construction is:

(of impairment caused by construction) × (% of Phase II construction starts) or
$(0.32\%) \times (24.9\%) = 0.08\%$.

These results are also shown in Exhibit 3–9.

3.5 Potential Limitations Associated with the Baseline Assumptions

There are a number of potential limitations associated with the analysis of existing programs and water quality in terms of providing a baseline for estimating benefits and costs. Although uncertainties exist in terms of defining the potentially regulated universe, the most difficult issues may be associated with assessing water quality. One limitation associated with use of the 305(b) data is that they are collected by numerous individuals with varying levels of expertise. That is, each individual applied his or her own judgment concerning interpretation of the survey instructions and findings. Another limitation is that the 305(b) surveys cover only a portion of the nation's waters, as indicated in Exhibit in 3–4. Therefore, EPA's assumption that 305(b) data characterizes the impairment of unassessed waters may or may not be accurate. In addition, these data reflect water quality in 1996 which may not be fully representative of current impairment levels.

Exhibit 3–9. Percent of Waterbody Impairment Potentially Attributable to Phase II Sources

Designated Use	Urban Runoff/ Storm Sewers[1]	Construction[2]	Land Development[2]	Total Phase II[3]
Rivers and Streams				
Aquatic Life Support	0.36%	0.08%	0.08%	0.52%
Fish Consumption	0.19%	0.04%	0.04%	0.28%
Primary Contact—Swimming	0.24%	0.05%	0.05%	0.34%
Secondary Contact—Boating	0.22%	0.05%	0.05%	0.32%
Lakes, Ponds, and Reservoirs				
Aquatic Life Support	0.70%	0.15%	N/A	0.85%
Fish Consumption	0.79%	0.17%	N/A	0.96%
Primary Contact—Swimming	0.56%	0.12%	N/A	0.69%
Secondary Contact—Boating	0.56%	0.12%	N/A	0.69%
Great Lakes Shoreline				
Aquatic Life Support	0.27%	0.18%	0.00%	0.45%
Fish Consumption	0.37%	0.24%	0.00%	0.61%
Primary Contact—Swimming	0.01%	0.01%	0.00%	0.02%
Secondary Contact—Boating	0.01%	0.01%	0.00%	0.01%
Estuaries				
Aquatic Life Support	1.23%	0.07%	N/A	1.31%
Fish Consumption	0.99%	0.06%	N/A	1.05%
Shellfish Consumption	1.15%	0.07%	N/A	1.22%
Primary Contact—Swimming	0.66%	0.04%	N/A	0.70%
Secondary Contact—Boating	0.99%	0.06%	N/A	1.05%

[1]Calculated by multiplying the percentages in Exhibit 3–9 by 37.4%. For example, the calculation for impairment to aquatic life support in river and streams is: (0.96%) × (37.4%) = 0.36%. Results subject to rounding.

[2]Calculated by multiplying the percentages in Exhibit 3–9 by 24.9%. For example, the calculation for impairment to aquatic life support in river and streams caused by construction is: (0.32%) × (24.9%) = 0.08%. Results subject to rounding.

4.0 POTENTIAL COSTS, POLLUTANT LOAD REDUCTIONS, AND COST EFFECTIVENESS

Based on internal review and comments received from the public on the EA that accompanied the proposed Phase II rule, EPA initiated several additional data collection activities and analyses to enable it to better estimate the incremental costs and pollutant loading reductions associated with the Phase II rule. This chapter describes these activities and analyses and presents revised estimates of costs and pollutant loading reductions. Specifically, Section 4.1 provides an overview of the methodology and discusses changes from the EA that accompanied the proposed rule. Section 4.2 discusses the revised analyses for estimating potential costs and presents the total costs for the Phase II rule, and Section 4.3 provides a summary of the results. Section 4.4 presents the potential pollutant loading reductions reflected in the revised analyses. Section 4.5 presents the results of an analysis of the cost effectiveness of the final rule. Section 4.6 presents the results of sensitivity analyses performed to evaluate the potential impact of several major assumptions used for the cost analysis. Finally, section 4.7 provides conclusions.

4.1 Overview of Methodology

This section provides an overview of the methodology used to estimate costs and pollutant loading reductions for both municipalities and construction sites subject to the final Phase II rulemaking. In general, the same approach that was used to estimate costs for the proposed rule was used for the final rule. However, additional data were collected, the methodology changed, and supplemental analyses were performed to strengthen and facilitate the analysis of the final rule. The specific components of the analysis are discussed below.

4.1.1 Municipalities

Municipalities that will be automatically designated by the Phase II rule are those that are located in an urbanized area and have a municipal separate storm sewer system (MS4) that serves a population of less than 100,000. The permitting authority may grant a waiver to automatically designated MS4s that serve a population of less than 1,000 (see sensitivity analysis number # 5, in Section 4.6 for the potential affect of the waiver on the cost analysis). In addition, other municipalities with MS4s may be designated by the permitting authority particularly if they have a population of at least 10,000 and a population density of at least 1,000 persons per square mile.

EPA estimated annual per household program costs for 5,040 automatically designated municipalities using data from a 1998 survey of municipalities conducted by the National Association of Flood and Stormwater Management Agencies (NAFSMA).[1] The survey obtained cost information from communities that currently conduct activities required by each of the Phase II minimum measures. Per household costs were developed by multiplying costs by minimum measure per MS4 by the number of persons/household (as indicated by US Census data), then dividing by population per MS4. Average costs were calculated for each minimum

[1]EPA did not include the 27 Federally-recognized Native American Indian Tribes and 39 municipios (Puerto Rico) in the municipal cost and benefit analysis. If EPA were to add these Tribal and Territorial governments to the analysis, costs and benefits would likely increase proportionately.

measure, then summed across all minimum measures to estimate costs for whole program implementation.

These findings were verified by comparing them to actual storm water program expenditures reported by 26 Phase I municipalities. The Phase I municipalities studied were selected because of their tenure in the Phase I program and their detailed cost information for Phase I program elements. In addition, many of the municipalities examined were smaller cities that more closely reflect the population of Phase II municipalities.

An average annual per household administrative cost was also estimated to address application, record keeping, and reporting requirements of the final rule. The average annual administrative per household cost was added to the program per household cost to derive a total average per household cost. To obtain the national estimate of compliance costs, EPA multiplied the total per household cost by the expected number of households in Phase II municipalities.

4.1.2 Construction Site Runoff Controls

The final Phase II rule regulates construction starts disturbing one to five acres of land. Specifically, small construction site owners or operators will be required to plan and implement appropriate erosion and sediment control BMPs.

In estimating incremental costs attributable to the final rule, EPA estimated a per-site cost for sites of one, three, and five acres and multiplied the cost by the total number of Phase II construction starts in these size categories to obtain a national cost estimate. Several steps were involved in obtaining the national estimates and are summarized below.

EPA used building permit information from the US Bureau of the Census and construction start data from fourteen municipalities around the country to estimate the number of construction starts that would be affected by the Phase II rule. From this information, EPA estimated the number of construction starts disturbing between one and five acres of land.[2] EPA reduced the construction site universe by 15% to account for those starts that are anticipated to qualify for waivers (63 FR 1583).[3]

For analysis of per-site costs, EPA created 27 model sites of typical site conditions in the United States. The model sites considered three different site sizes (one, three, and five acres), three slope variations (3%, 7%, and 12%), and three soil erosivity conditions (low, medium, and high). EPA used the WEF database to develop and apply BMP combinations appropriate to the model site conditions. BMP costs for erosion and sediment control were estimated for each model site using standard cost estimates from RS Means (RS Means, 1997a and 1997b). Based on the assumption that any combination of these site factors is equally likely to occur on a given site,

[2]Based on public comments received on the proposed rule, EPA considered including oil and gas exploration sites but, upon further review, determined that few, if any, such sites actually disturb more than one acre of land.

[3] It should be noted that to obtain a waiver, construction site owners/operators must certify that they meet certain criteria, e.g., the construction activity occurs in an area of negligible rainfall or the permitting authority has completed wasteload allocations that are part of total maximum daily loads that address the pollutants of concern.

EPA averaged the matrix of estimated costs to develop an average cost for sites disturbing one, three, and five acres of land.

Administrative costs for the following elements required under the Phase II rule were estimated per construction site and added to each BMP cost: submittal of a notice of intent (application) for permit coverage; notification to municipalities; development of a storm water pollution prevention plan; record retention; and submittal of a notice of termination. The total per-site costs were then multiplied by the total number of Phase II construction starts disturbing one to two, two to four, and four to five acres of land to obtain the national cost estimate.

EPA also estimated per-site administrative costs for that portion of the construction universe expected to qualify for a waiver. These are costs associated with completing and submitting a waiver certification form. The per-site waiver costs were then multiplied by the total number of Phase II construction sites that are expected to be waived from the construction program.

4.1.3 Post-Construction Runoff Controls

The Phase II municipal program requires municipalities to develop, implement, and enforce a program that addresses storm water runoff from new development and redevelopment sites on which land disturbance is greater than one acre and that discharge into a regulated MS4. On new development and redevelopment sites, EPA recommends that post-development runoff conditions should not be different from predevelopment conditions in a way that adversely affects water quality.

While implementation of this rule will likely include a mix of planning, site design, and structural approaches, the cost analysis focused on structural controls (installation and maintenance of structural best management practices, or BMPs) because development of nationally-applicable planning and site design measures was infeasible.

EPA developed average annual BMP costs for sites of one, three, five, and seven acres. The analysis accounted for varying levels of imperviousness that characterize residential, commercial, and institutional land uses (i.e., per-site BMP costs are highest for intensely used commercial sites (85% impervious coverage), lowest for residential sites (35% impervious coverage), and moderate for a mixed category including institutional, commercial, and residential uses (65% impervious coverage).

Using information presented in an EPA Office of Science and Technology study (Preliminary Data Summary of Urban Storm Water Best Management Practices, US EPA, Office of Science and Technology, December 1998b), EPA developed a combination of BMPs for the model sites and calculated costs based on the amount of storm water runoff expected from sites of varying imperviousness. EPA then calculated a weighted average BMP cost for each of the model sites. Per-site costs were adjusted to reflect two factors: 1) a cost reduction associated with the anticipated use of a nonstructural practice, the redirection of rooftop runoff, and 2) anticipated cost savings because the new BMPs will reduce peak storm water flows, allowing developers to save on construction costs when they build sewer connections.

The adjusted per site BMP cost was then multiplied by the total number of construction sites that are located in Phase II urbanized areas to obtain a national cost estimate. EPA did not include sites that disturb greater than 10 acres in the analysis because the construction general permit (CGP) already requires post-construction controls on those sites (63-FR 7858).

4.1.4 Phase I Industrial Activities

The proposed Phase II rule included a no exposure exemption for Phase I industrial sources which stated that if an industrial facility could show that no materials or material handling/processing activities were exposed to storm water, then the industry would be exempt from Phase I permit requirements (63 FR 1536). EPA assumed that no costs would be associated with this exemption provision. EPA included this exemption in the final Phase II rule and maintained the same assumption. Estimated cost savings resulting from the no exposure exemption are presented in Chapter 9.

4.2 Analyses of Potential Costs

This section provides a detailed description of the procedures used to estimate the potential incremental costs of the Phase II rule and presents per household municipal costs, per site construction costs, per site costs for post-construction controls, costs to state and federal agencies, and national cost estimates. Assumptions used and limitations of the analyses are also described.

4.2.1 Municipal Costs

National Phase II municipal cost estimates are a function of the number of entities to be regulated and unit costs. EPA estimated national municipal costs by determining the number of municipalities that would need to apply for a Phase II storm water permit, estimating the number of households in the Phase II municipalities, and developing unit costs for compliance. The following section discusses how EPA estimated national compliance costs for municipalities.

Phase II Municipal Universe

EPA verified the Phase II municipal universe by reviewing a current list of US Bureau of the Census municipalities meeting the definition of a Phase II MS4, i.e., a municipality located in an urbanized area that has an MS4 serving less than 100,000 people, and associated populations. All Phase I co-permittees that meet the definition of a Phase II MS4 were identified from EPA's Phase I MS4 database and removed from the Phase II municipal universe to ensure that no double counting of municipalities occurred. The final list is presented in the final rule (citation when available). It is important to note that the Phase II universe is dynamic since populations change and Phase II municipalities often become co-permittees with Phase I MS4s as individual Phase I permits are issued. Following review of the Census data, EPA estimated the Phase II municipal universe to be 5,040 MS4s with a total population of 85 million people and 32.5 million households (see Chapter 3, Section 3.2).

Establishing Per Household Costs

In order to obtain incremental cost estimates for Phase II municipalities, EPA reviewed a survey of the Phase II community provided by the National Association of Flood and Stormwater Management Agencies (NAFSMA0).[4] Using the list of potential Phase II designees published in the Federal Register (63 F.R. 1616 - 32), NAFSMA contacted more than 1,600 jurisdictions in a survey mailed on July 31, 1998 (see Appendix B–1, Exhibit B–1a). The goal of the survey was to solicit information from those communities about the proposed Phase II NPDES storm water program. The survey sought to identify current storm water spending levels in Phase II municipalities as well as to identify future needs for these communities. One hundred twenty-one surveys were returned to NAFSMA. Fifty-six of those surveys reported cost information that was used to develop a national snapshot of potential costs for Phase II municipalities.

Several of the survey questions correspond directly to the minimum measures required by the Phase II storm water rule. Communities were asked whether they currently conduct those activities required by the minimum measures, and, if so, annual costs were also obtained. These costs form the basis for the municipal cost estimate used in this analysis. The survey data covers the following five minimum measures: public education/outreach, illicit discharge detection and elimination, construction site storm water runoff control, post-construction storm water management in new development and redevelopment, and pollution prevention/good housekeeping for municipal operations. (The NAFSMA survey did not specifically address municipal costs for public participation. It is EPA's belief that respondents considered public participation costs as part of public education and outreach efforts.)

The following steps were followed to conduct the analysis:

- Raw data was keyed in from the NAFSMA Phase II Raw Data Report, and re-ordered by municipal population sizes. Those respondents without population data were omitted from the analysis. Subsets of the respondents were able to provide cost data for each of the minimum measures, as shown in Appendix B–1, Exhibit B–1b.
- Per household costs were calculated by dividing costs per minimum measure per MS4 by the population of that MS4, then multiplying the result by 2.62 persons/household.
- Average and percentile costs (0, 25%, 50%, 75%, 95%, 100%) were calculated for each minimum measure, then summed across all minimum measures to determine hypothetical average and percentiles for whole program implementation (see Appendix B–1, Exhibit B–1c).
- One municipality's response to the survey question on municipal runoff control costs (question 6) was removed from the data set as a disproportionately huge "outlier" (almost 15 times the mean cost for all other municipalities and 4 times greater than the next highest per capita cost). This is documented in Appendix B–1, Exhibit B–1b.

[4]The National Association of Flood and Stormwater Management Agencies is an organization of public agencies whose function is the protection of lives, property and economic activity from the adverse impacts of storm and flood waters. The mission of the Association is to advocate public policy, encourage technologies and conduct education programs which facilitate and enhance the achievement of the public service functions of its members.

The average annual household cost (before accounting for administrative costs) was found to be $8.93.

In addition to expenditures associated with implementing Phase II program elements, Phase II municipalities will have to comply with administrative requirements. These include submittal of an application for coverage under the Phase II program, record keeping, and reporting. While some municipalities may have incorporated these costs into the figures reported in the NAFSMA survey, this was not assumed, and EPA therefore developed an additional estimate of administrative costs. EPA used estimates provided in the EA for the proposed rule, which were based on US Department of Labor (US DL) wage rates (US DL, 1995) and EPA's "Information Collection Request (ICR) for Revisions to the NPDES: Storm Water Discharges" (US EPA, 1990). EPA used labor hours reported in the ICR and matched the hours to US DL wage rates. The wage rates were adjusted to 1998 dollars using the Consumer Price Index. EPA estimated municipal application costs, over a five-year permit cycle, to be $805, record keeping costs to be $375, and reporting costs to be $6,445 per municipality. EPA estimated costs per household based on the Phase II municipal population of 85 million, 5,040 Phase II municipalities, and 2.62 persons per household. Costs were averaged over the five year NPDES permit term to obtain an annual administrative cost of $0.23 per household (Exhibit 4–1).

Exhibit 4–1. Annual Municipal Administrative Costs (1998 dollars)

Administrative Requirement	Estimated Hours Over Five Years	Estimated Annual Cost Per Municipality [1,2]	Total Annual Cost [2,3]	Annual Cost Per Household [4]
Municipal application	30	$161	$811,440	$0.02
Record keeping	14	$75	$378,000	$0.01
Reporting	240	$1,289	$6,496,560	$0.20
Total[5]	**284**	**$1,525**	**$7,686,000**	**$0.23**

[1]Based on a wage rate of $26.86 per hour.
[2]Costs were averaged over the permit term of five years.
[3]Based on a universe of 5,040 municipalities.
[4]Based on a population of 85 million people and 2.62 persons per household.
[5]Totals subject to rounding.

The annual administrative costs per household were added to the annual per household costs for the Phase II program elements to obtain a total annual per household cost ranging from $0.42 to $54.91 for the survey respondents. The mean and percentile range of total annual per household costs is presented in Exhibit 4–2.

Alternative Approach for Establishing Per Household Costs. As an alternative method and point of comparison with the NAFSMA-based approach described above, EPA reviewed annual reports from 35 Phase I MS4s to obtain incremental cost estimates for Phase II municipalities. Cost data was only available for 26 of those MS4s; EPA calculated annual per household cost estimates for each of these Phase I MS4s by using actual expenditures reported in their individual annual reports. The initial 35 Phase I MS4s were targeted because they had been in the Phase I program for nearly one NPDES permit term, were smaller cities that more closely reflected the population of Phase II municipalities, and had detailed data reflecting actual program

implementation costs.[5] EPA extracted costs from the Phase I annual reports for comparable Phase II program elements. EPA calculated a total annual cost for each municipality for the Phase II program elements. EPA then divided the annual costs by the relevant number of households in each Phase I municipality based on household data from the US Bureau of the Census to obtain a per household estimate. After adding annual per household administrative costs (see discussion above), annual per household program costs ranged from $0.62 to $60.43, with an average of $9.08, for the 26 Phase I MS4s. The range of costs obtained using this method is shown in Exhibit 4–2. The cost range and mean values obtained using this method are similar to those found using the NAFSMA survey data.

Exhibit 4–2. Mean and Percentage Findings: Estimated Annual Per Household Cost of Compliance for Phase II Municipalities (1998 dollars)

Percentile	NAFSMA Annual Per Household Cost [1,2,4]	Phase I Adjusted Annual Per Household Cost [3,4]
100th (Maximum)	$54.91	$60.43
95th	$36.57	$42.10
75th	$10.40	$10.51
Mean	**$9.16**	**$9.08**
50th (Median)	$4.19	$2.86
25th	$1.32	$1.46
0th (Minimum)	$0.42	$0.62

[1]Calculated from NAFSMA 1998 Phase II Survey responses that reported costs associated with implementing one or more of five Phase II minimum control measures. Percentiles were each determined per measure, then percentiles were added across all measures and sums multiplied by 2.62 people/household.

[2]These estimates removed the effect of one disproportionately huge "outlier" (almost 15 times the mean cost for all other municipalities and four times greater than the next highest per capita cost) in one municipality's estimate of its annual municipal runoff control costs.

[3]Costs extracted and adjusted from 26 Phase I MS4 annual reports, considering only those minimum measures for which comparable cost estimates could be derived. Thus, the annual per household costs reported for each MS4 is the sum of only those measures which the MS4 was implementing when the report was prepared.

[4]All costs incorporate administrative costs of $0.23/household, based on Exhibit 4–1.

National Municipal Costs

To determine potential national level costs for municipalities, EPA divided the Phase II population (85 million) by the number of persons per household to determine the number of households in the Phase II universe. The number of households was then multiplied by the per household compliance cost ($9.16). Exhibit 4–3 shows the annual estimated national Phase II municipal costs to be approximately $297 million.

[5]EPA evaluated the annual reports submitted by 35 Phase I MS4s. The 35 annual reports included one MS4, Orange County, California, with 31 co permittees. Twenty percent of the 35 MS4s have populations of less than 100,000 people and 74% of the Orange County permittees have populations of less than 100,000 people.

Exhibit 4–3. Estimated National Phase II Municipal Annual Costs

Per Household Costs (1998 Dollars)	Total Number of Households in Phase II Municipalities[1]	Estimated National Phase II Municipal Annual Cost (1998 Dollars)
$9.16	32,458,365	$297,318,623

[1] See Chapter 3, Section 3.2, for description of methodology used to determine the Phase II municipal universe.

4.2.2 Construction Costs

The Phase II rule includes two provisions that may result in additional costs to the construction community. The first provision requires the owners and operators of construction sites disturbing one to five acres of land to plan and implement erosion and sediment control BMPs. Similar to the national municipal cost estimates, EPA first estimated the universe of construction starts that would be required to submit an application for a storm water permit and then estimated unit costs (compliance costs) for each site to comply with the regulatory requirements. EPA also estimated the universe of construction starts that would qualify for a waiver and then estimated per site administrative costs (waiver costs) associated with obtaining a waiver. The following sections describe how EPA estimated national construction costs for sites disturbing between one and five acres of land and provide cost estimates for this measure.

The second provision requires the implementation of post-construction storm water runoff controls on construction sites located in Phase II municipalities. The Phase II municipal program requires municipalities to develop, implement, and enforce a program that addresses storm water runoff from new development and redevelopment sites on which land disturbance is greater than one acre and that discharge into a regulated MS4. EPA estimated incremental costs attributable to the post-construction runoff control measure. To develop a cost estimate associated with this measure, EPA estimated a per site BMP cost, including operation and maintenance, for 12 model sites of varying size and imperviousness. The per site BMP cost was then multiplied by the total number of multi-family, institutional, and commercial construction starts that are located in Phase II urbanized areas to obtain a national cost estimate.

Erosion and Sediment Control Costs

Phase II Construction Universe. For the final Phase II rule, EPA expanded the Prince George's County estimates of construction starts by collecting additional data. EPA conducted an extensive search to identify municipalities that record the area disturbed for each construction site and the number and types of structures (single family dwelling, townhouses, etc.) constructed in each development. The municipalities contacted include:

- Amarillo, TX
- Arvada, CO
- Atlanta, GA
- Austin, TX
- Baltimore County, MD
- Bellingham, WA
- Bismarck, ND
- Boise, ID
- Boulder, CO
- Bozeman, MT
- Canton, OH
- Cape Girardeau, MO
- Carbondale, IL
- Cary, NC
- Cedar Rapids, IA
- Cheyenne, WY
- Columbia, MO
- Dane County, WI
- Davenport, IA
- Denver, CO
- Douglas County, CO

- Duluth, MN
- Durham, NC
- Eureka, CA
- Eugene, OR
- Fairfax County, VA
- Flagstaff, AZ
- Fort Collins, CO
- Great Falls, MT
- Henrico County, VA
- Jefferson County, CO
- Kansas City, MO
- Kenosha City, WI
- Kenosha County, WI
- Lacey, WA
- LaCrosse City, WI
- LaCrosse County, WI
- Leon County, FL
- Lexington, KY
- Longmont, CO
- Loudoun County, VA
- Madison, WI
- Marion County, OR
- Milwaukee, WI
- Monroe County, NY
- New Britain, CT
- North Kansas City, MO
- Ogden, UT
- Oklahoma City, OK
- Olympia, WA
- Omaha, NE
- Overland Park, KS
- Owensboro, KY
- Peoria, IL
- Prince George's County, MD
- Racine City, WI
- Racine County, WI
- Raleigh, NC
- Reno, NV
- Rochester, NY
- Rochester, MN
- Rutland, VT
- St. Louis County, MO
- Salem, OR
- Sante Fe, NM
- Santa Rosa, CA
- Spokane, WA
- Springfield, MO
- Stark County, OH
- Tallahassee, FL
- Tulsa, OK
- Tuscon, AZ
- Waukesha, WI
- Waukesha County, WI
- Wichita, KS

Of the municipalities listed above, the following fourteen had sufficient data to support the analysis: Austin, TX; Baltimore County, MD; Cary, NC; Fort Collins, CO; Lacey, WA; Loudoun County, VA; New Britain, CT; Olympia, WA; Prince George's County, MD; Raleigh, NC; South Bend, IN; Tallahassee, FL; Tucson, AZ; and Waukesha, WI.

Data collected from these municipalities varied widely in the total number of construction starts and in the distribution of starts by size category (one- to two-acre, two- to three-acre, etc.). Municipalities with large land areas and population (Baltimore County, Maryland and Prince George's County, Maryland) generally recorded a greater number of construction starts than those with small land areas and population (Lacey, Washington and Waukesha, Wisconsin). Exhibit 4–4 provides data for some of the factors influencing this range, including population, percent population growth, median household income, and municipal land area for these communities.

The Phase II construction start universe was estimated using the number of construction starts and corresponding disturbed area data collected from the 14 municipalities. The number of construction starts indicating a disturbance of one to five acres for the 14 municipalities was totaled and divided by the total number of building permits for those areas (see Appendix B–2). The resulting ratio was then used to estimate the Phase II construction start universe as described in Appendix B–2. Exhibit 4–5 shows the results of the data collection effort.

Exhibit 4–4. Summary Characteristics of Municipalities Where Construction Start Data was Collected

Municipality	Population 1996 (Estimates)[1]	Population Growth 1990 to 1996	Median Household Income (1989)	Area (Sq. Mi.)
Austin, TX	541,278	+14.7%	$25,414	217.8
Baltimore County, MD	720,662	+4.1%	$38,837	599.0
Cary, NC	75,676	+70.5%	$46,259	31.2
Fort Collins, CO	104,196	+19.1%	$28,826	41.2
Lacey, WA	27,381	+42.0%	$29,726	10.1
Loudoun County, VA	133,493	+54.9%	$52,064	520.0
New Britain, CT	71,512	–5.3%	$30,121	13.3
Olympia, WA	39,006	+15.6%	$27,785	16.1
Prince George's County, MD	770,633	+5.6%	$43,127	486.0
Raleigh, NC	243,835	+15.0%	$32,451	88.1
South Bend, IN	102,100	–3.2%	$24,131	36.4
Tallahassee, FL	136,751	+9.6%	$34,764	63.3
Tucson, AZ	449,002	+9.1%	$21,748	156.3
Waukesha, WI	60,197	+5.8%	$36,192	17.3
United States	265 million	+6.6%	$35,225	

Source: US Department of Commerce, Bureau of the Census. [http://www.census.gov].
[1]US Census Bureau Data (1996).

EPA estimates that there were 123,145 Phase II construction starts which would incur incremental costs for Phase II in 1994.[6] The number of potential construction starts was increased 1.3% annually to estimate the potential number of starts in year 1998.[7] This yields a construction start universe of 129,675 ($123{,}145 \times 1.013^4$). As in the EA for the proposed rule, 15% or 19,452 of those starts are expected to take advantage of the waiver provision in the Phase II rule. The construction starts that take advantage of the waiver provision will incur administrative costs associated with the waiver. The other 110,223 starts would incur costs associated with obtaining a storm water permit.

[6]The methodology for estimating the number of construction starts is provided in Appendix B–2.

[7]Based on data collected from the US Bureau of the Census the annual growth rate for the number of building permits issued from 1980 to 1994 was 1.3%. This growth rate is used to estimate future construction starts from the 1994 baseline. However, EPA recognizes the growth rate for construction starts fluctuates yearly and does not necessarily increase each year.

Exhibit 4–5. Number of Construction Starts by Disturbed Area Size

Municipality	Number of Construction Starts by Disturbed Area Size							Total All Sizes	Total 1–5 Acres	% of Phase II Starts
	0–1 Acre	1–2 Acres	2–3 Acres	3–4 Acres	4–5 Acres	5–10 Acres	>10 Acres			
Austin, TX	113	61	29	19	17	44	128	411	239	58%
Baltimore County, MD	71	113	61	44	39	81	11	495	328	66%
Cary, NC	30	52	26	24	11	27	21	191	143	75%
Fort Collins, CO	29	17	16	17	17	34	49	179	96	54%
Lacey, WA	7	3	2	1	2	5	3	23	15	65%
Loudoun County, VA	15	14	4	6	10	32	31	112	49	44%
New Britain, CT	15	1	6	0	0	6	2	30	22	73%
Olympia, WA	31	4	5	2	2	8	10	62	44	71%
Prince George's County, MD	180	30	12	9	5	76	6	318	236	74%
Raleigh, NC	13	7	15	10	9	19	15	88	54	61%
South Bend, IN	26	21	19	16	12	35	43	172	94	55%
Tallahassee, FL	148	58	18	17	13	32	34	320	254	79%
Tucson, AZ	33	32	21	13	17	21	64	201	116	58%
Waukesha, WI[1]	5	8	6	5	1	5	0	30	25	83%
Total Number of Starts	752	453	259	194	164	972	68	2632	1822	69%

[1]Data for Waukesha does not include residential (single or multi-family) dwellings. Data includes all other categories.

Per-Site Compliance Costs: Installation and O&M.. To estimate Phase II construction site compliance costs, EPA developed 27 model construction sites in an effort to reflect site conditions and erosion and sediment control practices throughout the country. The model sites varied in size (one, three, and five acres), soil erosivity (low, medium, and high), and slope (3%, 7%, and 12%). Using guidance contained in US EPA (1992a), EPA developed combinations of BMPs for the model sites to mimic commonly accepted erosion and sediment control practices. BMPs were selected based on guidance contained in Brown and Caraco (1997). The types of BMPs placed on each site varied based on the unique conditions of the site. For example, for sites with shallow slopes and low erosivity, few BMPs are required. In contrast, on larger, steeper, and more erosive sites, more BMPs are needed. Exhibit 4–6 shows the mix of BMPs selected for the various model sites. In developing the mix for each model site, EPA assumed that entities, when faced with the need for installation of BMPs, would select the most cost effective mix of BMPs. Detailed drawings of the model sites (i.e., site plans), assumptions, and BMPs that could be used under the Phase II rule are found in Appendix B–3.

Following the development of the model sites, EPA estimated the BMP costs for each site using RS Means (RS Means 1997a and 1997b). A description of each BMP used for the model sites, average price, and efficiency are summarized in Exhibit 4–7. Based on the mix of BMPs assumed for each model site presented in Exhibit 4–6, combined with the costs provided for each BMP in Exhibit 4–7, EPA derived total estimated costs for each model site (Exhibit 4–8).

Exhibit 4–6. BMPs Used for the Model Sites

Site Size (acres)	Soil Erodibility	Slope		
		3%	7%	12%
1	low	a	a,b	a,c,e
	med	a,b	a,c,e	a,c,e
	high	a,c,e	a,c,e	c,e,f,g1
3	low	a,b	a,c,e	c,d,e,f,g2
	med	a,c,e	a,c,e	c,d,e,f,g2
	high	a,c,e	c,d,e,f,g2	c,d,e,f,g2
5	low	a,c,d,e	c,d,e,f,g3	c,d,e,f,g3
	med	a,c,d,e	c,d,e,f,g3	c,d,e,f,g3
	high	c,d,e,f,g3	c,d,e,f,g3	c,d,e,f,g3

a = silt fence
b = mulch
c = seed and mulch
d = stabilized construction entrance
e = stone check dam
f = earthen dike directing runoff to sediment trap
g = sediment trap (1=1,800 cf, 2=5,400 cf, 3=9,000 cf)

Exhibit 4–7. Description of BMPs Used for 27 Model Construction Sites

BMP	Description	Use on Model Site Plans	Price 1998 ($)	Removal Efficiency (%) for Total Suspended Solids[1]
Silt Fence	Sediment controlling device constructed from a geotextile fabric stapled to a wood stake. Polypropylene or wire mesh reinforcement is often incorporated for support. The lower six inches of the fence are installed in a trench and backfilled. Commonly used on small construction sites, usually installed around the perimeter of the disturbed area. Not appropriate where concentrated flows occur or for clay soils.	Placed along the lower perimeter of the site, curved slightly upland on the ends. A quantity of silt fence would be used to control runoff from soil stockpiles.	$1.13 per Linear Foot	Sandy loam: 80–99% Silt loam: 50–80% Silt clay loam: 0–20%
Mulch (Hay)	Erosion preventing practice which disperses the energy of raindrops, thereby decreasing splash erosion and increasing infiltration. Spread by hand or mechanically, usually up to an inch in depth (two to three tons/acre). An excellent choice for small sites as a low price erosion control with fairly easy maintenance and installation. Source: Brown, W. and Caraco, D. (1997).	On severe sites, mulch was specified for coverage on the entire site. On less severe sites, mulch was specified for coverage on half the site.	$0.21 per Square Yard	Sand, Silt loam: 90–100% Silt clay loam: 70–95%
Seed and Mulch	Used to establish a temporary stand of grass. Grass reduces the velocity of runoff and increases infiltration while its roots hold soil in place. Mulch is used to reduce rainfall impact and to hold seeds in place. Seed and mulch are used on a majority of the study sites.	On severe sites, seed and mulch was specified for coverage on the entire site. On less severe sites, seed and mulch was specified for coverage on half the site.	$0.43 per Square Yard	90–100%
Stabilized Construction Entrance	Areas where points of ingress/egress are stabilized with coarse stone over a bed of geotextile fabric. Soil tracking can lead to significant sediment pollution, as it tends to wash into the street drainage system. Stabilized construction entrances are used to dislodge soil from the treads of truck tires before exiting the site.	Not used on smaller sandy sites, since these soils do not tend to track from the site.	$15.72 per Square Yard	Na

Exhibit 4–7. Description of BMPs Used for 27 Model Construction Sites *(continued)*

BMP	Description	Use on Model Site Plans	Price ($) 1998	Removal Efficiency (%) for Total Suspended Solids
Stone Check Dam	Piles of 1.5" to 3" stone placed in swales and at outlets, usually on a bed of geotextile fabric. Cause water to pond behind the structure, thereby reducing the velocity and force acting on the soil. *Source:* US DOT. (1995). Capture sediment entering the swale from project grading activities and serve as a backup to the stabilized construction entrance, capturing any sediment washed into the swale from the street. Superior in removal efficiency and cost to hay bale check dams because hay bale dams need constant maintenance, are difficult to install properly, and frequently fail. *Source:* Brown, W. and Caraco, D (1997).	Used at various intervals in the swale on most of the study sites.	$61.53	na
Earth Dike	Ridges of soil constructed to direct the flow of sediment-laden storm water to a treatment device or area. Usually seeded and mulched if expected to remain in service for an extended period of time.	The dikes appearing on the study sites are used in place of silt fence where soil type (clay) or steepness preclude its use. The dikes direct flow from the entire site to either a sediment trap or detention pond.	$0.74 per Linear Foot	na
Sediment Trap (1,800, 5,400 and 9,000 CF)	Designed to intercept and retain runoff from disturbed areas for a long enough period of time to allow suspended sediment to settle out. Best suited for small construction sites with a maximum drainage area of five acres. Relatively inexpensive and easy to install in comparison to other frequently used practices such as silt fencing. *Source:* Brown, W. and Caraco, D. (1997).	Sediment traps appear on study sites with steep sites and clay soils. The traps are placed in the southeast corner of the site. Earth dikes convey runoff to the sediment trap from the upland areas of the site. The discharge from the sediment trap is stabilized with a stone apron.	$513.32 (1,800 CF) $1,669.47 (5,400 CF) $2,671.20 (9,000 CF)	60%

Source: RS Means (1997a) and RS Means 1997b.
Na = Not Available.

Exhibit 4–8. Estimated Cost of BMPs for the Model Sites (1998 dollars)

Site Size (acres)	Soil Erodibility	Cost by Slope			Average Cost
		3%	7%	12%	
1	low	$317	$814	$1,422	$1,206
	med	$814	$1,422	$1,422	
	high	$1,422	$1,422	$1,799	
3	low	$1,978	$3,804	$6,047	$4,598
	med	$3,804	$3,804	$6,047	
	high	$3,804	$6,047	$6,047	
5	low	$6,245	$9,334	$9,519	$8,709
	med	$6,245	$9,334	$9,519	
	high	$9,334	$9,334	$9,519	

EPA attempted to match construction start data collected from the fourteen municipalities to the model sites; however, data was unavailable on soil erodibility or slope. So, EPA calculated an average cost for each model site size by soil erodibility level across the slope categories. To obtain the average cost for a site size, all values were added across each soil erodibility category (low, medium, or high) for each site size and divided by the number of slope and soil erodibility cost categories. These values are presented in Exhibit 4–8.[8]

EPA developed an average BMP cost for one, three, and five acre starts for all soil erodibilities and 3%, 7%, and 12% slopes. The average BMP cost was estimated to be $1,206 for a one acre site, $4,598 for a three acre site, and $8,709 for a five-acre site.

Per-Site Compliance Costs: Administrative. Additional construction costs resulting from compliance with the final Phase II rule include the following: costs to submit a notice of intent (NOI) for coverage under the existing Construction General Permit (63 FR 7858); costs to notify municipalities about the project; costs for the development of a storm water pollution prevention plan (SWPPP); costs for record retention; and costs to submit a notice of termination (NOT) at the completion of the project. For purposes of estimating costs of the final Phase II rule, these other administrative costs were based on those presented in the EA for the proposed rule. Each of these other costs, estimated on a per-site basis, are discussed below. In analysis of the final rule, each other per-site cost was summed and added to the average site cost for a total compliance cost estimate per construction site.

[8]EPA considered estimating construction costs by weighted average, unfortunately the number of construction starts for each acre size, soil erodibility, and slope is unknown. In the fourteen municipalities in which data was collected few record slope, but none included soil erodibility.

EPA used labor categories and hourly rates to estimate labor costs for activities by construction sources. The fully loaded rates in 1998 dollars are $34.19 for engineering assistant, $33.27 for drafter, and $22.57 for clerical support (US DL, 1993), (ENR, 1998), (RS Means, 1998). It is assumed that an engineering assistant and drafter would work on the development of SWPPP. An engineering assistant is assumed to work on the NOI, Notification of Municipalities, and NOT. Clerical support is assumed for record keeping.

- **NOI** Under the Construction General Permit (CGP), owners/operators of construction sites must complete an NOI to obtain coverage. EPA estimated the burden for completing the NOI form to be 3.7 hours with an associated labor cost of $126.50 (adjusted to 1998 dollars) (63 FR 7858).

- **Notification of Municipalities** Under the CGP, owners/operators of construction sites must notify the local municipality that they are operating an NPDES permitted construction site within their jurisdiction. EPA estimated the burden to be 0.5 hours and the cost of this notification to be $17.10 (adjusted to 1998 dollars).

- **SWPPP** Under the final Phase II rule, all construction site owners/operators will be required to develop and implement a SWPPP. The requirements for the SWPPP are identical to those included in the CGP, except for making the plans available for public review. The SWPPP requirements include the following: description of site conditions; identification of controls to be used to reduce the offsite transport of pollutants; regular maintenance of controls; and biweekly inspections of controls. Because Phase II construction sites are smaller than those regulated under the CGP, EPA assumed inspections will occur on a monthly, rather than a biweekly, basis.

Exhibit 4–9 presents the specific requirements for development and implementation of a SWPPP, associated low and high costs to complete each element, and an average cost for development and implementation of the SWPPP. In implementing the SWPPP, EPA assumed the life of a construction site to be six months (NAHB telecommunication, July 1998).

Exhibit 4–9. Storm Water Pollution Prevention Plan Requirements and Unit Cost Estimates (1998 Dollars)

Cost Elements	Estimated Quantity (Hours) (Low)	Estimated Quantity (Hours) (High)	Estimated Cost[1] (Low) (1998 dollars)	Estimated Cost[1] (High) (1998 dollars)
1. Contents of the Plan				
a. Site Description				
• Description of the Nature of Construction Activity	0.25	1	$8.55	$34.19
• Description of the Intended Sequence of Major Activities	0.25	1	$8.55	$34.19
• Estimate of Total Area Expected to be Disturbed	0.1	0.5	$3.42	$17.10
• Runoff Coefficient[1]	0.1	0.5	$3.42	$17.10
• Site Map	0.5	4	$16.64	$133.08
• Name of Receiving Waters	0.1	0.1	$3.33	$3.33
b. Controls to Reduce Pollutants				
i. Erosion and Sediment Controls	0.5	4	$17.10	$136.76
ii. Storm Water Management	0.5	2	$17.10	$68.38
iii. Other Controls	0.1	1	$3.42	$34.19
iv. State and Local Controls	0.1	0.5	$3.42	$17.10
c. Maintenance	2	6	$68.38	$205.14
d. Inspections[2]	3	6	$102.57	$205.14
• Inspection Report	1.5	6	$51.29	$205.14
e. Non-storm Water Discharges	0.5	1	$17.10	$34.19
2. Deadlines for Plan Preparation and Compliance	NCA[3]	NCA	NCA	NCA
3. Signature and Plan Review	1	1	$34.19	$34.19
4. Keeping Plans Current	NCA	NCA	NCA	NCA
5. Additional Requirements	NCA	NCA	NCA	NCA
6. Contractors	0.1	0.1	$3.42	$3.42
Total[4]	10.6	34.7	$361.87	$1,182.63
Average[5]	22.7		$772.25	

[1] Costs based on labor wage rate of $11.78 per hour for engineering assistant, except for site map and name of receiving waters which are based on drafter's wage of $11.58 an hour (US DL, 1993). These wage rates were escalated to 1998 dollars by using the Engineering News Record's Construction Cost Index, (www.enr.com/cost/costcci.asp). These labor were also inflated by 50% for fringe and 60% for overhead and profit. Source: RS Means, 1998a and RS Means 1998b.

[2]Construction is assumed to last six months at every site. The inspection at the smallest sites is assumed to take ½ hour per inspection event and at large sites (4–5 acres) one hour per inspection event.

[3]NCA = No Costs Associated.

[4]Totals may not add because of rounding.

[5]The average hours and costs was estimated by adding the low and high estimates and dividing by two.

- **Records Retention** Under the CGP, the owner/operator of a construction site must retain all records required under the permit for three years from the date of final stabilization. EPA estimated the cost for record retention to be $4.51 per site. This assumes that approximately 0.2 hours would be spent filing documents relevant to the site.

- **NOT** Under the CGP, upon final stabilization of the site, the owner/operator must submit an NOT to the permitting authority. EPA estimated the cost for submitting an NOT to be approximately $17.10 (adjusted to 1998 dollars) and the burden to be 0.5 hours to complete the form.

From this analysis, EPA estimated total average compliance costs (BMP plus other costs) for a Phase II construction site of $2,143 for sites disturbing between one and two acres of land, $5,535 for sites disturbing between two and four acres of land, and $9,646 for sites disturbing between four and five acres of land. A summary of the other administrative construction per-site costs is presented in Exhibit 4–10.

Exhibit 4–10. Estimated Other Administrative Phase II Construction Costs Per Site (1998 Dollars)

Administrative Requirement	Cost
NOI	$126.50
Municipal Notification	$17.10
SWPPP	$772.25
Record Retention	$4.51
NOT	$17.10
Estimated Total Cost (per site)	$937.46

Per-Site Waiver Costs. The permitting authority may waive permitting requirements for Phase II construction sites under two conditions. Construction sites can be waived if they are either located in areas with low rainfall potential or if water quality analyses show that there is no need for regulation. EPA estimated the cost for preparing and submitting a written waiver certification to be approximately $34.19. The corresponding hour burden is one.

National Construction Costs. EPA's estimate of national level incremental annual costs combines compliance costs for construction starts that disturb between one and five acres and administrative costs for construction starts that are expected to qualify for a waiver. To estimate national level incremental annual compliance costs, EPA multiplied the total cost of compliance, for one to two acre, two to four acre, and four to five acre sites by the total number of Phase II construction starts within each of those size categories. Exhibit 4–11 indicates the estimated construction compliance cost by climatic zone (climatic zones reflect regional variations in rainfall intensity and amount.) To estimate national level incremental annual waiver costs, EPA multiplied the total cost of preparing and submitting a waiver certification form by the construction universe that is expected to qualify for a waiver. Exhibit 4–12 summarizes the estimated national construction compliance and waiver costs.

Exhibit 4–11. Estimated National Phase II Construction Compliance Costs by Climatic Zones for Year 1998 (1998 Dollars)

Climatic Zone	Representative City	Number of Starts 1–2 Acres	Number of Starts 2–4 Acres	Number of Starts 4–5 Acres	Total Starts	Costs for Starts 1–2 Acres	Costs for Starts 2–4 Acres	Costs for Starts 4–5 Acres	Total Costs
A	Portland, OR	1,683	1,471	659	3,813	$3,608,528	$8,141,052	$6,360,054	$18,356,897
B	Boise, ID	1,508	1,345	576	3,429	$3,232,932	$7,443,548	$5,556,280	$16,455,088
C	Fresno, CA	2,388	2,018	974	5,380	$5,118,068	$11,171,812	$9,400,679	$26,039,422
D	Las Vegas, NV	7,154	6,256	3,035	16,445	$15,335,047	$34,628,344	$29,276,500	$80,306,157
E	Denver, CO	1,787	1,613	636	4,036	$3,829,714	$8,928,128	$6,135,764	$18,893,606
F	Bismarck, ND	560	469	156	1,185	$1,199,916	$2,595,370	$1,508,877	$5,304,163
G	Helena, MT	1,067	921	348	2,336	$2,287,796	$5,098,377	$3,354,650	$10,740,823
H	Amarillo, TX	3,295	2,838	1,152	7,285	$7,063,767	$15,708,383	$11,110,516	$33,882,666
I	San Antonio, TX	1,105	960	414	2,479	$2,368,045	$5,314,569	$3,997,033	$11,679,647
K	Duluth, MN	2,957	1,796	326	5,078	$6,339,106	$9,939,565	$3,141,089	$19,419,760
M	Des Moines, IA	9,335	7,599	2,695	19,629	$20,009,581	$42,063,182	$26,002,165	$88,074,928
N	Nashville, TN	5,801	4,707	1,705	12,212	$12,434,357	$26,052,990	$16,445,128	$54,932,475
P	Atlanta, GA	5,157	2,956	1,127	9,241	$11,054,430	$16,364,835	$10,875,252	$38,294,517
R	Hartford, CT	6,909	5,324	2,116	14,348	$14,808,848	$29,468,120	$20,412,901	$64,689,869
T	Charleston, SC	1,194	675	263	2,132	$2,560,342	$3,736,824	$2,535,496	$8,832,662
V	Hawaii	504	423	218	1,145	$1,080,648	$2,340,928	$2,099,447	$5,521,023
W,X,Y	Alaska	22	20	8	50	$47,885	$112,127	$72,563	$232,575
Total		52,426	41,389	16,408	110,223	$112,379,010	$229,108,154	$158,284,394	$499,771,558

Note: Number of sites include only those where storm water BMPs are not currently required by Federal or State programs. Totals may not add because of rounding.

Exhibit 4–12. Phase II Erosion and Sediment Control Annual Costs

Construction Costs	Universe	Estimated Total National Annual Costs (1998 dollars)
Compliance Costs	110,223	$499,771,558
Waiver Costs*	19,452	$665,064
Total	129,675	$500,436,622

*Based on an engineering assistant's wage of $34.19 per hour. U.S. Department of Labor, 1996.

Post-Construction Costs

EPA developed an analysis of potential costs to the construction and land development sector that may result from post-construction runoff control measures in municipal storm water management programs. The analysis and results are described in this section and Appendix B–4.

Cost Analysis Summary. The Phase II municipal program requires municipalities to develop, implement, and enforce a program that addresses storm water runoff from new development and redevelopment sites on which land disturbance is greater than one acre and that discharge into a regulated MS4. EPA did not include sites that disturb greater than 10 acres in the analysis because the construction general permit (CGP) already requires post-construction controls on those sites (63-FR 7858). On new development and redevelopment sites, EPA recommends that post-development runoff conditions should not be different from predevelopment conditions in a way that adversely affects water quality. Municipalities may select from an array of structural and non-structural options in implementing this measure.

While implementation of this rule will likely include a mix of planning, site design, and structural approaches, the cost analysis focused on structural controls (installation and maintenance of structural BMPs) because development of nationally-applicable planning and site design measures was infeasible. As detailed in Appendix B–4, EPA developed average annual BMP costs for sites of one, three, five, and seven acres. The analysis accounted for varying levels of imperviousness that characterize residential, commercial, and institutional land uses (i.e., per-site BMP costs are highest for intensely used commercial sites (85% impervious coverage), lowest for residential sites (35% impervious coverage), and moderate for a mixed category including institutional, commercial, and residential uses (65% impervious coverage). Exhibit 4–13 summarizes the weighted average total per-site costs for each of the modeled sites.

Exhibit 4–13. Summary of Per-Site Average Total Costs by Acreage and by Percent Imperviousness

	Average BMP Costs (1998 dollars)		
Area (Acreage)	35% Impervious (Multi-Family Residential)	65% Impervious (Multi-Family/Commercial)	85% Impervious (Commercial)
1 Acre	$2,277	$4,867	$10,192
3 Acres	$5,172	$12,068	$15,260
5 Acres	$8,760	$14,389	$17,497
7 Acres	$15,865	$29,248	$68,996

Average per-site costs were multiplied by the number of construction starts for each category to determine national post-construction runoff control costs. Exhibit 4–14 summarizes the number of construction starts by acreage category that may be affected by the Phase II rule. In developing this estimate, EPA removed construction starts that were located in counties with roughly equivalent programs under CZARA in the following states: Rhode Island, Delaware, Maryland, Pennsylvania, Florida, South Carolina and Alaska. However, this is not a complete list of all the potentially equivalent programs that are in effect in Phase II municipalities and so the estimated number of construction starts should be considered a conservatively high estimate of the number of potentially affected by the post-construction runoff control provision.

Exhibit 4–14. Estimated Number of Construction Starts Potentially Affected by the Phase II Post-Construction Runoff Control Provision

	Construction Starts (1998)[1]			
Area Acreage	Multi-Family Residential (35%)	Multi-Family/ Commercial/ Institutional (65%)	Commercial (85%)	Totals
1 Acre	221	2,942	2,505	5,668
3 Acres	287	2,451	1,939	4,677
5 Acres	228	822	523	1,573
7 Acres	244	818	384	1,445
Totals	981	7,033	5,351	13,364

[1] Totals may not add due to rounding.

Exhibit 4–15 summarizes the estimated costs that construction site operators could incur nationally when complying with requirements established by municipalities for the post-construction runoff control minimum measure. This approach to estimating costs on a per-site basis implicitly assumes that this measure is implemented by installing structural BMPs on a site-by-site basis. As noted above, however, the Phase II Storm Water rule allows flexibility in how MS4s design and implement their post-construction runoff control programs. Consequently,

some programs may adopt alternative approaches that may be more cost effective than site-by-site BMPs.

To derive a national average for BMP costs, the cost estimates were based upon a weighted average of five commonly used structural BMPs. The weighting factors did take into account possible site size limitations for use of certain BMPs for the four site size categories, however, this is not a complete list of potential structural BMPs. Therefore, many developers have considerable flexibility to either implement structural or nonstructural BMPs. This flexibility cannot be readily incorporated into the weighted average. Given a construction operators incentives to minimize overall project costs, it is reasonable to assume that construction operators will use the most cost-effective approach to comply with any post-construction runoff program enacted by a municipality. The most cost-effective BMP is site dependent, and so cost-effectiveness could not be considered in the cost analysis either. Therefore, the weighted national average should be considered the high end of a potential range of costs. The following section explains how EPA accounted for cost savings and uncertainties related to these costs.

Exhibit 4–15. Estimated Post-Construction Runoff Control Costs

Area	35% Impervious (Multi-Family Residential)	65% Impervious (Multi-Family/ Commercial/ Institutional)	85% Impervious (Commercial)	Total Cost (1998 dollars)
1 Acre	$503,163	$14,318,035	$25,530,478	$40,351,676
3 Acres	$1,486,961	$29,571,535	$29,588,931	$60,647,426
5 Acres	$2,001,641	$11,835,630	$9,151,038	$22,988,309
7 Acres	$3,863,272	$23,910,571	$26,494,414	$54,268,258
Total Cost	$7,855,037	$79,635,771	$90,764,861	$178,255,669

Additional Options for Post-Construction Control. The post-construction control provision allows for an array of structural and non-structural options for municipal implementation. These options include:

- improved site/construction design that minimizes impervious areas or redirects runoff to grassy surfaces
- site-based local controls, such as buffer strips and riparian zone preservation
- other municipal regulatory approaches, such as reduced parking requirements for commercial facilities and changes to zoning and comprehensive plans, and
- requiring structural BMPs for new development and redevelopment sites.

Some of these options may result in cost savings to municipalities and land developers. In this section, several site-specific examples of cost savings associated with post-construction storm water management are presented. For example, reductions in levels of imperviousness through reducing roadway travel widths, minimizing setback requirements, using looped roads, and providing compact car spaces are all strategies that may also lower site development costs (Ewing, 1998). With the exceptions noted in Appendix B–4, however, these types of savings are not incorporated into the national cost estimate because they depend on site-specific conditions and municipal ordinances.

Examples compiled by NRDC (1998) of how structural and nonstructural BMPs can reduce costs associated with traditional storm sewers include:

- Design changes for a new vehicle maintenance facility at Fort Bragg reduced parking lot paved surfaces from 19.1 acres to 14.3 acres with grassed islands and detention basins to reduce the size of storm water conveyance pipe. Cost savings included a $800,000 reduction in paving expenditures, $400,000 in storm drain costs, and $400,000 in excavation costs.

- A planned mall expansion in Farmington, Connecticut required an additional 4.7 acres in parking for peak shopping periods. The developer installed reinforced turf instead of asphalt, which allowed water infiltration, thereby avoiding any costs to expand the existing storm drain system and build a $1 million detention pond.

- Vegetated swales, percolation beds and ponds make up the surface drainage system of the Village Homes residential subdivision in Davis, California. The surface drainage system saved $800 per lot in infrastructure costs over a traditional subsurface drainage system. Furthermore, the system was able to handle the retention and infiltration needs of a 50-year storm, including overflow from nearby conventional drainage systems.

- Storm water redesign elements for the Oregon Museum of Science and Industry in Portland, Oregon, redirected storm water into parking lot medians, which were enlarged to create mini-wetlands. These changes generated construction cost savings of $78,000 by reducing the number of manholes and catch basins, and the amount of piping and trenching needed to handle storm water.

Other examples of potential cost savings of structural and nonstructural BMPs include:

- Cluster developments for housing subdivisions can reduce capital costs by 10% to 33% by reducing the length of the required infrastructure; reduce grading costs substantially by avoiding the need to clear and grade 35% to 60% of total site area; and lower the cost of storm water conveyance and treatment by reducing site impervious cover from 10% to 50% depending on size/layout (Schueler, 1997).

- A comparison between conventional development plans and alternatives that decreased impervious surface in three Delaware counties showed development cost savings ranging from 39% to 63%; conservation techniques included reducing street widths, reducing lot size,

cluster developments, woodland preservation, and vegetated BMPs (DE DNRED, 1997 as cited in Center for Watershed Protection, 1998).

- Some types of well-designed structural or nonstructural BMPs can increase nearby property values because of the amenities associated with by a nearby open space, greenbelt, or year-round pond, or they can serve a dual purpose such as providing water for irrigation (Schueler, 1997).

Exhibit 4–16 presents results of a study conducted by the Delaware Department of Natural Resources and Environmental Control and the Brandywine Conservancy that examined comparative site development costs associated with storm water management (Delaware Department of Natural Resources and Environmental Control, 1997). Four case study sites were selected; these sites had actual development proposals with conventional storm water management designs. Conservation design alternatives were developed for these sites, and associated costs were compared to the conventional approaches. These alternatives used such approaches as concentrating development to reduce road lengths and impervious coverage, using natural site hydrology for conveying and treating storm water, careful selection of water infiltration areas based on soils, and revegetating key infiltration areas. Costs for such nonstandard items as revegetation were included in the cost comparison.

The average cost per lot for conventional development approaches was $16,464. The average cost per lot for conservation development approaches was $8,611, or just over half of the conventional development costs for storm water management systems. While these case study sites were larger than sites addressed by Phase II rule, the results nonetheless point to the possibility of significant cost savings resulting from creative planning and site design approaches.

Based on the flexibility offered by these potentially lower-cost BMP and development options, EPA considers the estimated annual cost for the post-construction runoff control provision, shown in Exhibit 4–15, to be the high end of a range of potential costs. This is due to the great deal of uncertainty in the number of potential starts, the flexibility in the types of post-construction runoff control measures adopted by each Phase II municipality, and the wide array of potential control options available to construction operators. As a result, EPA has chosen to present post-construction runoff control costs may range from 25% of the site-by-site costs represented in Exhibit 4–15, resulting in a range of costs from $44.5 to $178.2 million, as shown in Exhibit 4–17 below. Exhibit 4–18 shows the total estimated costs for the Phase II construction program, which consists of erosion and sediment control provision costs and post-construction runoff control provision costs.

Exhibit 4–16. Comparison of Site Development Costs Associated with Storm Water Management: Conventional Development vs. Conservation Development

	Chapel Run Sussex County, DE 96 Acres 142 Lots	New Castle County, DE 19 Acres 55 Lots	Tharpe Knoll Kent County, DE 33 Acres 23 Lots	Pleasant Hill Farm Kent Cty, DE 84 Acres 90 Lots
Project Costs for Storm Water Management				
Conventional Development	$2,460,200	$541,400	$561,650	$1,284,100
Conservation Development, Strategy 1	$888,735	$199,692	$339,715	$728,035
Conservation Development, Strategy 2	$1,174,716	Only one strategy evaluated.	$244,800	Only one strategy evaluated.
Costs Per Lot				
Conventional Development	$17,325	$9,844	$24,420	$14,268
Conservation Development, Strategy 1	$6,259	$3,631	$14,770	$8,089
Conservation Development, Strategy 2	$8,273		$10,643	

Source: Conservation Design for Stormwater Management, Delaware Department of Natural Resources and Environmental Control and the Brandywine Conservancy, September 1997.

Exhibit 4–17. Estimated Range of Post-Construction Runoff Control Costs (1998 Dollars)

	Low Cost Estimate	High Cost Estimate
Annual National Cost	$44,563,917	$178,255,669

Exhibit 4–18. Total Phase II Construction Program Costs (1998 Dollars)

	Cost Estimate
Erosion and Sediment Control Costs	$500,436,622
Post-Construction Runoff Control Costs	$44,563,917 – $178,255,669
Total Construction Costs	$545,000,539 – $678,692,291

4.2.3 Federal Costs

In administering the Phase II storm water program, the EPA will incur costs in its role as the permitting authority for the affected entities within non-NPDES authorized states and territories.[9] EPA must review and manage the application, certification, reporting, and notice requirements for these affected entities. The associated costs are based upon the amount of annual labor the agency will need to devote to these tasks.

There are approximately 10,711 construction starts which will have the EPA as the NPDES permitting authority; and of these starts 85% will need to come into compliance with Phase II while the other 15% will likely qualify for a waiver.[10] Using data from the 1990 Census, it was estimated that there are 357 MS4s, located in non-NPDES authorized states, that will come under the jurisdiction of the Phase II rule. This number includes incorporated places, counties, and minor civil divisions (i.e., unincorporated towns and townships), Federally-recognized Native American Indian Tribal lands, and municipios (Puerto Rico). Exhibit 4–19 reports the estimated costs to EPA as a result of Phase II permitting authority requirements.

Exhibit 4–19. Estimated Federal Annual Costs (1998 dollars)

Phase II Program Activity	Respondents Per Year[1]	Burden Hours per Respondent[2]	Hourly Labor Costs[3]	Estimated Cost[4]
Construction Program				
Waiver Cert. Processing & Review	1,607	1	$28.37	$45,590
NOI Processing & Review	9,104	1	$28.37	$258,280
NOT Processing	9,104	0.5	$28.37	$129,140
Small MS4 Program				
NOI Processing & Review	357	0.8	$28.37	$8,102
Report Processing & Review	357	1.6	$28.37	$16,205
Annual Total				$457,318

[1] The number of respondents per year was based on the 1990 Bureau of Census data for small MS4s and 8.26% of total starts that are in non-NPDES states and territories in exhibit B–2–3 and B–2–4 for construction.
[2]Burden hours per respondent was estimated by EPA.
[3]Hourly labor costs are based upon an average annual Federal employee salary of $39,338, divided by 2,080 labor hours per year and then increased 50% to represent overhead costs (US Office of Personnel Management, 1998).
[4]Estimated cost is the product of the respondents per year, hours per respondent, and hourly labor costs.

[9] These states and territories are expected to be Maine, New Hampshire, Massachusetts, Puerto Rico, District of Columbia, New Mexico, Arizona, Idaho, and Alaska.

[10] Using the information provided in Exhibits B–2–3 and B–2–4 from Appendix B, it was determined that 8.26% of the total starts are in the states and territories that EPA will be the NPDES permitting authority for the Phase II rule. 129,675* 0.0826= 10,711.

4.2.4 State Costs

Those states and territories that possess NPDES permitting authority, will incur costs related to the review and management of the application, certification, reporting, and notice requirements for the Phase II MS4s and construction starts under their jurisdiction. Based on 1990 Bureau of the Census data calculations, there are 4,749 Phase II regulated small MS4s located in NPDES-authorized States and Territories. This number includes incorporated places, counties, and minor civil divisions (i.e., unincorporated towns and townships). For the activity of developing designation criteria and using them to assess small MS4s located outside of an urbanized area, a respondent universe of 44 is used to represent each of the NPDES-authorized States and Territories for which this activity must be done. Exhibit 4–20 provides an estimate of the cost burden to the states and territories for administering the Phase II rule.

Exhibit 4–20. Estimated State Annual Costs (1998 dollars)

Phase II Program Element	Respondents Per Year[1,2]	Burden Hours per Respondent[3]	Hourly Labor Costs[4]	Estimated Cost
Construction Program				
Waiver Cert. Processing & Review	17,845	1	$26.87	$479,495
NOI Processing & Review	101,119	1	$26.87	$2,717,068
NOT Processing	101,119	0.5	$26.87	$1,358,534
Small MS4 Program				
NOI Processing & Review	4749	0.8	$26.87	$102,085
Report Processing & Review	4749	1.6	$26.87	$204,169
Annual Total				$4,861,350

[1] The number of respondents per year was based on the 1990 Bureau of Census data for small MS4s and 91.7% of total starts that are in NPDES states and territories in exhibit B–2–3 and B–2–4 for construction

[2]The number of respondents in each category represents the estimated respondents located within the 44 NPDES-Authorized States and Territories.

[3]Burden hours per respondent was estimated by EPA.

[4]The hourly labor rate for NPDES Authorized States and Territories was based on the average hourly rate for state and municipal employees as determined by the U.S. Department of Labor, Bureau of Labor Statistics (US DL, 1997).

4.3 Summary of Results

A summary of the potential costs from implementing the Phase II municipal measures and construction site erosion and sediment controls is presented in Exhibit 4–21. Once the Phase II storm water rule is fully implemented, the total annual cost for implementing the rule is expected to range from $847.6 to $981.3 million (assuming 129,675 construction starts, 13,364 construction starts relevant to the post-construction analysis, and 32.5 million households in 5,040 municipalities). The largest portion of the total cost is associated with erosion and sediment controls at construction sites.

Exhibit 4–21. Potential Annual Costs for Phase II Storm Water Regulation

Phase II Element	Universe	Estimated Total National Annual Costs (1998 dollars)
Municipal	32,458,000 Households	$297,318,623
Construction	129,675 Erosion & Sediment Control Starts and 13,364 Post-Construction Starts	$545,000,539 – $678,692,291
Federal and State	53 States and Territories	$5,318,668
Total		$847,637,830 – $981,329,582

4.4 Potential Pollutant Loading Reductions Resulting from the Phase II Rule

From the new data collected and the revised and new analyses conducted for the final Phase II rule, EPA developed two estimates of potential pollutant loading reductions from municipalities and construction starts.

4.4.1 Pollutant Loading Reductions from Municipalities

It is widely accepted that there are many different types of pollutants in storm water runoff depending on land use activities. The Nationwide Urban Runoff Program (NURP), a study conducted by EPA from 1978–1983, monitored the levels of pollutants in storm water runoff from 28 municipalities (US EPA, 1983). NURP found the following pollutants in the municipal storm water runoff: oil and grease, TSS, nitrogen, phosphorus, pathogens, lead, copper, zinc, other metals, biological oxygen demand (BOD), and chemical oxygen demand. However, there are no national studies to date that estimate pollutant loading reductions due to the implementation of municipal storm water controls.

To estimate municipal pollutant loading reductions for the final Phase II rulemaking, EPA used the results from a 1997 EPA draft report that calculated national municipal loading reductions for TSS based on results of the NURP study (Hagler Bailly Services, 1997). Each aspect of the municipal pollutant loading reduction methodology used in analysis of the final Phase II rule is explained in more detail below. While estimating the pollutant loading reduction for TSS does not capture the full extent of potential loading reductions that result from implementing municipal storm water controls, this provides a minimum estimate of the reductions that may result from the Phase II rule.

EPA conducted a draft study in 1997 to determine the benefits of all NPDES wet weather programs including storm water, combined sewer overflows, and sanitary sewer overflows (Hagler Bailly Services, 1997). The study uses NURP monitoring data as a baseline, and estimates loading reductions for TSS based on the assumed implementation of specific controls. Only TSS was analyzed because data was readily available for that pollutant. In the 1997 draft study, runoff volume was estimated from the land area for 405 urbanized areas defined by the 1990 Census and identified in EPA's 1995 Report to Congress entitled "Storm Water Discharges Addressed by Phase II of the National Pollutant Discharge Elimination System" (US EPA, 1995a). Municipalities located in the 405 urbanized areas (less 21 combined sewer overflow

(CSO) exempt cities) are included in Phase I and Phase II of the storm water program. Runoff was estimated using population density and rainfall data.

The baseline TSS concentrations in storm water runoff in the 1997 EPA draft study were obtained from Table 6–4 of the EPA manual entitled, "Urban Runoff Pollution Prevention and Control Planning" (US EPA, 1993b). Baseline concentrations were found to range from 141 mg/L to 224 mg/L for TSS. The storm water data in the manual were taken from the NURP study (US EPA, 1983). The NURP data have been widely accepted and referenced as reasonable estimates of pollutant concentrations in urban storm water runoff.

Based on a review of literature on BMP effectiveness, EPA determined that BMPs are 20% to 80% effective. Therefore, EPA assumed that BMPs would reduce pollutants in storm water by between 20% to 80%. Exhibit 4–22 shows the resulting estimates of TSS reductions attributable to the implementation of BMPs required under the NPDES storm water program.

Exhibit 4–22. Estimated Ranges of Daily TSS Reductions from EPA's Phase I and Phase II Storm Water Programs

BMP Efficiency (%)	Volume (mgd)	Baseline Conc. (mg/L)		Baseline Loads (tons/day)		Reductions (tons/day)	
		Low	High	Low	High	Low	High
20	27,584	141	224	16,219	25,766	3,244	5,153
80	27,584	141	224	16,219	25,766	12,975	20,613

Source: US EPA, 1997a.

It should be noted that removal efficiencies depend on how much of the estimated runoff actually is affected by structural and nonstructural BMPs. At this time, no supporting data has been collected and analyzed to indicate how much of the total runoff in urban areas will be affected by storm water BMPs. Therefore, this analysis assumes that all runoff is controlled by BMPs which may not accurately reflect the actual reduction attributable to the storm water programs.

For analysis of the final Phase II rule, EPA developed a TSS reduction for Phase II by comparing total municipal populations between Phase I and Phase II and distributing the loading reductions proportionally. The total population for the 405 urbanized areas evaluated in the 1997 study was estimated at 160 million (US EPA, 1995a). Of the 160 million, the total Phase I MS4 population is 75 million while the total Phase II municipal population is 85 million (US EPA, 1995a). This results in 54% of the loading reduction attributable to implementation of the Phase II program.[11] Exhibit 4–23 shows the proportion of TSS loading reductions EPA attributed to Phase II municipalities on a daily and annual basis for both 20% and 80% BMP effectiveness. EPA anticipates that municipalities will strive to achieve 80% effectiveness when implementing their storm water programs.

[11]EPA considered comparing Phase I and Phase II storm water loadings by miles of infrastructure but was unable to determine the miles of storm water sewers in the municipal universe.

Exhibit 4–23. Estimated TSS Loading Reductions for Phase II Municipalities

BMP Efficiency (%)	Tons/Day		Tons/Year	
	Low	High	Low	High
20	1,751	2,783	639,115	1,015,795
80	7,006	11,131	2,557,190	4,062,815

Source: US EPA, 1997a.

4.4.2 Pollutant Loading Reductions from Phase II Construction Starts

To estimate pollutant loading reductions from Phase II construction starts, the US ACE developed a model based on EPA's 27 model sites to estimate sediment loads from construction starts with and without Phase II controls (US ACE, 1998). The US ACE model uses the construction site version of the Revised Universal Soil Loss Equation (RUSLE) to generate sediment delivery estimates for 15 climatic regions with each of the following variations: three site sizes (one, three, and five acres), three soil erodibility levels (low, medium, and high), three slopes (3%, 7%, and 12%), and the BMP combinations from EPA's 27 model sites. The 15 climatic regions were used in an effort to represent the various climatic conditions throughout the United States. Sediment delivery represents the quantity of sediment that bypasses the BMPs placed at the base of the hill slope.

Pollutant loading reductions for the Phase II construction universe were determined using an average for one, three, and five acre sites with medium erodibility and slopes ranging from 3% to 12%. This approach is consistent with that used in the construction cost analysis.

To determine the weighted average sediment load per Phase II construction site, the sediment loads developed by the US ACE for one, three, and five acre sites of medium soil erodibility were multiplied by the number of construction starts disturbing between one and two, two and four, and four and five acres of land in each climatic zone. The total loadings were summed and then multiplied by the ratio of construction starts in each size category by the total number of each construction sites for each climatic zone. This provided an average sediment load per climatic region for Phase II construction sites with moderately erodible soil. Then, the average loads per climatic region were multiplied by the ratio of total Phase II construction starts in each climatic zone to the total Phase II construction starts nationwide to obtain a national weighted average sediment load per site. This methodology was used to calculate sediment loads from construction starts with and without Phase II controls. The US ACE model was also used to derive an estimate of potential sediment load reductions attributable to soil erosion controls. These values, as presented in Exhibit 4–24, indicate that the weighted average soil loss per start was 96.1 tons and the potential reductions in soil loss could be 89.6 tons. The sediment loss calculation used in the analysis is based on a version that was developed to model construction sites. Actual soil loss may vary from site to site due to the pattern and extent of soil disturbance as well as the placement of building materials and the buildings on the site.

Exhibit 4–24. Weighted Average Sediment Loadings and Loading Reductions (tons) from Phase II Construction Sites of Medium Soil Erodibility

Climatic Region	Representative Community	Average Loading—No Controls (tons)	Average Loading—With Controls (tons)	Average Loading Reduction (tons)
A	Portland, OR	52.3	1.8	50.5
B	Boise, ID	9.1	0.7	8.4
C	Fresno, CA	9.2	0.3	8.9
D	Las Vegas, NV	6.0	0.1	5.9
E	Denver, CO	30.9	1.9	29.0
G	Bismarck, ND	37.0	2.2	34.8
G	Helena, MT	10.4	0.7	9.8
H	Amarillo, TX	78.3	5.8	72.5
I	San Antonio, TX	202.5	16.3	186.2
K	Duluth, MN	61.6	4.0	57.6
M	Des Moines, IA	124.3	9.8	114.5
N	Nashville, TN	176.5	12.4	164.0
P	Atlanta, GA	213.0	15.5	197.5
R	Hartford, CT	100.7	4.4	96.2
T	Charleston, SC	294.7	16.9	277.9
Weighted Average[1]		96.1	6.5	89.6

Source: Derived from US ACE (1998).

[1]EPA estimated the weighted average loads based on the slope, erosivitity of the soil, and the number of construction starts in each size category.

To determine the reduction in soil loss using the estimated 80% effectiveness rate, EPA multiplied the weighted average soil loss per start (89.6 tons) by 80%. This resulted in an estimated reduction in soil loss of 71.7 tons per-site. Multiplying this reduction by the 110,223 construction starts expected to implement erosion and sediment controls for the year 1998, results in an estimated 7.9 million ton reduction in soil loss annually.

4.4.3 Summary

A summary of the total annual national loading reduction estimates attributable to the Phase II rule, for both municipalities and construction starts, is presented in Exhibit 4–25.

Exhibit 4–25. National Reduction Estimates for Municipalities and Construction Starts (tons/year)

Phase II Element	20% Reduction	80% Reduction
Municipal TSS Loading	639,115	4,062,815
Soil loss from Construction Sites	1,975,196	7,900,785

4.5 Cost Effectiveness

For purposes of this regulatory analysis, cost effectiveness is defined as the incremental annualized cost of a pollution control option per incremental pound of pollutant removed annually by the control option. Cost-effectiveness analysis can thus be used to compare pollutant removal costs across regulatory alternatives. This type of analysis is limited for the Phase II rule because EPA was only able to quantify potential reductions in TSS loadings. EPA also anticipates that the rule will result in reductions in oil and grease, nitrogen, phosphorus, pathogens, lead, copper, zinc, and other metals.

EPA compared the potential costs per pound of TSS removed from Phase II municipalities to the costs estimated for publicly owned treatment works (POTW) to remove this same pollutant. This approach is parallel to the cost reasonableness test established by EPA in developing technology-based effluent limits for conventional pollutants (see 51 FR 24982). Under this approach, EPA compares industry costs with that of an "average" POTW with a flow of 2.26 million gallons per day (mgd) and costs of $0.70 (1998 dollars) per pound of pollutant removal (BOD and TSS).

Based on this cost effectiveness analysis, the rule may result in Phase II municipalities experiencing costs of between $0.04 (80% BMP efficiency; high end reduction) and $0.18 (20% BMP efficiency; low end reduction) per pound of TSS removed.[12] While EPA anticipates 80% effectiveness at reducing pollutant loading following program implementation, both low and high end reduction costs are low compared to the $0.70 (1998 dollars) established for POTWs to remove BOD and TSS.[13] Thus, the requirements of the final Phase II rule appear to be cost effective. This is particularly true since EPA's analysis of cost-effectiveness is based solely on removal of one of many pollutants believed present in storm water discharges.

4.6 Sensitivity Analyses

Due to the diversity of municipalities and various conditions of construction sites nationwide, the analysis of costs will likely reflect some uncertainty. A sensitivity analysis identifies the assumptions that may bias the final cost estimates. The purpose of this sensitivity analysis is to examine the importance and magnitude of the key assumptions used in the analysis. In its analysis, EPA may have overestimated municipal costs because municipalities that are currently implementing some components of the Phase II municipal program were not considered. EPA is uncertain of the activities municipalities will take to achieve compliance with the regulation, therefore estimating compliance costs is difficult. For example, EPA is uncertain about the number of municipalities that will be designated, by the permitting authority, to apply for a Phase II municipal permit. The potential also exists for construction activities to occur on areas with slopes greater than 12%; however, the number of starts, and for that matter the number of starts at any given slope is unknown. To determine the sensitivity of costs to the assumptions used in the analysis, EPA performed six sensitivity analyses as presented below. To be conservative,

[12]Cost effectiveness is based on the total cost of the rule because the municipal component includes construction activity within the watershed.

[13]The technologies used for secondary treatment at POTWs removes both BOD and TSS at the same time. Therefore, estimating the tons of TSS removed from secondary treatment is not possible.

EPA used the higher potential cost estimates for post-construction controls in the sensitivity analyses (see Exhibit 4–15).

Scenario One. As discussed in Section 4.2.1, the annual per household costs for the Phase II program elements ranged from $0.42 to $54.91. Estimated costs of the municipal program, presented in Section 4.2, are based on the mean of $9.16 per household. For this sensitivity analysis, EPA estimated national annual Phase II municipal costs using the median of $4.19 per household. The results are presented in Exhibit 4–26a.

Exhibit 4–26a. Results of Sensitivity Analysis for Scenario One

Assumption	Estimated Total National Annual Costs (1998 dollars)
Original Estimates as Presented in Section 4.3	$981,329,582
Scenario One — Estimate of Municipal Program Cost adjusted to Reflect Median[1]	$820,011,508
Percentage Change from the Original Estimate	–16.44%

[1]Based on per household costs of $4.19.

Scenario Two. As discussed in Section 4.2.1, the annual per household costs for the Phase II program elements ranged from $0.42 to $54.91. Estimated costs of the municipal program, presented in Section 4.2, are based on the mean of $9.16 per household. For this sensitivity analysis, EPA estimated national annual Phase II municipal costs using the 75th percentile of $10.40 per household. The results are presented in Exhibit 4–26b.

Exhibit 4–26b. Results of Sensitivity Analysis for Scenario Two

Assumption	Estimated Total National Annual Costs (1998 dollars)
Original Estimates as Presented in Section 4.3	$981,329,582
Scenario Two—Estimate of Municipal Program Cost adjusted to Reflect 75th Percentile[1]	$1,021,577,955
Percentage Change from the Original Estimate	4.10%

[1]Based on per household costs of $10.40 and 129,675 construction starts.

Scenario Three. To estimate municipal costs in Section 4.2.1, EPA used estimates of the number of households located in automatically designated Phase II communities. To develop this scenario, EPA estimated annual Phase II municipal costs by increasing the number of households to include 10% of the 4,539,440 potentially designated municipal households (see Exhibit 3–2). The results are presented in Exhibit 4–26c.

Exhibit 4–26c. Results of Sensitivity Analysis for Scenario Three

Assumption	Estimated Total National Annual Costs (1998 dollars)
Original Estimates as Presented in Section 4.3	$981,329,582
Scenario Three—Estimate of Municipal Program Cost Adjusted to Include 10% of the Households Located in Potentially Designated Communities[1]	$985,487,709
Percentage Change from the Original Estimate	0.42%

[1]Based on per household costs of $9.16, 129,675 construction starts, and an increase of 453,944 households.

Scenario Four. As presented in Section 4.2.2, to estimate Phase II construction site costs, EPA developed 27 model construction sites in an effort to reflect site conditions and erosion and sediment control practices throughout the country. The model sites varied in size (one, three, and five acres), soil erosivity (low, medium, and high), and slope (3%, 7%, and 12%). Many municipalities do not allow construction on very steep slopes, therefore slopes greater than 12% were not considered for the main analysis. However, for this sensitivity analysis, EPA included a slope value of 18%. The methodology used to develop the cost for this analysis is consistent with that used in Section 4.2.2. The results are presented in Exhibit 4–26d.

Exhibit 4–26d. Results of Sensitivity Analysis for Scenario Four

Assumption	Estimated Total National Annual Costs (1998 dollars)
Original Estimates as Presented in Section 4.3	$981,329,582
Scenario Four—Estimate of Construction Program Cost Adjusted to Include 18% Slope Variable[1]	$1,077,118,232
Percentage Change from the Original Estimate	9.76%

[1]Based on per household costs of $9.16 and 129,675 construction starts.

Scenario Five. To estimate municipal costs in Section 4.2.1, EPA used estimates of the number of households located in automatically designated Phase II communities. However, if all the municipalities that could potentially receive a waiver from the permitting, did receive a waiver, the number of households would be reduced. For this scenario, EPA estimated annual Phase II municipal costs by first subtracting those municipalities that serve less than 1,000 people from the list of Phase II municipalities. This subtraction represents the maximum number of municipalities (1,001) that could potentially qualify under the waiver provision. As a result, the total number of Phase II households are reduced by 107,539. The adjusted number of households was then multiplied by the average per house hold cost to determine total municipal costs. The results are presented in Exhibit 4–26e.

Exhibit 4–26e. Results of Sensitivity Analysis for Scenario Five

Assumptions	Estimated Total Annual National Costs (1998 dollars)
Original Estimate as Presented in Section 4.3	$981,329,582
Scenario Five—Estimate of Municipal Program Cost Adjusted to Reflect the waiver provision for municipalities serving less than 1,000	$980,343,435
Percentage Change from the Original Estimate	–0.10%

1. Based on a Phase II municipal population of 84,908,666 people (32,350,707 households) and 129,675 construction starts.

Scenario Six. To estimate state and federal administrative costs in Sections 4.2.3 and 4.2.4, EPA only considered those costs that are likely to be incurred on an annual basis. There, are start-up costs associated with the administration of Phase II by the permitting authorities. However, it is uncertain how often these costs will be incurred. As described in Appendix B–5, some of the start-up activities may occur only once while others may be done each permit cycle. For example, the incorporation of 401 certification language into the general permit language is likely to only need to be done once, while the designation of additional MS4s may occur occasionally at the beginning of each new permit cycle. Due to this uncertainty, and the relatively small magnitude of these costs when annualized (see Appendix B–5), EPA decided against including these costs within the cost analysis. However, to assess the potential impact of these costs a sensitivity analysis was conducted. Scenario six assumes that all start-up costs are incurred once every permit cycle of five years. The results are presented in Exhibit 4–26f.

Exhibit 4–26f. Results of Sensitivity Analysis for Scenario Six

Assumptions	Estimated Total Annual National Costs (1998 dollars)
Original Estimate as Presented in Section 4.3	$981,329,582
Scenario Five – Estimate of Federal and State administrative costs adjusted to include annualized start-up costs.[1]	$981,381,188
Percentage Change from the Original Estimate	0.005%

[1]A description of start-up costs can be found in Appendix B–5.

As demonstrated in Scenario One, selection of mean versus median makes a significant difference (16%) in national costs results. Scenario Two shows that use of the 75th percentile per household cost in estimating national municipal costs closely approximates the national municipal costs for the mean value, differing by just 4%. In Scenario Three, the change in assumptions regarding the municipal universe did not make a significant difference in cost outcome. The sensitivity analysis for construction costs (Scenario Four) shows that national costs may increase by $96 million annually when assumptions regarding construction activities on slopes are reconsidered. The sensitivity analysis for the municipal waiver provision showed that the waiver provision is unlikely to have a significant effect on the total costs. Finally, the sensitivity analysis for federal and state administrative start-up costs demonstrates that these costs will have no significant effect on total costs.

4.7 Conclusion

EPA estimates the total annual costs of the rule to be between $847 and $981 million. This estimate includes approximately $297 million attributable to the municipal component, approximately $545 to $678 attributable to construction controls, and $0.46 million and $4.9 million for federal and state administrative costs, respectively. The cost-effectiveness analysis shows the Phase II rule to be cost effective. For municipalities, costs are expected to range from $0.04 to $0.18 per pound of TSS removed compared to $0.70 per pound of TSS removed for POTWs. In addition, only TSS was considered in the municipal pollutant loading reduction analysis and it is well known that many other pollutants are found in storm water discharges, e.g., nitrogen, phosphorus, lead, copper, and zinc. The municipal minimum measures required by the final Phase II rule are expected to assist in removing these other pollutants as well. Other increases in cost effectiveness may result if certain assumptions used in this analysis were adjusted with respect to the results of the sensitivity analysis (mean municipal costs versus mean values, etc.).

5.0 QUALITATIVE ASSESSMENT OF BENEFITS

The Phase II rule requires regulated municipalities to develop a storm water management program comprising six minimum measures that are expected to reduce the impact of storm water runoff on the nation's waters. The rule also requires owners of construction sites that disturb between one and five acres to implement erosion and sediment controls. This chapter qualitatively assesses the potential benefits of both the municipal measures and construction controls. Chapter 6 presents an analysis of those benefits quantified for this Economic Analysis.

A number of potential problems are associated with assessing the benefits resulting from the municipal program, including identifying the regulated municipalities as sources of current impairment to waters and determining the likely effectiveness of the various measures. Water quality modeling may assist in the identification and determination of the relative sources of impairment; however, past experience may be the only source of information on program effectiveness. The assessment presented here relies on existing literature for the evaluation of both the municipal program and construction runoff program effectiveness, as well as for the anticipated environmental impacts. The construction site controls discussion is further supplemented by EPA's model of the potential effectiveness of these controls and anticipated sediment loads during wet weather events.

5.1 Municipal Minimum Measures

Under the Phase II rule, municipalities with storm sewer systems serving populations of less than 100,000 located in Census-designed "urbanized areas" will be required to control storm water runoff through the implementation of six municipal minimum measures. EPA expects that these measures will reduce storm water flows and loadings of pollutants including BOD, oil and grease, metals (lead, copper, nickel, cadmium, zinc), phosphorus, nitrogen, some pathogens from illicit discharges, street debris, and construction sites. These reductions will lead, in turn, to improved water quality and habitat in receiving waters, resulting in a range of benefits.

5.1.1 Description of Measures

The six municipal minimum measures are described below. The anticipated benefits of these measures are discussed in Section 5.1.2.

Public Education and Outreach

The public education measure requires municipalities to inform citizens, organizations, and businesses about local water quality problems, how storm water runoff affects local water bodies, and how detrimental effects can be prevented. The benefits of a public education program could be measured by the number of households, organizations, or businesses that alter their behavior in an attempt to reduce the impacts of storm water runoff. EPA expects that public education will result in reduced pollutant loadings due to an increased awareness of the causes of water quality impairment. For example, a BMP education program in the Lake Tahoe watershed used a newsletter to educate residents about the cause and effect relationship between land use practices and water quality, and provided "how to" information on specific BMPs

(Christopherson, 1995). The results of this program, documented through a telephone survey of newsletter readers and nonreaders, showed that readers were better able to correctly identify the causes of declining water quality (37% versus 26%) and increased algae growth (65% versus 45%), and were more familiar with the term "BMPs" (38% versus 14%). Readers also accounted for 80% of the reported implementation of BMPs.

In another example, Montana State University conducted a voluntary private well water testing program involving instructional videos, written instructions, and well water sample collection and submission (Bauder, 1993). The impact of the program was assessed through a questionnaire that was mailed out 1 year after results of the water testing program were distributed to program participants. Forty-four percent of program participants returned the questionnaires with 65% indicating that they understood the test results that they had received the previous year; only 3.5% did not understand the test results. Seventy percent of respondents reported an improved ability to make decisions about water quality, and 84% rated the program as moderate to very effective at increasing public awareness of water quality issues. The average value placed on the program information and testing opportunity was $108 per person, nearly nine times more than the cost of participation. By the end of the program, 12% had purchased point-of-use treatment equipment and 8% had made changes in land use practices. Twenty-five percent thought they should initiate a regular sampling and testing program compared to 15% of respondents that, prior to the program, had indicated occasional testing (once every five years or less) of their water supply.

The Tillamook Bay Rural Clean Water Project in Oregon also conducted a public education program to educate the local agricultural community about water quality issues (Ryan, 1989). The program involved one-on-one contact between Soil Conservation Service employees and farmers, visits and tours of successful BMPs, newsletters, brochures, and presentations. Public participation in local water quality problem solving was encouraged through workshops and the activity of the Citizen Advisory Committee. The program earned the participation of 98% of the farmers in the critical areas; 73% of whom implemented BMPs. Four years after the program began, there was a 40% to 60% improvement in bacteria conditions in the Bay and a 50% to 80% improvement in the rivers (Ryan, 1989).

Public Involvement and Participation

The public involvement and participation measure requires municipalities to involve members of a community in the development, implementation, and review of a municipality's storm water management program; for example, acting as citizen representatives on a local storm water management panel, attending public hearings, working as citizen volunteers to educate other individuals about the program, or participating in volunteer monitoring efforts. EPA expects public participation to increase the awareness of water quality problems, increase the acceptance of storm water control programs by the local community through participation in the decision-making process, and improve water quality as a result of greater public involvement in storm water management. The benefits of public participation programs are difficult to measure because it is hard to value an increase in participation or an improvement of program design.

Illicit Discharge Detection and Elimination

The illicit discharge detection and elimination measure requires the owner or operator of a regulated small municipal separate storm sewer system to demonstrate awareness of the system; to develop a storm sewer map showing the location of major pipes, outfalls, and topography; to effectively prohibit illicit discharges into the separate storm sewer system; to implement appropriate enforcement procedures; to develop and implement a plan to detect and address illicit discharges, including illegal dumping into the system; and to inform public employees, businesses, and the general public of hazards associated with illegal discharges and improper disposal of waste, through programs such as storm drain stenciling. EPA expects that the identification of illicit discharges and their subsequent elimination will reduce the flows and pollutant loadings entering small streams and storm sewer systems.

For example, during a 12-month period, the Houston, Texas, Public Utilities Department identified 132 sources of discharges leading to Buffalo Bayou, the local drinking water source, with estimated flow rates ranging from 0.3 to 31.5 liters per second. Houston's program involved monthly sampling from bridge crossings; analysis of samples for carbonaceous biochemical oxygen demand, ammonia and nitrate nitrogen, pH, TSS, DO, temperature, fecal coliform, and chlorine residual; comparison of samples to baseline flow concentrations; weekly sampling of temperature, dissolved oxygen (DO), and fecal coliform in stream reaches suspected of contamination; boat sampling to identify the contaminating outfall along the reach; and, finally, a land-based search to pinpoint the source. Of the flows identified during the program, 85% were due to broken or clogged wastewater lines and 10% were due to illicit connections (Glanton et al., 1992). Eight months after an illicit discharge detection and elimination program began, fecal bacteria log mean concentration was reduced from 20,000 colonies/100 mL to 2,000 colonies/100 mL. In this example, the impacts of illicit discharge programs can be measured by reduced flows and pollutant loadings resulting from the elimination of discharges.

Construction Site Storm Water Runoff Control

Municipal separate storm sewer system operators are required to develop, implement, and enforce programs that will result in the reduction of pollutants, particularly sediment and site-generated wastes, in storm water runoff from construction activities. Program requirements include preconstruction review of site management plans, regular inspections during construction, and provisions for receipt and consideration of information provided by the public. Construction site operators will implement on-site controls that include BMPs, such as silt fences or detention basins. EPA expects that implementing such programs will result in reduced pollutant loadings and flows entering small streams, with benefits including improved water and habitat quality. These impacts, which EPA has modeled (see Section 5.2.1), can be measured through performance measures for construction site controls (i.e., BMP effectiveness).

Post-Construction Storm Water Management in New Development and Redevelopment

The new development and redevelopment measure requires that land developers attempt to maintain predevelopment runoff conditions through controls that prevent or minimize water quality impacts from runoff and through adequate long term operation and maintenance of

BMPs. Examples of these controls include minimization of site disturbance and vegetative cover preservation, minimization of impervious areas, maintenance or restoration of natural infiltration, wetland protection, and use of vegetated drainageways or riparian buffers. EPA expects that such foresight during development will result in the prevention of sediment and flow runoff. The impacts can be measured through the loadings reductions based on performance estimates for the implemented controls.

Pollution Prevention/Good Housekeeping for Municipal Operations

The good housekeeping measure requires that storm sewer systems and storm water pollution control structures are properly operated and maintained with the goal of preventing or reducing pollutant runoff from municipal operations. Examples include long term inspection procedures for structural storm water controls to reduce the discharge of floatables and other pollutants from the separate storm sewers and controls in an attempt to reduce or eliminate the discharges of pollutants from streets and other municipally controlled paved areas. An example of a pollution prevention procedure is training municipal employees regarding the reduced application of pesticides on municipally-owned golf courses or parks. EPA expects that activities such as street or storm drain cleaning will reduce the pollutant loads carried in storm water flows, with benefits measured as the loadings reductions.

These cleaning techniques, however, vary in effectiveness depending on the size of particles removed. The inability to remove small particles means that techniques are less effective at reducing the loading of pollutants that tend to adhere to very small particles. For example, the city of Bellevue, Washington, found that street cleaning three times per week removed about only 10% of urban runoff pollutants; catch basin cleaning twice a year was estimated to be about 25% effective (Pitt and Bissonnette, 1984). Thus, the benefits of good housekeeping measures may be predominantly those associated with reduced floatables, such as enhanced recreation resulting from improved aesthetics (e.g., swimming, beach use, and hiking along the water).

5.1.2 Anticipated Benefits from the Municipal Minimum Measures

The Phase II rule is intended to reduce the harmful pollutant loadings and flows carried in storm water runoff. These reductions will affect the quantity and quality of storm water runoff, improve water quality, and result in a variety of benefits to users of affected waters. The types of benefits associated with the individual measures depend on the specific pollutants that are reduced.

Enhanced Commercial Fisheries

Pollutants in storm water (e.g., bacteria, solids, toxics) can adversely affect fisheries by reducing the possibilities of reproduction and survival, leading to lower yields, contamination and closure, or the elimination of a species. Approximately 27% of the square miles of estuaries surveyed for shellfishing use violated shellfishing harvesting criteria (US EPA, 1998a). Of the estuaries surveyed, 18% identified storm water as a source of impairment (US EPA, 1998a). The reduction of pollutants and the resulting improvement in water quality from public education,

public participation, and illicit discharge detection and elimination may contribute to the recovery of these fisheries. Good housekeeping and street sweeping may also contribute to these benefits, although to a lesser extent due to the lower effectiveness of reducing pollutants that adhere to small particles, such as metals.

Enhanced Opportunities for Recreational Fishing

Pollutants in storm water runoff may result in decreased numbers or size of sport fish or shellfish species, or eliminate specific species from receiving waters. Fish or shellfish caught in impaired waters also may be unsafe to eat. As of September, 1996, there were 2196 fish consumption advisories in 47 states, the District of Columbia, and American Samoa—65% of these advisories restrict the consumption of fish caught in lakes (US EPA, 1998). Approximately 24% of estuaries, 17% of rivers and streams, 35% of lakes, ponds, and reservoirs, and 98% of Great Lakes shoreline are not/partially supporting or in nonattainment for fish consumption use (US EPA, 1998a). The public education, public participation, and illicit discharge detection and elimination measures are expected to result in reduced pollutant loadings and improved water quality that may increase the number, size, and quality of fish in receiving waters, thereby opening up new areas to fishing, enhancing the experience for existing users, and possibly increasing activity associated with recreational fishing (e.g., nonconsumptive wildlife users often accompany individuals engaged in recreational fishing). Good housekeeping and street sweeping, by improving aesthetics associated with recreational fishing sites, may also contribute to enhanced opportunities for recreational fishing and related activities.

Enhanced Opportunities for Subsistence Fishing

Pollutants in storm water runoff may decrease the numbers or size of edible fish species or eliminate specific species from receiving waters. Fish caught in impaired waters also may be unsafe to eat, or may have low recommended limits for consumption. Through water quality improvements, the number, size, and quality of fish may improve, thereby opening up new areas to fishing, enhancing the experience for existing users, and increasing the safe consumption limits.

Enhanced Opportunities for Hunting

Pollutants in storm water runoff may decrease the habitat quality for waterfowl species, resulting in reduced numbers, reduced breeding, or the elimination of specific species from receiving waters. Additionally, birds feeding from impaired water bodies also may be unsafe to eat. Through water quality improvements, the number and quality of waterfowl may improve, thereby opening up new areas to hunting and enhancing the experience for existing users.

Enhanced Opportunities for Boating

Although boating does not necessitate human contact with water, boaters are sensitive to water quality. High turbidity, eutrophication, odors, floating trash, and other visible contamination can discourage boaters from using a waterway. However, storm water controls may offer benefits to

boaters by reducing contamination entering impaired waters and increasing water clarity, thereby opening up new areas to boating and enhancing the experience for existing users.

Enhanced Opportunities for Swimming

Because swimming necessitates direct contact with water, swimmers may have concerns about water contamination and its relation to aesthetic preferences and potential health risks. Turbidity, algae blooms, odors, floating trash, and other visible contamination, as well as posted health hazard warnings, can discourage swimmers from using a water body. In 1993, 180 million Americans visited ocean and bay beaches (Weber, 1995). The Natural Resources Defense Council (NRDC, 1997) reported 2,596 beach closures (1,054 of which were in California) or advisory days due to sources such as overflowing sewers and storm drains (each day that a beach was closed was counted as a separate day). In addition, it should be noted that many coastal states do not monitor beaches or monitor only portions of their coastline (NRDC, 1997), so many more beach closings and advisory days may have been necessary. Additionally, local health departments restricted recreation at 342 individual sites at least once during 1995 and 1996. Storm water controls may offer benefits to swimmers by making waters suitable for swimming where currently it is not desirable or safe.

Enhanced Opportunities for Noncontact Recreation

Activities such as picnicking, jogging, biking, photography, and camping do not necessitate direct contact with water; however, water quality affects the ability to enjoy these activities when in close proximity to water. High turbidity, eutrophication, odors, floating trash, and other visible contamination can discourage recreational activity near a water body. However, storm water controls may offer benefits by reducing contamination and allowing impaired waters to be used as focal points for recreational activities where they are not currently in demand for such use. These improvements also may enhance the experiences for current users.

Enhanced Nonconsumptive Wildlife Uses

Wildlife viewing activities can be affected by impaired water quality through the reduced quantity and variety of species living in or near water bodies. An estimated 76.1 million people participated in nonconsumptive wildlife use in 1991, with 54.7 million observing wildlife and 19.1 million observing waterfowl and shorebirds (US EPA, 1994). Storm water controls that result in greater numbers or diversity of viewable wildlife species will produce benefits measurable by increased trips and greater amounts of wildlife seen per trip.

Reduced Flood Damage

Storm water runoff controls may mitigate flood damages by providing additional storage capacity, diversion of runoff, and reduced sedimentation from flood waters. The benefits from reduced flows and sedimentation can be measured by the reduced damage from flood flows and the reduced amounts of sediment deposited by flood waters requiring cleanup.

Drinking Water Benefits

Storm water was identified as a major source of impairment in 3% of surveyed rivers and streams and 6% of surveyed lakes, reservoirs, and ponds (US EPA, 1998a). Numerous municipal, industrial, and agricultural users treat the surface waters of streams, rivers, and lakes prior to their use for drinking water, manufacturing, or power generation. Pollutants from storm water runoff, such as solids, toxics (including pesticides), and bacteria, may impose additional costs for treatment or even render the water unusable, thereby forcing the use of an alternative source. Standards for drinking water, manufacturing, and power generation vary considerably, but reducing runoff may result in avoided treatment and savings for municipalities, commercial facilities, and farmers.

Polluted water also can cause damage to household pipes and appliances. Lowering contaminant levels can reduce this damage. Benefits for drinking water can be measured by the avoided additional treatment to compensate for contributions of storm water runoff to water sources, but also may be considered benefits under the federal drinking water program.

Water Storage Benefits

Storm water was identified as a major source of impairment in 6% of impaired lakes, ponds, and reservoirs surveyed (US EPA, 1998a). The heavy load of solids deposited by storm water runoff can lead to rapid sedimentation of reservoirs and other receiving water bodies, meaning a loss of needed water storage capacity, which must either be replaced (if possible) or the existing reservoirs must be dredged. The benefits of storm water controls, in particular the construction site runoff measure, can be measured by reduced storage replacement or reservoir dredging and reduced costs of cleaning out storm sewers.

Navigational Benefits

Storm water sediment loads also are delivered to and deposited in harbors and rivers critical to navigation and commerce. Where the waters are used for navigation, solids must be dredged and disposed of to maintain the utility of the waterway. In 1995, 251 million cubic yards of material were dredged from navigational waterways (US ACE, 1996). An estimated 5% of this can be attributed to roads and construction sites, representing 12.6 million cubic yards of material (Clark et al., 1985). Benefits of storm water runoff controls can be measured by avoided dredging and disposal costs.

Reduced Illness from Consuming Contaminated Seafood

Storm water controls may reduce the presence of pathogens in seafood caught by commercial or recreational anglers. Bean et al. (1996) identified 679 cases of shellfish-vectored disease between 1988 and 1992. Rippey (1994) estimated that illnesses were under reported by a factor of 20 or more, leading to an annual estimate of 2,700 cases of illness each year. Benefits from decreased levels of pathogens may include lower incidences of illnesses due to raw or partially cooked seafood.

Reduced Illness from Swimming in Contaminated Waters

Swimmers may accrue similar benefits, especially when storm water runoff contains high levels of bacteria or parasites. Epidemiological studies demonstrate that swimmers who immerse their heads in waters with high densities of bacterial indicators bear a greater risk of contracting gastrointestinal or respiratory illnesses than those who do not immerse their heads (Haile et al., 1996). Benefits of decreased pathogen levels may include a reduction of such bacteria-related illnesses.

Enhanced Aesthetic Value

When storm water affects the appearance or quality of a water body, the desirability of working, living, traveling, or owning property near that water body is similarly affected. A reduction in storm water pollution and excessive flows resulting in the improved quality of a water body, such as more diverse or plentiful vegetation or wildlife, or overall better water quality, will result in benefits as these waters recover and become more desirable locations near which people want to live, work, travel, or own property.

Other Ecosystem Improvements

Increased peak flows resulting from urbanization (e.g., from increased impervious surfaces) can cause catastrophic damage in receiving streams and stream valleys, including streambank or streambed erosion, vegetation damage, inundation and flooding, and sediment deposition. Forested areas, wetlands, estuaries, and shorelines can become submerged under water or sediment can be deposited by storm flows. Impacts include loss of land, ecosystem and habitat damage, and high downstream sediment loads. Benefits from reduced flows can be measured by the reduced need for streambank, streambed, vegetation, or near stream and shore maintenance. Other benefits can be measured by the reduced need to remove sediment from downstream reaches or to repair ecosystem or property damage resulting from high sediment loads.

5.2 Construction Site Controls

The Phase II rule requires that construction sites between one and five acres in size control storm water to prevent the runoff of sediment and pollutants into nearby water bodies. Typical methods of controlling runoff include BMPs such as the minimization of site disturbance or vegetation removal and silt fencing. EPA expects the implementation of such programs to result in reduced pollutant loadings and flows entering small streams with subsequent benefits in the form of improved water quality and habitat of receiving waters.

5.2.1 Model of Construction Site BMP Effectiveness

To estimate the effectiveness of the erosion and sediment control practices for which costs were estimated in Chapter 4 for the 27 model construction sites, EPA and the US ACE modeled the effectiveness of the practices in reducing soil loss from those model sites using the Revised Universal Soil Loss Equation (RUSLE) (US ACE, 1998). Although RUSLE is limited to the

development of average annual sediment loss, the model provides insight into how construction practices can impact soil loss from a site and how these impacts can vary regionally across the United States. Specifically, disturbances to the soil can result in sediment loss increases ranging from 140% to 2,210% depending on the climatic region. The results show varying effectiveness of BMPs and may be useful for site planning. For example, silt fencing alone may not be sufficient for sandy soils. Alternatively, some combinations of BMPs may overcompensate and thus fewer controls may be needed.

Offsite transport of soil lost during construction was modeled for one location using Agricultural Nonpoint Source Pollution Model (AGNPS), an empirically based, single event watershed runoff, erosion, and pollution transport model (US ACE, 1998). Although the RUSLE model is considered more credible for calculating soil loss, the AGNPS model provides insight into how material is transported within a watershed. The model was used to determine sediment movement through three generalized watershed sizes under varying degrees of construction. The results showed that soil type, watershed size, and construction site location with respect to the outlet of a watershed are important determinants in the transport of soil through a channel to a downstream portion of the watershed.

For all watershed, slope, and construction densities tested, approximately half of the eroded soil from upland portions of a watershed with silt or clay soil was yielded to a downstream portion of the watershed (US ACE, 1998). However, for sandy watersheds, only a small portion of eroded soil was deposited downstream. Upland construction sites had far less impact than those located near watershed outlets. And, the model showed that construction in smaller watersheds results in a larger percentage increase in sediment yield from the watershed—up to a 70% increase in yield for 30 acres of construction in a 99-acre watershed compared to a 12% increase in yield for 30 acres of construction in a 639-acre watershed.

5.2.2 Anticipated Benefits of Construction Site Controls

Implementation of construction site BMPs is expected to improve the water quality and physical condition of both small streams and larger water bodies. Runoff from construction sites may be particularly damaging to *small streams* because of the streams' typically small flow volume and channel size, thus lessening the ability to accommodate high flows and large sediment loads.

Siltation has been identified as the leading pollutant or process affecting rivers and streams in the nation (US EPA, 1998a). Although agriculture produces the largest sediment load, construction results in the most concentrated form of erosion and the rate of erosion from construction sites may exceed that of agricultural land by ten to twenty times (Water Environment Federation, 1992).

During storms, construction sites may be the source of sediment-laden runoff, which can overwhelm a small stream channel's capacity, resulting in streambed scour, streambank erosion, stream "blow out," and destruction of near-stream vegetative cover. As the flow velocity decreases, sediment from construction site runoff settles out, blanketing the streambed, burying macroinvertebrates, and eliminating the natural stream substrate. Streams that are overwhelmed by runoff can become wider and, consequently, exhibit shallower base flow, lose the natural

riffle-run morphology, lose to erosion vegetative cover that shades the stream and mitigates temperature swings, and lose their habitat value for aquatic species. The recurrence of high storm water flows maintains these degraded conditions, ultimately resulting in water quality and habitat degradation. The prevention of sediment and flow runoff from construction sites will mitigate this degradation.

Although small streams are frequently the first water body with which storm water comes into contact, these streams subsequently drain into *larger streams, rivers, ponds, lakes, wetlands, bays, estuaries, or oceans*. Thus, stream reaches affected by construction activities often extend well downstream of the construction site. For example, between 3.0 and 3.5 miles of stream below construction sites in the Patuxent River watershed were observed to be impaired by sediment inputs (Klein, 1979). It is near these downstream water bodies that a large share of the population lives or participates in water-dependent recreation. When small stream habitat and water quality degrades, the downstream systems also are affected, suffering poorer water quality and less upstream habitat for aquatic-dependent species. When small stream habitat and water quality improves, downstream water bodies also will realize water quality and habitat improvements, resulting in benefits for the population living nearby or using the resource for recreation, as described below.

Enhanced Commercial Fisheries

Sedimentation can adversely affect fisheries by reducing the possibilities for reproduction and survival of fish, leading to lower yields or the elimination of a species. Excessive sediment loads can bury fish eggs and stream substrates favorable for fish reproduction. Additionally, excessive flows may wash eggs downstream.

Enhanced Opportunities for Recreational Fishing

Construction site runoff may increase turbidity in receiving waters and blanket streambeds with sediments, covering eggs or favorable substrates for egg laying. This, in turn, leads to adult mortality from impaired feeding or respiration, decreased reproductive success resulting in decreased numbers or size of sport fish, or the elimination of a specific species from receiving waters. Through water quality improvements, the number, size, and quality of fish may improve, thereby opening up new areas to recreational fishing and enhancing the experience for existing users.

Enhanced Opportunities for Subsistence Fishing

Construction site runoff may increase turbidity in receiving waters and blanket streambeds with sediments, covering eggs or favorable substrates for egg laying. This, in turn, leads to adult mortality from impaired feeding or respiration, decreased reproductive success resulting in decreased numbers or size of edible fish, or the elimination of a specific species from receiving waters. Through water quality improvements, the number, size, and quality of fish may improve, thereby opening up new areas to fishing and enhancing the experience for existing users.

Enhanced Opportunities for Hunting

Construction site runoff may decrease the habitat quality for waterfowl species through the burying of food sources, inundation of habitat, or damage to nesting areas, resulting in reduced numbers, reduced breeding, or the elimination of a specific species using receiving waters. Through water quality improvements, the number and quality of waterfowl may improve, thereby opening up new areas to hunting and enhancing the experience for existing users.

Enhanced Opportunities for Boating

Although boating does not necessitate human contact with the water, boaters are sensitive to water quality. Sediment runoff from construction sites results in turbidity, which may discourage boaters from using a waterway. However, storm water controls may offer benefits by reducing sediment loads entering impaired waters and increasing water clarity, thereby opening up new areas to boating and enhancing the experience for existing users.

Enhanced Opportunities for Swimming

Turbidity in surface waters may reduce the safety of waters for swimming. For example, swimmers may be unable to judge the depth of cloudy waters or to see vegetation that may interfere with swimming. Storm water controls offer benefits to swimmers by making waters suitable for swimming where it currently is not desirable or safe.

Enhanced Opportunities for Noncontact Recreation

Activities such as picnicking, jogging, biking, photography, and camping do not necessitate contact with the water; however, water quality affects the ability to enjoy these activities in close proximity to water bodies. High turbidity may discourage recreational activity adjacent to water bodies. However, storm water controls may offer benefits by encouraging impaired waters to be used as focal points for recreational activities where they are not currently in demand for such use and by enhancing the experiences for current users.

Enhanced Nonconsumptive Wildlife Uses

Wildlife viewing activities are affected by impaired water quality through the reduced quantity and variety of species living in or near water bodies. Construction site storm water controls that result in lower turbidity and sedimentation will make food and breeding habitats more accessible; thus, greater numbers or diversity of viewable wildlife species will be available. Benefits are measurable by increased trips and greater amounts of wildlife seen per trip.

Reduced Flood Damage

Storm water runoff controls may mitigate flood damages by providing additional storage capacity, diversion of runoff, and reduced sedimentation from flood waters. The benefits from reduced flows and sedimentation can be measured by the reduced damage from flood flows and the reduced amounts of sediment deposited by flood waters requiring cleanup.

Water Storage Benefits

The heavy load of solids deposited by storm water runoff can lead to rapid sedimentation of reservoirs and other receiving water bodies, meaning a loss of needed water storage capacity, which must either be replaced, if this option exists, or the existing reservoirs must be dredged. The benefits of storm water controls can be measured by reduced storage replacement, or reservoir dredging and reduced costs of cleaning out storm sewers.

Navigational Benefits

Storm water sediment loads also are delivered to and deposited in harbors and rivers critical to navigation and commerce. Where the waters are used for navigation, solids must be dredged and disposed of to maintain the utility of the waterway. In 1995, 251-million cubic yards of material were dredged from navigational waterways (US ACE, 1996). An estimated 5% of this can be attributed to roads and construction sites, representing 12.6-million cubic yards of material (Clark et al., 1985). Benefits of construction site runoff controls can be measured by avoided dredging and disposal costs.

Enhanced Aesthetic Value

When storm water affects the appearance or quality of water bodies, the desirability of working, living, traveling, or owning property near that water body is similarly affected. A reduction in storm water sediment loads and excessive flows resulting in the improved quality of a water body, such as increased water clarity or more diverse or plentiful vegetation or wildlife, will result in benefits when impaired waters recover and become more desirable locations near which people want to live, work, travel, or own property.

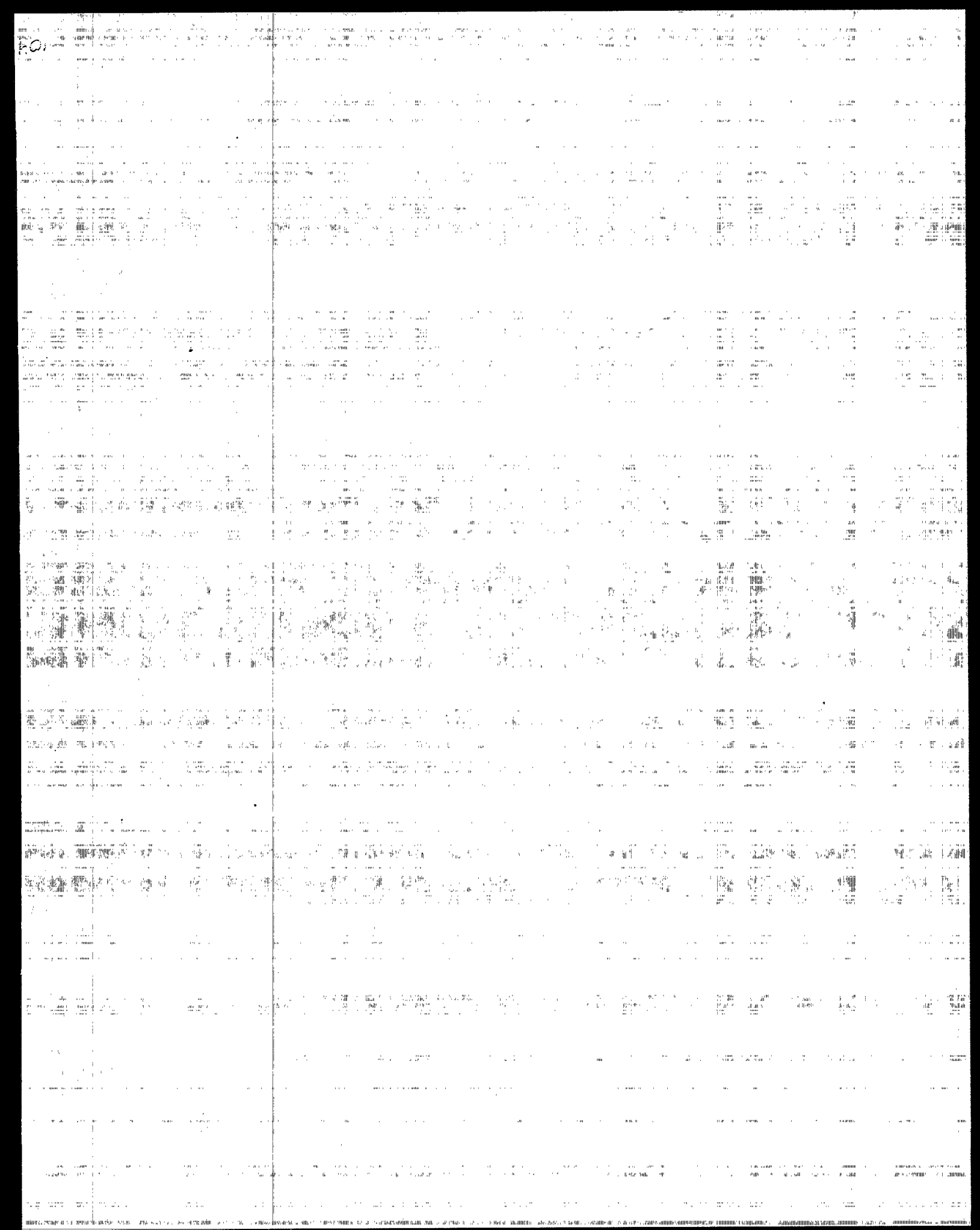
Other Ecosystem Improvements

Increased peak flows resulting from urbanization (e.g., from increased impervious surfaces) can cause catastrophic damage in receiving streams and stream valleys such as streambank or streambed erosion, vegetation damage, inundation and flooding, and sediment deposition. Forested areas, wetlands, estuaries, and shorelines can become submerged or sediment can be deposited by storm flows. Impacts include loss of land, ecosystem and habitat damage, and high downstream sediment loads. Benefits from reduced flows can be measured by the reduced need for streambank, streambed, vegetation, or near stream and shore maintenance. Other benefits can be measured by the reduced need to remove sediment from downstream reaches or to repair ecosystem or property damage resulting from high sediment loads.

5.3 Conclusions

This chapter described the six municipal minimum measures that comprise the municipal storm water program as well as the construction site runoff program. Both programs are expected to control the impacts of storm water runoff and result in benefits to the nation's waters. Benefits include improved recreation, such as fishing, swimming, or boating; reduced flood damages;

reduced drinking water and water storage requirements; reduced illness and health risks; enhanced aesthetic value; and finally, improved ecosystem health. Chapter 6 contains the discussion of the quantification and valuation of benefits.



6.0 QUANTITATIVE ASSESSMENT OF BENEFITS

This chapter reports estimates of the potential value of quantifiable benefits of the Phase II rule. It begins with an overview of the economic concepts and analytical issues associated with defining benefit categories and developing quantified and monetized benefits estimates. This framework for the benefits analysis is in Section 6.1.

EPA estimated benefits using two separate approaches.[1] The first approach utilized the National Water Pollution Control Assessment Model (NWPCAM) to model reductions in pollution loadings due to the municipal minimum measures and soil erosion control provisions of the Phase II rule. The changes in loadings are translated into changes in water quality in a model that estimates water quality for more than 600,000 river reaches in the United States. Section 6.2 briefly describes the modeling approach and benefit valuation method. This method transferred willingness-to-pay estimates (WTP) from a national study of the value of water quality improvements (Mitchell and Carson, 1986) to derive benefits.

EPA's second approach, which is described in Section 6.3, has separate estimates of the benefits for the municipal minimum measures and the soil erosion control provisions and also provides estimates for some marine benefits. The benefit analysis for the municipal minimum measures provision used national water quality assessment data reported under Section 305(b) of the Clean Water Act to estimate both the impact of urban storm water runoff on national water quality and the subsequent benefits of efforts under the Phase II rule to mitigate this source of water quality impairment. The valuation step of the analysis incorporated estimates from Carson and Mitchell (1993) of household WTP to improve national water quality. EPA also used a benefits transfer analysis to estimate potential human health and recreation benefits associated with marine water impacts. For the soil erosion control provision, EPA estimated the share of national construction activity affected by the rule to apportion a household WTP value reported in Paterson et al. (1995) for soil erosion control policies.

Section 6.4 describes the key limitations and uncertainties in the benefits estimated using either approach and provides sensitivity analyses for selected sources of uncertainty. Section 6.5 presents a comparison of benefits estimated using the two approaches.

[1] In the economic analysis for the proposed rule, EPA used a "top down" approach to estimate economic benefits. That is, EPA estimated the potential total economic benefits of all wet weather programs and then allocated the benefits to individual programs using best professional judgement. The use of best professional judgement introduced uncertainty into the benefits estimates. In addition, the top down approach differed from the "bottom up" approach used to estimate the cost of the proposed storm water rule, which developed unit costs per municipality and construction start that were multiplied by the estimate of affected municipalities and starts. Therefore, for this analysis, EPA developed two bottom up approaches for estimating benefits from the rule.

6.1 Framework for Estimating Benefits

Economic benefits refer to the dollar value associated with all outcomes of the rule that lead to higher social welfare and reflect estimated changes in consumer and producer surplus. These surplus values reflect the degree of well-being enjoyed by people given different levels of goods or services and prices, and are widely accepted concepts of applied welfare economics (see, for example, Freeman, 1993). An important component and potential limitation of this conceptual foundation is that benefit values are related to how environmental changes are perceived and valued by humans. Some analysts, however, argue that ecological benefits accrue and are separate from the values placed by humans on the protection and enhancement of habitat and living species. But because there would be no way to assign a value to such benefits for consideration in a benefit-cost analysis, ecological values are considered to be included within the traditional use and nonuse (passive use) benefits discussed below.

6.1.1 Definition of Benefit Categories

To move from the qualitative assessment of benefits presented in Chapter 5 to quantitative estimates of value, EPA first categorized the potential outcomes as they relate to different uses of the affected water resources, using, as a starting point, a list of categories developed for the analysis of the California Toxics Rule (US EPA, 1998). Categorizing benefits in this manner helps ensure that all benefits are identified and double counting is avoided. The potential benefit categories associated with water quality improvements are shown in Exhibit 6–1.

Use Benefits

Use benefits include all of the current direct and indirect ways that people expect to make physical use of the resource (Mitchell and Carson, 1989). Direct use benefits are those that result from enhanced recreational water activities such as swimming or boating, or from reduced exposure to contaminants (e.g., the avoided illness cases reported in Appendix C). Diversionary benefits are also direct use benefits and include avoided water storage replacement costs and water treatment costs. Indirect use benefits are those that result from water quality improvements that enhance other, nearby activities. For example, improvements in water quality may sustain waterfowl habitat, enhancing bird watching. A wide range of direct and indirect use benefits are expected to result from the Phase II rule.

Exhibit 6–1. Potential Benefits of Water Quality Improvements

In-Stream Use	• Commercial fisheries, shell fisheries, and aquaculture; navigation • Recreation (e.g., fishing, hunting, boating, swimming) • Subsistence fishing • Human health risk reductions
Near-Stream Use	• Water-enhanced noncontact recreation (e.g., picnicking, photography, jogging, biking, camping) • Nonconsumptive use (e.g., wildlife viewing, hiking near water) • Flood control (reduced property loss and risk to health and safety)
Diversionary Use	• Industry/commercial (process and cooling waters) • Agriculture/irrigation • Municipal drinking water (treatment cost savings, water storage dredging and construction savings, and human health risk reductions)
Aesthetic Use	• Residing, working, traveling, and owning property near water, etc.
Passive Use	• Existence (satisfaction gained from knowing the resources exist and knowing others enjoy the resources; ecologic value, including reduced mortality and morbidity, improved reproductive success, increased diversity of aquatic and piscivorous wildlife, improved habitat for threatened and endangered species, and improved integrity of aquatic and aquatic-dependent ecosystems) • Bequest (intergenerational equity)

Note: Previous analyses have included option value as a potential benefit of environmental improvement. For this analysis, EPA adopted Freeman's (1993) conclusion that option value does not exist as a separate benefit category.

Nonuse (Passive Use) Benefits

Nonuse or passive use benefits include the values humans place on the resource apart from their desire to use the resource. Storm water runoff can negatively impact aquatic and wildlife species, as well as the ecosystems in which they live and reproduce. Control of harmful quantities of runoff and loadings can result in ecological benefits, including reduced mortality and morbidity of aquatic and other wildlife; improved reproductive success of aquatic and other wildlife; increased diversity of aquatic and other wildlife; improved conditions for successful recovery of threatened and endangered species; and otherwise improved health of aquatic and aquatic-dependent ecosystems. Passive use values may stem from a sense of stewardship for an aquatic resource or from knowledge that others do and can use a resource (vicarious consumption). These values also may arise from the desire to preserve the resource for future generations (bequest value) or from a philanthropic sense of environmental responsibility.

6.1.2 How Benefits Arise from Water Quality Improvements

Freeman (1993) describes three functional relationships that link a particular regulatory action to beneficial outcomes: the relationship between resource quality and pollution control; the relationship between resource quality and human use of the resource; and the relationship between economic value and human use of the resource (Exhibit 6–2). Thus, estimating the potential benefits of implementing storm water controls involves the use of applied economic theory, but also requires involving a range of other types of information on the biological and

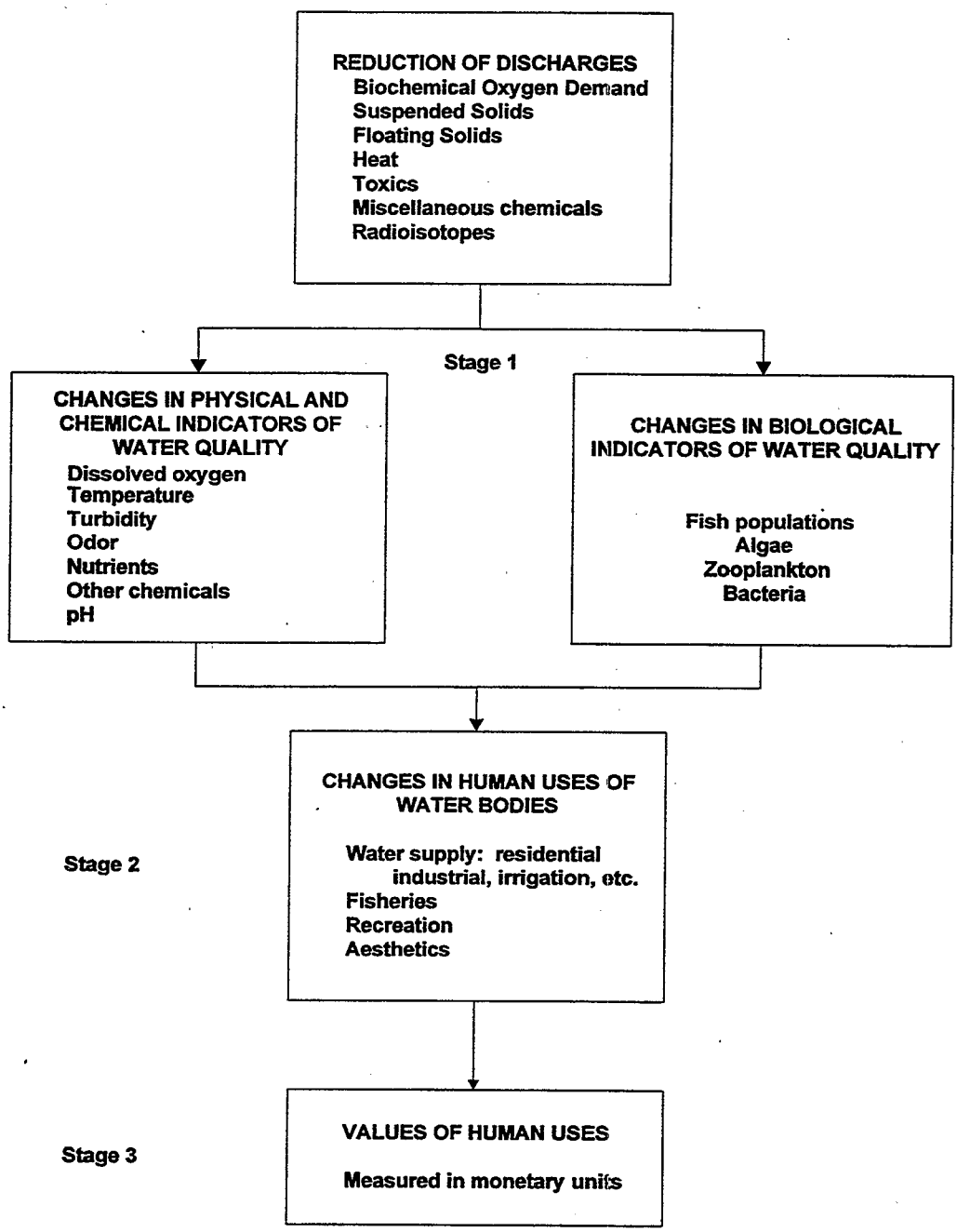
ecological links between aquatic and other wildlife and their environments. Exhibit 6–2 depicts the stages involved in determining the benefits associated with environmental improvements. Although developing information to shed light on all stages of this process can be challenging, Freeman notes that it is particularly difficult to determine the link between resource quality and human use of the resource (Stage 2 in Exhibit 6–2). This difficulty arises because only in rare cases is the level of resource use a simple function of a single water-quality indicator such as dissolved oxygen (Freeman, 1993). Instead, some uses (e.g., commercial fisheries, recreation) depend, in complex ways, on the whole range of physical, chemical, and biological water-quality indicators (Freeman, 1993).

For example, Freeman notes that species distributions of fish, algae, zooplankton, and bacteria may be affected by changes in physical and chemical parameters of water quality, and not necessarily in the same manner, such that even providing a descriptive characterization at this stage is a formidable task. In addition, defining which water quality parameters are most important in influencing uses of a water body (such as fishing or swimming) requires extensive research (Freeman, 1993). Freeman notes that the development of predictive models for these parameters is a major research priority.

Despite the many difficulties associated with determining Stage 2 in Exhibit 6–2, there is a well-developed theory of economic value for use at Stage 3 of a benefits analysis where monetary value is placed on things such as improved recreational opportunities, increases in fish production, or the availability of a particular fish species (Freeman, 1993). However, even at this stage, difficulties arise. For example, the travel cost method is often used to value site specific recreation and is sometimes a preferred approach because it relies on observed behavior to determine value. The method uses travel costs to a recreation site as surrogate prices. With information on travel costs and the frequency of an individual's use of a site, demand functions can be developed and consumer surplus estimated. However, the travel cost method has shortcomings when attempting to value changes in the quality characteristics of a resource. For example, as Bockstael et al. (1989) discuss, the method only includes sites that are visited, excluding sites that indeed may have desirable quality characteristics that are not necessarily more expensive. The wide array of services and quality characteristics among sites in conjunction with population centers also makes it difficult to discern which aspects of environmental quality are being valued. As a result, determining use value can be difficult despite the availability of data based on observed behavior.

Another example of potential difficulties at Stage 3 is related to estimating nonuse or passive use values. Total resource value is thought to consist of personal use value, including existence and bequest values (Stevens et al., 1991). Indeed, Stevens et al. (1991) note that preliminary evidence suggests that existence value may be the most important component of value. Contingent valuation (CV) is the only technique capable of measuring existence values and this technique has been ruled as an appropriate and acceptable means of estimating nonuse values in a damage claim (US Court of Appeals, 1989). A National Oceanic Atmosphere Administration

Exhibit 6–2. The Production of Benefits from Improved Ambient Water Quality



Source: Freeman (1993). Reproduced with permission.

(NOAA) "Blue Ribbon" Panel (1993) also evaluated CV for determining nonuse values in litigation and concluded that well-designed studies provide an "adequately reliable benchmark." However, there is concern that many CV respondents may not be able to provide meaningful answers to valuation questions (see, for example, Stevens et al., 1991). For example, 25% of the respondents who stated that they were not willing to pay for the existence of species that were the subject of a CV survey protested for ethical reasons, claiming that wildlife values should not be measured in dollar terms (Stevens et al., 1991). Stevens et al.'s (1991) results lead them to argue that benefit-cost analysis should generally not be used to make decisions about the existence of wildlife. As supporting evidence, they provide the case of the snail darter, which had no economic value prior to its discovery (Randall and Stoll, 1983); thus, small changes in information or knowledge may produce large shifts in existence value (Stevens et al., 1991).

6.2 National Water Quality Model Approach

For this analysis, EPA simulated baseline water quality impairment and improved water quality for the Phase II municipal minimum measures and construction site controls using the National Water Pollution Control Assessment Model (NWPCAM). Documentation for this analysis is provided in Appendix E.

NWPCAM estimates water quality parameter values and the associated level of use support for the 632,000 miles of rivers and streams in the EPA's Reach File Version 1 (RF1), which covers a fraction of the 3,600,000 river and stream miles in the continental United States.[2] The water quality parameters in the NWPCAM are biological oxygen demand (BOD5), total suspended solids (TSS), dissolved oxygen (DO), and fecal coliforms (FC). NWPCAM incorporates geographical and hydrological information as it produces estimates of the water quality parameters, which are converted to use support designations based on the standards for FC, BOD, DO, and TSS shown in Exhibit 6–3. The model computes the designation for each river and stream segment of one mile or less by:

- Determining the values for each water quality parameter based on loadings and river reach data
- Comparing these values to the reference conditions for meeting each of the use categories
- Assigning the use to the entire segment.

The model classifies a stream or river segment based on an exceedance of any of the four criteria presented in Exhibit 6–3. For example, if the segment meets the FC, BOD5, and TSS criteria for swimming, but it meets the DO only for game fishing, then the segment is classified as supporting game fishing. If any of the boating criteria are exceeded, then the segment is classified to indicate no recreational use support.

[2]This model was used for the Executive Order on "Infrastructure" that was reviewed by Office of Management and Budget (OMB). EPA also used an older version of this model as documented in the appendix of the Economic Analysis for the Proposed Phase II rule submitted for OMB review.

Exhibit 6–3. NWPCAM Water Quality Ladder

Beneficial Use	Fecal Coliforms (MPN/100 mL)	Dissolved Oxygen (mg/L) / (% sat.)	5-day BOD (mg/L)	Total Suspended Solids (mg/L)
Drinking	0	7.0 / 90	0	5
Swimming	200	6.5 / 83	1.5	10
Game Fishing	1000	5.0 / 64	3.0	50
Boating	2000	3.5 / 45	4.0	100

Source: Bondelid et al., 1999.

To estimate the impact of the soil erosion control provision on water quality, the construction start modeling component of the model estimates loadings reductions by simulating the effects of various BMPs (e.g., seed and mulch of the model, and sediment traps) using the Revised Universal Soil Loss Equation (RUSLE). The analysis is based on a U.S. Army Corps of Engineers (1998) report on BMPs for small construction sites and is described in more detail in Appendix E. Note, however, that the NWPCAM does not address potential impacts of post-construction controls.

The construction part of the NWPCAM contains a "small streams" submodel that adds 34,500 miles of small streams to the original NWPCAM/RF1 framework. This "small streams" submodel is included in the model to address the fact that many construction starts are not located next to the larger streams contained in the overall NWPCAM/RF1 river framework, but they are located near smaller streams. With the addition of the small streams, the submodel routes the loadings from construction sites to the overall RF1 framework. The model treats the community with construction sites as a point source. For each community with construction sites, the submodel assumes one small stream to transport loadings to the nearest RF1 stream. The submodel decays the loadings using the same assumptions that the rest of NWPCAM uses. Data for flow in the small streams is based on a hydrologic analysis that relates distance from RF1 to drainage area and then uses an RF1 flow analysis to estimate mean summer flow as a function of the drainage area. For this initial work on small streams, the model includes a straight-line distance from the construction sites to RF1 (i.e., stream sinuosity is not taken into account).

6.2.1 Potential Fresh Water Quality Improvements

Using the NWPCAM, EPA simulated baseline water quality and improved water quality caused by the anticipated loading reductions from municipal point sources and construction sites affected by the Phase II rule. These water quality changes are estimated for a river reach that is located immediately below a discharge source.

Baseline Simulation Conditions

EPA used NWPCAM to estimate baseline water quality conditions nationwide using the following assumptions to estimate baseline loadings from various point and nonpoint sources including urban and rural sources:

- All combined sewer overflows (CSOs) are controlled by detention basins and the assumed runoff capture rate is 85%, which is based on NEEDS Survey assumptions
- Detention basin controls are at each of the 1,723 individual NWPCAM Phase I urban sites and the assumed runoff capture rate is 85%
- Construction start BMPs are in place in areas with existing State programs
- Construction start BMPs are in place at sites greater than five acres.

A statistical groundtruthing of the model to storage and retrieval ambient water quality data indicates that the NWPCAM produces a reliable baseline estimate that can be considered a reasonable predictor of the actual use support for the 1990s.

Phase II Scenario Conditions

The Phase II conditions include the baseline conditions and are assumed to further impose the following:

- Detention basin controls at each of the 5,038 individual NWPCAM Phase II urban sites with an assumed runoff capture rate of 85%
- Construction start BMPs are in place at sites between 1 and 5 acres.[3,4]

NWPCAM requires an engineering surrogate for treatment of specific pollutants contained in discharges, whereas the Phase II program includes both structural and nonstructural controls. Therefore, the model uses detention basins as a proxy to represent the impact of the municipal program. Based on surveys of existing literature on removal of pollutants from detention basins, EPA assumed controls on the urban runoff loadings would remove 33% of BOD5, 60% of TSS, and 70% of FC. These removal rates can be considered conservative median values; as noted below in Section 6.3, EPA believes that the actual implementation of the Phase II minimum

[3]The Phase II municipalities identified in the model are 5,038, instead of 5,040 used for the cost analysis and the second benefit analysis approach, because matching for two of the municipalities could not be made in the population data bases used for the model.

[4]The Phase II construction starts used by NWPCAM to estimate benefits (120,447) differ from the starts used to estimate costs in Chapter 4 and benefits using the water quality assessment approach (110,223). EPA updated the construction start estimates for the latter analyses with building start information from additional communities after entering the construction start data into the model. Moreover, the structure of the data made it very difficult to use it for the modeling purpose. However, the sensitivity analysis described later in this section shows that this difference in the construction starts does not effect the benefit estimates significantly.

measures will result in an overall program effectiveness of approximately 80%. Pollutant loadings sources in the model include 37,005 municipal and industrial point sources, 742 CSO loadings on 505 reaches, urban and nonpoint source loading estimates at 42,479 individual places, rural loadings (primarily from agriculture), and construction starts. The summary of the regulated universe and the assumptions are presented in Exhibit 6–4.

Exhibit 6–4. NWPCAM Summary of Key Model Assumptions for the Storm Water Phase II Benefits Analysis

Variable	Baseline Analysis	With Phase II Implementation
Number of Construction Starts	Current State Programs: 100,316 Phase I: 184,520	Phase 11: 120,047 Phase II "R" Waivers: 13,057 0–1 Acres (unregulated): 91,332
Number of Acres of Construction Starts (Estimated from Input Dataset of Numbers of Starts)	Current Programs: 207,869 Phase I: 1,845,204	Phase I: 289,819 Phase II Waivers: 33,517 0–1 Acres (unregulated): 45,491
Construction Site Parameters	7% Slope, Medium Soils	7% Slope, Medium Soils
Construction Site BMPs	1. Between 0 and 4 Acres: Silt Fence, Seed & Mulch, and Stone Check Dams 2. Greater than 4 Acres: Seed and Mulch, Stone Check Dams, and Sediment Traps	1. Between 0 and 4 Acres: Silt Fence, Seed & Mulch, and Stone Check Dams 2. Greater Than 4 Acres: Seed and Mulch, Stone Check Dams, and Sediment Traps
Combined Sewer Overflows (CSOs)	742 CSOs on 505 Reaches	
CSO Runoff Control	Detention basin-level of control for CSOs, capturing 85% of the runoff, with 33% removal of BOD5, 60% removal of TSS, and 70% removal of FC.	
Urban Runoff Sources *Note:* Population adjustments made to reflect 1998 values and populations served by CSOs.	Phase I: 1,723 Places, 72.4 million people Not Phase I or II: 35,718 Places with 81.7 million people	Phase II: 5,038 Places, 78.5 million people
Urban Runoff Controls	Capture 85% of the runoff, with 33% removal of BOD5, 60% removal of TSS, and 70% removal of FC.	Capture 85% of the runoff, with 33% removal of BOD5, 60% removal of TSS, and 70% removal of FC.

The number of miles projected by NWPCAM to meet the designated uses as defined in the Resources for the Future water quality ladder under the baseline and the Phase II conditions are summarized in Exhibit 6–5. Miles are reported for swimming, game fishing, boating, and no support. The exhibit also shows the net change miles for each use category. For example, the net change of an additional 4,548 miles that meet fishing and boating water quality standards accounts for improvements in miles that were previously classified as boatable or no support minus the miles that were previously classified as fishing and boating that improved to swimmable.

Because the model uses water quality parameters rather than designated uses to determine impairment levels, the implied number of impaired miles is approximately twice as large as the impaired miles reported in the 305(b) data (US EPA, 1998a). According to impairment data summarized in Exhibit 3–4, approximately 36% of the 693,905 surveyed river and stream miles in the nation are classified as impaired based on their respective designated uses. Thus, 249,800 miles are impaired. In contrast, in NWPCAM any river stretch that does not meet swimmable water quality standards will be considered impaired. Consequently, the model estimates that approximately 447,600 miles are impaired. This will tend to generate a larger benefit estimate than the approach in Section 6.3, which is based on 305(b) data.

Exhibit 6–5. Summary of Miles Meeting Designated Uses Under Baseline and Scenario Phase II Conditions

Use Support	Baseline Miles (mid–1990s)	Phase II Miles	Change in Miles (Phase II—Baseline)
Swimming, Fishing, and Boating	219,547	223,674	4,127
Fishing and Boating	418,190	422,738	4,548
Boating	480,515	483,451	2,936
No Support	186,589	183,653	–2,936
Total Miles	667,104	667,104	n/a

6.2.2 Potential Value of Improved Fresh Waters

EPA monetized the changes in designated uses of stream reaches using Carson and Mitchell's (1993) estimates of household WTP for incremental water quality improvements. EPA determined the number of households in the proximity of an affected stream reached by overlaying the modeled water quality results with population data from the 1990 Census of Populated Places and Minor Civil Divisions, updated to 1998 population levels. EPA then developed economic benefits based on these household estimates and estimates of household WTP.

Carson and Mitchell (1993) estimated the magnitude of WTP for incremental improvements in fresh water quality on the basis of their 1983 national survey. In the survey, respondents were asked to value three minimum levels of fresh water quality:

- Boatable: the value to keep the nation's waters from falling below boatable water quality
- Fishable: the value to raise the minimum standard from boatable to fishable
- Swimmable: the value to raise the minimum standard from fishable to swimmable.

Carson and Mitchell (1993) reminded respondents of several reasons for valuing fresh water quality:

- Using fresh water for boating, fishing, and swimming
- Using areas near fresh water for picnicking, bird watching, and staying in a vacation cottage
- Getting satisfaction from knowing that other people use fresh water resources
- Knowing that the nation's water is cleaner.

In addition, respondents were provided with the following information regarding baseline water quality:

- The (then current) minimum level of water quality is boatable
- Most of the nation's's fresh water bodies are fishable
- About 70% to 80% of fresh water bodies are swimmable.

Respondents used a payment card displaying a wide range of payment amounts to indicate their household WTP. Carson and Mitchell corrected their WTP estimates for biases inherent in the response rate and adjusted them for inflation using the Consumer Price Index (CPI). The authors also discussed appropriate adjustments to their estimates based on changes in the regression variables that determined a household's WTP for water quality improvements: real income and attitudes toward pollution control. Carson and Mitchell noted that the University of Chicago's National Opinion Research Center's General Social Survey suggests an approximate 30% increase in the number of respondents who think that there should be more spending on pollution control; other survey organizations report similar or larger changes in attitudes. To update WTP estimates to 1998 levels, EPA made similar adjustments to the WTP amounts to account for inflation growth in real per capita income, inflation, and a 30% increase in attitudes toward pollution control.[5] The adjusted bids are shown in Exhibit 6–6.

[5] The adjustment for inflation is based on the change in the CPI from 1983 to 1998 (a 64% increase) as reported by the Bureau of Labor Statistics (U.S. Department of Labor, 1998). Note, however, that there is currently a debate regarding the accuracy of the CPI. Recent analysis indicates it may overstate inflation by about 1%. To adjust for changes in income and attitude, EPA adjusted the mean explanatory variables for income and attitude in the WTP function (Carson and Mitchell, 1993) by 28%, which is the change in personal disposable income (U.S. Department of Commerce, 1998b), and 30% respectively to recalculate WTP for the category of boatable to fishable. These changes to the explanatory variables resulted in a 38% increase in the calculated WTP. Consequently, EPA applied an adjustment factor of 1.38 to all WTP values.

Exhibit 6–6. Mean Annual Household WTP Amounts for Different Levels of National Water Quality

Water Quality Level	WTP[1] (1983 dollars)	Adjusted Corrected Bid[2] (1998 dollars)
Nonboatable to boatable	$93	$210
Boatable to fishable	$70	$158
Fishable to swimmable	$78	$177

Note: N=564

[1] Source: Carson and Mitchell (1993), annual household values adjusted for unit and item bias.

[2] Adjusted bid: bid as adjusted by Carson and Mitchell × adjustment for inflation × adjustment for changes in income and attitude = ($93) × (1.64) × (1.38).

These WTP estimates are applied to value improvements in local and nonlocal waters separately because the survey results indicated that changes in statewide water quality are more important than changes in water quality elsewhere. In their survey, Mitchell and Carson asked respondents to apportion each of their stated WTP values between achieving the water quality goals in their own state and achieving those goals in the nation as a whole. On average, respondents allocated 67% of their values to achieving in-state water quality goals and the remainder to the nation as a whole. Mitchell and Carson (1986) argue that for valuing local (substate) water quality changes 67% of the WTP value is a reasonable upper bound for the local multiplier; the remaining 33% of the value is applicable to nonlocal water quality changes.

To apply the Mitchell-Carson values to changes in local water quality where only a subset of the waters is affected, Mitchell and Carson (1986) describe three "multipliers." The first is a percent-local multiplier, which defines the percentage of the stated WTP amount that is applied specifically to water quality improvements in the local area in question. The second is an impairment multiplier, which describes how WTP changes in relation to the fraction of local water quality impairment that is addressed by the rule. The third is a population multiplier, which is simply the size of the population benefitting from the local improvement in water quality.

For this analysis, EPA defined the locality as urban sites and associated populations linked into the NWPCAM framework. In this analysis, "local" waters are defined as reaches that are located near each of the population locations. The definition of "local" depends on whether an area is classified as a Census populated place or minor civil division. For populated places, EPA drew a circle with an equivalent area to the place, centered on the place latitude/longitude coordinates given by the U.S. Census Bureau and considered any reaches that fell in whole or in part within that circle "local" to that place. For minor civil divisions, the closest reach is considered to be the "local" water. EPA estimated "local" benefits based on use support changes in reaches that are "local" to each population location. The benefits depend on the portion of the local and the national impaired waters improved as a result of the Phase II soil and erosion controls for construction sites and the municipal pollution prevention measures.

Using this methodology, the EPA estimated benefits of the Phase II rule to be $1.63 billion per year. This estimate does not include potential benefits of post-construction controls. A summary of the local and nonlocal benefits are presented in Exhibit 6–7.

Exhibit 6–7. Local and Nonlocal Benefits of Phase II Controls Estimated Using the NWPCAM[1]

Use Support	Local Benefits ($million/yr)	Nonlocal Benefits[2] ($million/yr)	Total Benefits ($million/yr)
Swimming, Fishing, and Boating	306.2	60.6	366.8
Fishing and Boating	395.1	51.9	447.0
Boating	700.1	114.6	814.7
Total	1,401.4	227.1	1,628.5

[1] Does not include potential benefits of post-construction controls.

[2] To estimate nonlocal WTP per household, the 33% of willingness is multiplied by the fraction of previously impaired national waters (in each use category) that attain the beneficial use as a result of the Phase II rule. To estimate the aggregate nonlocal benefits, nonlocal WTP is multiplied with the total number of households in the United States.

While the numbers of miles that the model estimates will change their use support seem small, the benefits estimates are quite significant. This is because urban runoff and, to a large extent, construction activity occurs where people actually reside and, consequently, the water quality changes mostly occur close to those population centers. NWPCAM indicates that the changes in pollution loads have the most effect immediately downstream of the pollution changes. This is because rivers "treat" the wastes (using similar processes that occur in a wastewater treatment plant) as they move downstream. As a result, the aggregate benefit is large because there are large numbers of households in these population centers that benefit from improved water quality. If water quality improves in reaches that are away from the population centers, their economic value is comparatively less. The model captures this economic phenomenon. Moreover, the model fully incorporates the construction starts modeling (including the "small streams") and an improved population database for the estimation of benefits.

6.2.3 NWPCAM Sensitivity Analysis

EPA investigated the impact of alternative assumptions for the NWPCAM approach. Specifically, EPA investigated the impact of different levels of control, such as 60% or 80% pollutant removals from municipal sources. EPA estimates that controls in the 60% to 80% range will increase economic benefits by $200 million to $300 million per year, respectively, compared to the original $1.63 billion estimate.

As another sensitivity analysis, EPA assumed that the construction starts sediment loadings were 25% higher or lower than originally assumed. The resulting local economic benefits estimates show a change of only plus or minus 5%.

6.3 National Water Quality Assessment Approach

EPA also estimated benefits using national water quality impairment data in the 305(b) report (US EPA, 1998a). EPA used the Carson and Mitchell WTP estimates discussed in Section 6.2 to

value the removal of designated use impairment in streams, rivers, and lakes attributed to the Phase II urban sources, which was discussed in Chapter 3. For estimating benefits of the sedimentation and erosion control (SEC) requirements of the rule, EPA used estimates of the value of the SEC program in North Carolina. The derivation of benefits is discussed in the following subsections.

6.3.1 Potential Benefits of Municipal Measures

As described in previous chapters, Phase II municipalities contribute loadings of nutrients, metals, oil and grease, and litter that result in impairment of the nation's rivers and streams, lakes, reservoirs, Great Lakes, estuaries, and oceans. The benefits of implementation of the Phase II municipal minimum measures to remove impairment depend on a number of factors, including the number, intensity, and duration of wet weather events; the success of the municipal programs; the site-specific water quality and physical conditions; the current and potential uses of the receiving waters; and the existence of nearby "substitute" sites of unimpaired waters. Because all these factors will vary substantially from municipality to municipality, data and information are not available with which to develop estimates of benefits measure by measure and water body by water body.

Previously, EPA developed a method for estimating the potential benefits of the storm water program using national-level data that can be adapted to shed light on the benefits of the Phase II rule. As part of an effort to quantify the value of United States' waters impaired by storm water discharges, EPA applied Carson and Mitchell's (1993) estimates of the WTP for incremental water quality improvements to estimates of waters impaired by storm water discharges as reported by states in their 305(b) reports.

To develop estimates of the potential value of waters impaired by Phase II municipal sources, EPA used the proportion of impairment estimated for just these communities as developed in Chapter 3. That is, the potential Phase II benefits are assumed to equal the WTP for the different water quality levels multiplied by the water quality impairment associated with Phase II municipalities (see Exhibit 3–9, Urban Runoff/Storm Sewers column) and multiplied by the relevant number of households (WTP × % impaired × # households). Although households in Phase II communities will most directly benefit from improved local water quality, the WTP values from Carson and Mitchell (1993) are applied to all households in the United States because these WTP values represent the benefits—including nonuse benefits—that will accrue to all households as a result of the water quality improvements of the Phase II rule. The 1998 population (270 million) was divided by the number of persons per household in 1997 (2.62) to arrive at an estimate of 103 million households.

To apply the WTP values, EPA assumed that aquatic life support and fish consumption categories in the 305(b) data are similar to the fishable level that respondents were asked to value in Carson and Mitchell's study. Likewise, EPA assumed that primary contact (swimming) is similar to the swimmable level and that secondary contact (boating) is similar to the boatable level. However, these matches are not exact, as measurement and reporting standards for 305(b) reports differ from state to state.

Using the equation described above, the WTP to bring water quality in lakes to the swimmable level is: ($177 adjusted WTP) × (0.56% impairment) × (103 million households) = $102.2 million.[6] The Carson and Mitchell estimates apply to all fresh water lakes and rivers. As shown in Exhibit 3–8, lakes are the most impaired by urban runoff/storm sewers, followed closely by Great Lakes, and then rivers. It is not clear, however, how the Carson and Mitchell values would be apportioned among rivers, lakes, and Great Lakes because the physical units reported in the 305(b) (river miles, lake acres, and Great Lakes shoreline miles) cannot be aggregated. In light of this problem, EPA developed a benefits range by applying the WTP values to the categories separately and assuming that the higher resulting value for lakes represents the high end of the range (i.e., assuming that lake impairment is more indicative of national fresh water impairment) and that the lower resulting value for impaired rivers represents the low end of a value range for all fresh waters (i.e., assuming that river impairment is more indicative of national fresh water impairment).

The designated uses given in the 305(b) data list two categories that can be interpreted as "fishable water quality:" aquatic life support and fish consumption. Calculating the WTP for each category and aggregating every category is likely to lead to double counting. Therefore, EPA used the sum across every category to determine an upper bound on both the low and high WTP estimates. To determine a lower bound on the low and high WTP estimates, EPA included only the aquatic life support category, the larger impairment impact, eliminating the fish consumption category. The resulting benefit estimates are presented in Exhibit 6–8. These results differ from the NWPCAM results, in part, because they exclude the soil erosion control impacts, which are valued separately. Furthermore, the changes in impairment levels based on the 305(b) data are substantially lower than the baseline impairment levels simulated using the NWPCAM. As noted earlier, the 305(b) data only identify impairments to designated uses, whereas the NWPCAM classifies as impaired any river reach that does not meet swimmable standards.

Exhibit 6–8. Potential Annual WTP Estimates for Fresh Water Impaired by Phase II Municipal Sources (1998 dollars)

Designated Use	Adjusted Household WTP	Impairment from Urban Runoff/ Storm Sewers	Aggregate WTP[1] (millions)
Low Estimate (Based on Impairment Data for Rivers)			
Aquatic Life Support	$158	0.36%	$58.7
Fish Consumption	$158	0.19%	$31.2
Primary Contact—Swimming	$177	0.24%	$42.7
Secondary Contact—Boating, etc.	$210	0.22%	$48.7
Subtotal (upper bound)[2]			$181.5
Subtotal (lower bound)[3]			$150.3

[6]Equation result is not exact due to rounding of factors.

Exhibit 6–8. Potential Annual WTP Estimates for Fresh Water Impaired by Phase II Municipal Sources (1998 dollars)

Designated Use	Adjusted Household WTP	Impairment from Urban Runoff/ Storm Sewers	Aggregate WTP[1] (millions)
High Estimate (Based on Impairment Data for Lakes)			
Aquatic Life Support	$158	0.70%	$113.7
Fish Consumption	$158	0.79%	$128.3
Primary Contact—Swimming	$177	0.56%	$102.2
Secondary Contact—Boating, etc.	$210	0.56%	$121.8
Subtotal (upper bound)[2]			$466.0
Subtotal (lower bound)[3]			$337.6

Source: US EPA, 1998a.

[1]Based on 103 million households (US Bureau of the Census, 1998a). Results subject to rounding.

[2]Totals may not add due to rounding. Includes all designated uses.

[3]Totals may not add due to rounding. Excludes fish consumption values.

Although the results provided in Exhibit 6–8 indicate the potential value of impaired waters, the extent to which impairment will be eliminated by the municipal minimum measures is not clear. The estimates are presented in Exhibit 6–9 for a range of potential effectiveness of municipal programs excluding post-construction control measures.

Exhibit 6–9. Potential Annual Benefits of Improving Fresh Water Impaired by Phase II Municipal Sources to Support Their Designated Uses (Millions of 1998 dollars)

Municipal Program Effectiveness[1]		
60%	**80%[2]**	**100%**
Low Estimate (based on impairment data for rivers)[3]		
$90.2–$108.9	$120.2–$145.2	$150.3–$181.5
High Estimate (based on impairment data for lakes)[3]		
$202.6–$279.6	$270.1–$372.8	$337.6–$466.0

[1] Figures subject to rounding.

[2] EPA expects that municipal programs will strive to achieve at least an 80% effectiveness.

[3] Adjusted for program effectiveness (e.g., for rivers: $150.3 × 80% = $120.2; $181.5 × 80% = $145.2).

6.3.2 Potential Benefits of Avoided Water Quality Impairments

The fresh water benefit analysis in Section 6.3.1 does not include prospective benefits that are expected to accrue from municipal measures to address post-construction runoff control. This is because the benefit analysis is based on current water quality impairment levels in the 305(b) report. Post-construction runoff control measures will mitigate future impairment to water

bodies by controlling contaminated storm water runoff from sites that are developed or redeveloped in the future. Without this provision, national water quality impairment would increase relative to the impairment levels currently reported in the 305(b). This section describes the approach developed by EPA to estimate potential benefits of avoiding future water quality impairment.

New development and redevelopment activities can increase the types and amounts of pollutants that enter waterways in storm water runoff by increasing the amount of impervious surface and the presence of contaminants. Storm water quality sampling results from EPA's Nationwide Urban Runoff Program show that development activities increase contaminant concentrations in runoff. Exhibit 6–10 compares mean concentrations of pollutants in runoff from residential and commercial areas with runoff from nonurbanized areas. Runoff concentrations of a wide variety of contaminants from land converted to residential and commercial use are fairly comparable, but both are substantially greater than runoff concentrations from nonurbanized land. Subsequent studies have shown that annual pollutant loadings from residential, commercial, and industrial areas can be one to three orders of magnitude greater than loadings from areas with low levels of impervious surface such as parks, and the concentrations of some pollutants in urban runoff are comparable to untreated domestic wastewater (US EPA, 1998a).

Exhibit 6–10. Mean Contaminant Concentrations in Storm Water Runoff from Developed and Nonurbanized Areas

Pollutant (units)	Residential Use	Commercial Use	Nonurban Use
BOD (mg/l)	10	9.3	—
COD (mg/l)	73	57	40
TSS (mg/l)	101	69	70
Total lead (µg/l)	144	104	30
Total Copper (µg/l)	33	29	—
Total Zinc (µg/l)	135	226	195
Total Kjeldahl Nitrogen (µg/l)	1900	1179	965
Nitrate + Nitrite (µg/l)	736	572	543
Total Phosphorus (µg/l)	383	201	121
Soluble Phosphorus (µg/l)	143	80	26

Source: US EPA (1983) as cited in US EPA (1998a).

Under the post-construction runoff control provision, developments in the urbanized areas of Phase II communities that disturb between one and ten acres may implement structural and nonstructural BMPs to minimize the impact of development on storm water runoff. These BMPs are designed to remove pollutants from storm water through settling or filtration. Studies of the types of BMPs included in the cost analysis in Chapter 4 demonstrate their effectiveness in reducing the pollutant loadings in runoff. Exhibit 6–11 summarizes some of the potential loadings reductions.

Exhibit 6–11. Effectiveness of BMPs in Removing Contaminants from Storm Water Runoff

BMP	Median Removal (Percent of Loading without BMP)									
	TSS	TDS	BOD/ COD/ TOC	Total N	Total P	FC	Cd	Cu	Pb	Zn
Detention Pond	7	ND	–1	5	10	ND	54	26	43	26
Infiltration trench/basin	99	ND	90	60–70	65–75	98	95–99	95–99	95–99	95–99
Sand Filter	87	16	66	44	44	51	ND	34	71	80
Swale	81	ND	67	ND	ND	–58	42	51	67	71

Source: US EPA (1998b)
Note: ND = insufficient data

EPA assumes that future new development and redevelopment activities in urbanized areas of Phase II communities will lead to further impairment of fresh water resources. To characterize the potential degree of the additional impairment attributed to urban runoff impairment sources that the rule addresses, EPA assumed that baseline impairment would increase at roughly the same rate as development. EPA calculated area disturbed to approximate the rate of development by dividing the annual development acreage implied in the cost analysis by an estimate of the total urbanized area in Phase II communities. The development acreage was calculated as the product of the number of construction starts in each size category by the midpoint acreage of that category. This generated a total disturbed area estimate of roughly 40,000 acres for the multi-family residential, commercial, and institutional construction starts. An additional 7,000 acres were added to this total to account for single family residential construction starts. These starts are excluded from the cost analysis because EPA determined that the flexibility of the rule would enable developers to satisfy the goals of this provision without incurring significant additional costs. However, due to the use of nonstructural practices such as improved site design that minimize impervious areas, they are part of the baseline development against which benefits are estimated.

Thus, the total disturbed area potentially affected by the rule is 47,000 acres, which accounts for about 0.17% of the 27.3 million acres of urbanized area in Phase II communities. Although a larger percentage of land in Phase II urbanized areas is disturbed on an annual basis, some of the disturbance should not further impair water quality because it falls under an equivalent runoff control program (e.g., industrial developments, developments that disturb more than 10 acres, and development in coastal counties that are covered by an equivalent CZARA program), and some of the disturbance that may further impair water quality is not affected by the rule (e.g., construction starts that disturb less than one acre). EPA also assumed that all of the construction starts in the cost analysis would cause future water quality impairments, regardless of whether they are new development or redevelopment starts.

Assuming that the incremental impairment of new development and redevelopment activities is roughly proportional to the amount of land disturbed, EPA multiplied the 0.17% by the urban

runoff/storm sewer impairment attributed to Phase II communities, shown in Exhibit 3–10. Exhibit 6–12 summarizes the resulting incremental impairment estimates, which EPA then multiplied by the adjusted household WTP values used in the fresh water analysis in Section 6.2.1 to obtain benefit estimates. These estimates range from a low of almost $308,000 to a high of over $950,000 per year for a single year of construction starts. Because the rule affects new construction starts each year, EPA assumes that it mitigates the potential water quality impairments from an additional 47,000 disturbed acres each year.

Exhibit 6–12. Potential Annual WTP Estimates for Fresh Water Impaired by One Year of New Development and Redevelopment Activities (1998 dollars)

Designated Use	Adjusted Household WTP	Impairment from Urban Runoff/ Storm Sewers	Incremental Impairment from New Development and Redevelopment Activities	Aggregate WTP[1] (millions)
Low Estimate (Based on Impairment Data for Rivers)				
Aquatic Life Support	$158	0.36%	0.0007%	$0.12
Fish Consumption	$158	0.19%	0.0004%	$0.06
Primary Contact—Swimming	$177	0.24%	0.0005%	$0.09
Secondary Contact—Boating, etc.	$210	0.22%	0.0005%	$0.10
Subtotal (upper bound)[2] Capitalized stream[4]				$0.37 $2.62
Subtotal (lower bound)[3] Capitalized stream[4]				$0.31 $2.17
High Estimate (Based on Impairment Data for Lakes)				
Aquatic Life Support	$158	0.70%	0.0014%	$0.23
Fish Consumption	$158	0.79%	0.0016%	$0.26
Primary Contact—Swimming	$177	0.56%	0.0012%	$0.21
Secondary Contact—Boating, etc.	$210	0.56%	0.0012%	$0.25
Subtotal (upper bound)[2] Capitalized stream[4]				$0.96 $6.74
Subtotal (lower bound)[3] Capitalized stream[4]				$0.69 $4.88

[1] Based on 103 million households (US Bureau of the Census, 1998a). Results subject to rounding.

[2] Totals may not add due to rounding. Includes all designated uses.

[3] Totals may not add due to rounding. Excludes fish consumption values.

[4] Annual benefits were capitalized over a 10-year period assuming a 7% discount rate.

Because these are annual WTP estimates to avoid incremental impairments to water quality, they accrue each subsequent year that O&M expenditures are incurred to maintain the effectiveness of BMPs. To adequately represent the annual social costs imposed by installing and maintaining BMPs on approximately 15,000 new construction starts per year, total annual BMP costs in Chapter 4 included construction costs and a capitalized O&M value representing the 10-year stream of the O&M costs that would be incurred annually to maintain those BMPs over time. To make the benefit analysis comparable with the cost analysis, EPA similarly capitalized the benefit stream that corresponds with this O&M stream, assuming the same 10-year period and 7% discount rate. The resulting ranges of annual benefits, which are ongoing benefits that have been capitalized to the year the BMP is installed, are shown in Exhibit 6–12 ($2.2 million to $2.6 million for the low estimate and $4.9 million to $6.7 million for the high estimate).

There are a number of potential biases in this approach. The 305(b) data may include new development or redevelopment impacts on water quality in other impairment source categories such as construction or habitat modification. Consequently, restricting the analysis to the urban runoff category may underestimate the potential impairment. Also, the assumption that future impairment will increase in a roughly proportional manner with the share of urban area that is disturbed may overestimate or underestimate water quality impacts. There is some evidence that the hydrologic impacts (e.g., streambed erosion) of storm water impacts are difficult to mitigate once impervious surface area surpasses 20%. The 305(b) results suggest, however, that such hydrologic changes are considered to be relatively minor sources of impairment compared to the types of contaminants found in urban runoff (e.g., siltation, nutrients, and pathogens). Nevertheless, if water quality throughout the urbanized areas is already substantially degraded such that incremental development activities have a small marginal impact on quality, then the analysis overestimates the potential impairment and subsequent benefits. If, however, water quality near undeveloped areas is relatively high, then the marginal impact of development activities may be greater than the proportional analysis suggests.

EPA applied the same municipal program effectiveness percentages used in Section 6.3.1 to the potential benefits of the post-construction runoff control provision. Assuming municipal program effectiveness ranges from 60% to 100%, Exhibit 6–13 summarizes the range of annual future benefits.

Exhibit 6–13. Potential Annual Benefits of Avoiding Future Fresh Water Impairments from New Development and Redevelopment Activities in Phase II Urbanized Areas (Millions of 1998 dollars)

Municipal Program Effectiveness[1]		
60%	80%[2]	100%
Low Estimate (based on impairment data for rivers)[3]		
$1.3–$1.6	$1.7–$2.1	$2.2–$2.6
High Estimate (based on impairment data for lakes)[3]		
$2.9–$4.0	$3.9–$5.4	$4.9–$6.7

[1] Figures subject to rounding.

[2] EPA expects that municipal programs will strive to achieve at least an 80% effectiveness.

[3] Adjusted for program effectiveness (e.g., for rivers: $2.2 × 80% = $1.7; $2.6 × 80% = $2.1).

6.3.3 Potential Value of Improved Marine Waters

The Phase II rule will affect marine waters as well as fresh waters. Consequently, EPA anticipates additional benefits as a result of improvements to marine waters. These benefits are not reflected in the analyses above because the WTP estimates from the Carson and Mitchell study only capture fresh water benefits.

Benefits to Commercial Fisheries

Commercial marine fisheries are a significant part of the nation's economy. In 1997, the value of the commercial finfish catch was $581 million and the value of the commercial shellfish catch was $1.04 billion (National Marine Fisheries Service, 1997). However, as noted in Chapter 2, the pollutants found in storm water such as pathogens and silt can adversely affect the productivity and viability of fisheries populations. Although several studies document the adverse effects of pollution on fish and shellfish, there are limitations to estimating marine commercial fishing benefits. To develop a defensible, "bottom-up" economic valuation approach EPA would need to quantify three links: how changes in urban runoff affect marine water quality, how changes in marine water quality affect fishery productivity, and how changes in fishery productivity affect the commercial catch and resulting producer and consumer surplus measures. Although there is limited information for the first and third links (e.g., the 305(b) water quality impairment data and total commercial catch values and estimates of surplus measures), there is little quantitative information regarding the second link. EPA is aware of proposed research efforts to develop such links between water quality variables and fishery characteristics, but research in not complete at this time. Thus, national level estimates are not feasible.

Despite these noted difficulties and the lack of national level data, EPA did attempt to characterize the impacts of storm water runoff on commercial fisheries for areas of the country where fisheries are a significant part of the economy: Puget Sound, Gavelston Bay, and the Gulf of Mexico. While fisheries experts and state officials were able to confirm that pathogens have indeed adversely affected or caused the closing of various fisheries, they were unable to identify

the source of contamination. Furthermore, those contacted were unaware of any completed comprehensive studies on the economic impacts of pollution on commercial fishing, including pollution associated with storm water runoff.

The baseline value of commercial fishing can be characterized using the available national level catch data described above. Because the national value of finfish and shellfish catches are high, even a small contribution to enhancing these values (e.g., through the reopening of shellfish beds) is potentially large. For instance, if controlling runoff from Phase II communities led to a relatively small 1% increase in the value of the shellfish catch, the corresponding market value would be about $10 million.

Benefits from Enhanced Marine Recreational Fishing

The 1996 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation reveals that 9.4 million anglers participated in saltwater fishing in 1996 (US Department of the Interior, 1998). In addition, a review of the literature by Freeman (1993) suggests that one year's access to a multi-species fishery per person could be as high as $120 to $1,200 (1998 dollars). If 9.4 million anglers participate in saltwater fishing, the potential value of marine recreational fishing is $1.1 billion to $11.3 billion per year. However, poor water quality may affect fishery populations and may negatively affect participation and the enjoyment associated with fishing trips. Thus, implementation of the Phase II rule may increase the value of fishing experiences and lead to increased participation.

There are, however, limitations associated with estimating the benefits to marine recreational fishing that are similar to those associated with commercial marine fishing. For instance, although travel cost models may provide information about how changes in catch rate affect recreational angling values, EPA lacks quantitative data regarding how loadings reductions are likely to affect fish populations and catch rates. In addition, as noted by Freeman (1993), benefit estimates are difficult to transfer because estimates vary widely based on the characteristics of individuals, species of fish studied, number of species included in the study, and estimation techniques. For these reasons, EPA did not estimate national benefits of recreational fishery improvements. Because marine recreational fishing is a highly valued activity, even a slight improvement could yield large benefits. For example, if controlling runoff from Phase II communities led to a relatively small 1% increase in recreational fishing, the corresponding potential value would be between $11 million to $113 million per year.

Benefits from Enhanced Marine Recreational Swimming

There is little question that marine recreational swimming is an activity enjoyed by many people. EPA estimates that Americans participated in approximately 1.3 billion nonpool swimming days in 1998, using current population estimates (US EPA, 1995c). Furthermore, EPA (US EPA, 1995c) estimates that approximately 44.6% of swimming trips were to the ocean. Multiplying these figures yields almost 580 million swimming trips to oceans per year. To approximate the number of people swimming at ocean beaches potentially impacted by the Phase II rule, EPA assumed that the total number of swimming trips is distributed among Phase I and Phase II beaches in the same way that the coastal population is distributed between Phase I and Phase II communities. Approximately 32.0 million people reside in Phase II communities that are located

in coastal counties and approximately 111.7 million US residents live in coastal counties. Thus, about 28.7% of the coastal population lives in Phase II communities, and the number of swimming trips allocated to Phase II communities is about 166 million trips, which is equivalent to approximately five trips per person per year for the coastal residents.

This approach may tend to overestimate the number of swimming trips to beaches in Phase II communities because it does not allocate trips to beaches that are located outside Phase I and Phase II communities, e.g., at national parks. On the other hand, however, this approach may tend to underestimate the number of swimming trips to beaches in Phase II communities because it assumes that a large share of trips occur in Phase I coastal communities (e.g., Baltimore and the Bronx) although many people in those communities may travel to beaches in smaller coastal communities to swim. In the absence of better national visitation data for Phase II beaches, EPA assumes that these potential sources of bias offset one another.

Unfortunately, fecal coliform concentration and other pollutants such as oil, grease, and litter, may degrade beach quality and thus inhibit people's enjoyment and participation in outdoor swimming. Degradation of beach waters can also result in beach closures that prohibit swimming, resulting in welfare losses. EPA anticipates that the Phase II rule will reduce these losses.

To evaluate the potential benefits of reducing beach closures in Phase II communities, EPA used information on beach use and closures from beaches in 159 Phase II communities in the EPA Beach Watch program. This program only includes data for beaches that monitor and report water quality and beach closures. There are 428 beaches in the dataset that are in Phase II communities; the number of beaches in Phase II communities that do not monitor or report is unknown. The data include daily visitation estimates and the reported number of closings for each beach in 1997, both categorized by weekday, weekend, holiday, peak and nonpeak season. EPA multiplied these visitation rates by the number of daily beach closings per beach and then summed over all the Phase II beaches in the dataset to produce a total of 86,100 lost beach days caused by beach closures. This estimate is subject to some limitations. It is important to note that several beaches in the dataset did not report visitation statistics and EPA estimated that zero visits were lost at these beaches, thereby understating lost beach days. Another limitation is that these beaches reported storm water as a significant source of pollution, but elevated bacteria levels were ultimately the reason for the closures. Some of the elevated bacteria levels may have sources other than storm water, so the estimate may overstate lost beach days.

To value these lost beach days, EPA reviewed two meta-analyses, Walsh et al. (1990) and Freeman (1993) to obtain a mean benefit measure of $30.00 per person per visit for a beach day.[7] The literature included in the meta-analyses mostly used the travel cost method to estimate the consumer surplus per person per day. The majority of these studies accounted for the effects of substitution between different beach sites with the use of dummy variables. However, some of the work included in the Walsh et al.(1990) meta-analysis that used the contingent valuation

[7] EPA used the mean of the aggregate value for swimming from the Walsh et al. (1990) and the value from the Leeworthy and Wiley (1991) study included in the Freeman (1993) analysis.The Leeworthy and Wiley estimates of $19.41 are in 1988 dollars and the Walsh et al. estimates of $22.97 are in 1987 dollars. To derive a mean benefit measure, both estimates were adjusted to 1998 dollars using the CPI.

method did not explicitly account for substitute sites, thus potentially biasing the estimate upward.

Using the $30.00 per person per day estimate of consumer surplus for a beach visit and the 86,100 lost beach days yields approximately $2.6 million in lost swimming benefits. This estimate is expected to be a subset of marine recreational swimming benefits because it does not account for the increased participation of those who are not currently swimming, but would do so after an improvement in water quality. That is, this value only represents the benefits existing users have at current water quality levels and does not account for the increased potential enjoyment of new and existing swimmers for a water quality improvement. Thus $2.6 million can be taken as a lower bound to lost marine swimming benefits.

The extent to which the Phase II rule will reduce the incidence of beach closures is uncertain. Exhibit 6–14 reports an effectiveness range for municipal programs that is similar to ranges reported earlier.

Exhibit 6–14. Potential Annual Benefits of Reducing the Number of Beach Closures in Phase II Communities (Millions of 1998 dollars)

Municipal Program Effectiveness [1]		
60%	80%[2]	100%
$1.6	$2.1	$2.6

[1] Adjusted for program effectiveness (e.g., $2.6× 80% = $2.1). Figures subject to rounding.

[2] EPA expects that municipal programs will strive to achieve at least an 80% effectiveness.

Benefits of Reduced Health Risks from Swimming

One of the anticipated benefits of the Phase II rule is a reduction in human health risks caused by swimming in contaminated waters. Although the Carson and Mitchell survey asked respondents to state a value for swimmable water quality, EPA does not believe that waters identified as swimmable according to federal standards are completely free of potential health risks. Indeed, EPA estimated that 19 out of 1,000 persons swimming in ocean and bays just meeting the acceptable standard of 35 enterococcus bacteria per 100 milliliter of water will become ill (EPA, 1986). In addition, the health risks associated with swimming in contaminated marine waters are not included in the estimates because the Carson and Mitchell study includes only fresh waters.

To estimate the benefits of reduced health risks associated with swimming in marine waters, EPA extrapolated health impacts from an epidemiological study of swimmers at Santa Monica Bay, conducted by Haile et al. (1996) to a national level. This section briefly summarizes the benefit analysis, which is discussed in further detail in Appendix C.

The Santa Monica Bay study of 13,278 swimmers found swimmers within 100 yards of storm drains experienced increased incidences of gastrointestinal and respiratory diseases, and that illness rates were often highest among those who swam in the immediate vicinity of the storm drain (Haile et al., 1996). The increased incidence of illness was associated with swimming in

areas where monitoring results showed high densities of bacterial indicators. The study identified illicit connections to storm sewer drains as possible sources of contamination.

EPA developed a method for extrapolating the results of the Santa Monica Bay study that did not require water quality monitoring data, which is often not available for beaches in Phase II communities. The Santa Monica Bay study reported "attributable numbers," which characterized the additional number of illnesses occurring among the people who swam near the storm sewer drains compared to baseline illness incidences among swimmers who were more than 400 feet away from a storm drain. These attributable numbers provide a means for estimating the number of incremental illnesses at total coliform (TC) concentrations above or below a 1000 cfu/100 ml cutpoint. EPA verified that concentrations above and below the cutpoint were possible at storm sewer drains (see Appendix C). Then, using exposure information from the Santa Monica Bay study, EPA estimated that of the 166 million swimming trips to beaches in Phase II communities, 11.6 million trips may bring swimmers within the vicinity of a storm sewer outfall (see Appendix C).

EPA multiplied the attributable numbers by the exposure range to obtain estimated incremental illnesses. For highly credible gastroenteritis two (HCGI 2), defined as a person having vomiting and fever, the additional cases range from 35,795 for low contamination to 118,501 for high contamination. For significant respiratory disease (SRD), defined as a person having fever and nasal congestion or fever, sore throat and cough with sputum, the increased cases range from 0 for low contamination to 119,199 for high contamination. Other health effects included fever, chills, nasuea, vomitting, diarrhea, cough, cough with phlem, runny nose, sore throat, and highly credible gastroenteritis one (HCGI 1), defined as a person having vomiting, diarrhea and fever or stomach pain and fever. These various conditions are expected to increase by 249,340 cases, for high contamination exposures. However, EPA only applied economic values to two of the health effects, significant respiratory disease (SRD) and highly credible gastroenteritis 2 (HCGI 2), because of the unknown overlap between other health effect categories and a lack of valuation information for many of the health effects.

If the Santa Monica Bay study results are indicative of national swimming activity, avoided health impacts among children may make up a disproportionate share of the potential health benefits. Among the study sample, children appeared more likely than adults to swim near storm sewer drains in the study; children made up 48% of the study sample, but they accounted for 62% of the subsample that swam within one yard of a drain.

Since SRD and HCGI 2 are the only health effects accounted for, the consquent health benefits are underestimated. For the SRD cases, EPA used WTP values reported in EPA (1997d) to avoid upper respiratory symptoms, which was $19 per case in 1990 dollars. The symptoms associated with this illness are head/sinus congestion, cough, and eye irritation (US EPA, 1997d), which are similar to the symptoms for the SRD category. This value potentially underestimates losses associated with SRD cases because it does not include the value of any foregone work or leisure activities. The Santa Monica Bay study did not collect such information. EPA assumed that the combination of symptoms was severe enough to constitute one mild restricted activity day per case, which is valued at $38 per day (US EPA, 1997d). EPA escalated both of these values to 1998 dollars using the CPI. The adjustment factor is 1.24, which equals 163.0 (annual average

CPI for 1998) divided by 130.7 (annual average CPI for 1990). The resulting values are $24 per case for upper respiratory symptoms and $47 per day for a mild restricted activity day.

For the HCGI 2 cases, EPA used cost of illness (COI) values estimated by Mauskopf and French (1991) for related gastrointestinal illnesses. Exhibit 6–15 summarizes the illnesses and symptoms valued by Mauskopf and French, average illness durations, and COI estimates based on medical and work loss estimates. EPA did not attempt to adjust the COI values to WTP values, which are generally higher because they account for nonpecuniary costs such as pain and suffering. The COI in Mauskopf and French were estimated on a per case basis. The symptoms for moderate salmonellosis better match the HCGI 2 symptoms (vomiting and fever). The potential duration for HCGI 2 cases, however, is more comparable to the three-day duration of mild salmonellosis: one to 10 days for viral infections and four to six days for *e. coli* infections (Center for Disease Control and Prevention, 1998 and 1994). Consequently, EPA used the $197 per-case cost ($1990) for a mild case of salmonellosis to value the benefits of avoided HCGI two cases; escalated for inflation, the COI value per case is $244 ($1998).

Exhibit 6–15. Cost of Illness Estimates for Gastrointestinal Illnesses

Illness	Symptoms	Length	Treatment	Total COI[1] ($1990)	Total COI[1] ($1998)
Mauskopf and French (1991)					
Botulism–mild	malaise, weakness, fatigue	5 days	antitoxin	$470	$583
Salmonellosis–mild	nausea/vomiting, diarrhea, abdominal pain, anorexia, weakness	3 days	oral fluids, antispasmodics	$197	$244
Salmonellosis–moderate	same as mild plus fever, headache, dehydration/ prostration	7 days	oral fluids, antispasmodics	$622	$771

Source: Mauskopf and French (1991).

[1]Original 1990 values escalated to 1998 values using the CPI for all items. The adjustment factor of 1.24 equals 163.0 (annual average CPI for 1998) divided by 130.7 (annual average CPI for 1990).

Exhibit 6–16 summarizes estimated health benefits associated with the Phase II rule. For each symptom category, EPA multiplied the number of cases estimated for the two exposure assumptions and the two TC concentration levels by the appropriate per case value. The annual benefit estimate for the low contamination assumption is $8.7 million. EPA believes this underestimates the potential low range of health benefits because the attributable number for SRD below the 1000 cfu/100 ml cutpoint is zero. A method based on a dose-response function would most likely generate a positive value for the low range of SRD cases. The benefit estimate for the high contamination assumption is over $37 million per year. This estimate most likely overstates annual benefits for these particular health effects because it assumes that concentrations at all storm sewer drains exceeds 1000 cfu/100 ml at all times swimmers are nearby, which is not likely. Exhibit 6–17 summarizes benefits after adjusting these values for the range of municipal program effectiveness assumptions.

Exhibit 6–16. Summary of Potential Marine Health Benefits by Symptom, Exposure Assumption, and Total Coliform Concentration at Outfall

Symptom	WTP or COI Value[1]	Low Contamination (TC <1000 cfu/100 ml)	High Contamination (TC >1000 cfu/100 ml)
HCGI 2	$244 per case	$8,733,980	$28,914,244
SRD	$24 per case $47 per day	$0	$8,463,129
Total		$8,733,980	$37,377,373

[1] COI value for HCGI is the per day value for a mild case of salmonellosis from Mauskopf and French (1991), adjusted from 1990 to 1998 dollars. The WTP value for a case of SRD is the sum of the upper respiratory symptom value and the mild restricted activity day value from EPA (1997b), adjusted from 1990–1998 dollars. In both instances, the adjustment factor is 1.24, which equals 163.0 (annual average CPI for 1998) divided by 130.7 (annual average CPI for 1990).

Exhibit 6–17. Potential Annual Benefits of Avoided Health Impacts from Swimming in Contaminated Marine Waters in Phase II Communities (Millions of 1998 dollars)

Municipal Program Effectiveness[1]		
60%	80%[2]	100%
$5.2–$22.4	$7.0–$29.9	$8.7–$37.4

[1] Adjusted for program effectiveness (e.g., $8.7 × 80% = $7.0). Figures subject to rounding.

[2] EPA expects that municipal programs will strive to achieve at least an 80% effectiveness.

6.3.4 Potential Benefits of Construction Site Controls

The national benefits of construction site storm water runoff controls will also depend on a number of factors, including the number, intensity, and duration of wet weather events; the effectiveness of the selected construction site BMPs; the site-specific water quality and physical conditions of receiving waters; the current and potential uses of receiving waters; and the existence of nearby "substitute" sites of unimpaired waters. Again, because these factors will vary substantially from site to site, data are not available with which to develop estimates of benefits for each site.

Nonetheless, a survey of North Carolina residents (Paterson et al., 1993) indicates that households are willing to pay for erosion and sediment controls similar to those contained in the Phase II program. This study provides one way to develop national level benefits estimates of the rule and, therefore, EPA chose to use benefit transfer methodology to apply the study results. Paterson et al's. (1993) study is applicable to the construction component of the Phase II rule not only because North Carolina's program requires similar controls, but also because the median income of North Carolina residents is just below the median income for the United States. The similarity of the median incomes indicates that the WTP estimates developed by Paterson et al.

(1993) may reflect the WTP of residents elsewhere in the United States. Furthermore, two other surveys conducted at approximately the same time—one in Maryland and one in Wisconsin—obtained comparable WTP estimates to improve water quality.

Value of North Carolina Storm Water Program

In North Carolina, any activity disturbing one or more acres is regulated by an erosion and sediment control program. In 1990, Paterson et al. (1993) conducted a CV survey of North Carolina residents in urban areas to determine their WTP for the program. For the survey sample, the authors randomly selected urban residents from one of three geographic regions in the state: Asheville (Mountain region), Durham (Piedmont region), and Wilmington (Coastal Plain region). These regions also represented a range of soil erosion conditions.

First, the survey explained the problems associated with sedimentation and the procedures commonly used to control soil erosion and prevent sedimentation. The "harmful or costly effects" from sedimentation described to respondents were (Malcom et al., 1990):

- Killing fish and other water life, reducing catches for fishermen
- Reducing the depth of streams, rivers, and lakes, increasing the possibility of flooding, and requiring expenditures for either flood control or the removal of sediment from the bottom by "dredging"
- Filling reservoirs with dirt, reducing the amount of water in the reservoir and requiring additional expenditures either to remove the sediment from the bottom of the reservoir or to build more reservoirs
- Causing rivers, streams, and lakes to appear muddy and less attractive to hikers and swimmers
- Filling channels used for recreational boating and commercial fishing, requiring removal of sediment by dredging.

Procedures available to developers for controlling sedimentation that were outlined and illustrated for respondents were (Malcom et al., 1990):

- Rapid completion of construction so that land is disturbed for short periods of time
- Construction of sediment trapping devices, including ponds and ditches, so that sediment is kept on the property, and does not wash into a nearby river, stream, or lake
- Construction of silt fences or check dams to catch or slow down sediment runoff before it reaches a nearby water body
- Use of stone-lined or paved channels to direct water runoff away from vegetation, especially on steep slopes
- Sodding and tree protection to preserve the natural ground cover.

Respondents were asked to assume that no funding sources for administration of the program existed, and that the public would pay for all administration, monitoring, and enforcement costs. Respondents were then asked about their recreational activities and to state their willingness to contribute to a special fund to administer, monitor, and enforce sediment control measures. Finally, respondents were asked about household characteristics and their opinions on environmental quality.

It is important to note that Paterson et al. conducted their survey in 1990, based on the state of contingent valuation (CV) science in the late 1980's; CV survey methods and analytical techniques have developed considerably since then. In particular, the survey predated publication of proposed recommendations developed by the NOAA Panel on Contingent Valuation (58 FR 4601). Nevertheless, the survey was reviewed and pretested prior to implementation (Lindsey, Paterson, and Luger, 1995) and the research team followed the recommendations in Mitchell and Carson (1989) to the extent possible (R. Paterson, personal communication, January, 1999). The authors also obtained technical advice from Dale Whittington, who is well recognized in the fields of water resource economics and nonmarket valuation.

Although the response rate to the mail survey was only 41%, this response rate is similar to response rates for other mail surveys that obtain WTP values for policy development. For example, a 1987 CV study for Mono Lake, California had a 44% response rate (J. Loomis, personal communication, January, 1999), and the recreation demand study for the Columbia River System Operation Review Environmental Impact Statement (Cameron et al., 1999) had a raw response rate of 36%.

Discussion of Survey Results

Paterson et al.'s (1993) analysis of the survey results indicated a mean of $20 per year (in 1990 dollars). This estimate is a simple statistic calculated from the open-ended valuation question that followed the dichotomous choice question. EPA adjusted the mean WTP value to $25 to account for inflation from 1990 to 1998.[8]

The good that the authors asked respondents to value was a program that would administer, monitor, and enforce requirements that developers control erosion from construction sites. It is likely that the average household WTP responses reflect values for avoiding the sedimentation damages caused by construction site erosion because the survey discussed these types of damages (especially impacts on water-based recreational activities) and included photos showing examples of eroded construction sites with descriptions of adverse watershed impacts. Furthermore, 56% of the respondents reported participating in water-based recreational activities and would be more likely be familiar with water quality impacts on these activities than people who do not engage in such recreation activities (Lindsey, Paterson, and Luger, 1995).

The respondents provided only their WTP for a state program that would help protect water quality (respondents were told that developers would pay for their own erosion control measures). Therefore, they may have provided lower bound estimates of their WTP to prevent

[8]Based on the change in the CPI from 1990 to 1998 (1.25%) as reported in the Economic Report of the President (Office of the President, 1998). Note again that currently there is a debate regarding the accuracy of the CPI.

construction site sedimentation damages in urban runoff either because they internalized development price increases or because they engaged in free riding behavior.

The survey did not provide specific quantitative information about how water quality would be affected by the program[9]. This potentially raises the question of whether the respondents are valuing a well-defined environmental good or whether their WTP really reflects a willingness to support environmental quality in general. It is useful to note, however, that a coincident water quality study obtained higher WTP estimates for a specific good: reduced nutrient loadings in urban runoff for the Chesapeake Bay. Lindsey (1992) obtained WTP estimates for a new government program to reduce nutrient loadings to the Chesapeake Bay from urban storm water runoff. Annual WTP for a 4% reduction in loadings was $42 and the WTP for a 1% reduction was $24 (Lindsey, Paterson, and Luger, 1995). This study demonstrates scope effects (i.e., WTP varies with the level of provision and, thus, provides evidence it represents values for an environmental good rather than a "warm glow") and elicits WTP for a similar type of water quality impact (i.e., a small change in the effect of urban runoff on water quality). Consequently, it provides support for the contention that the WTP values in the North Carolina study represent benefits of improved water quality[10]. It further suggests that the WTP values obtained in the North Carolina study are not particular to North Carolina residents.

Benefit Transfer of Survey Results

Although North Carolina's erosion and sediment control program is similar to the construction site controls of the Phase II rule, the program covers all activities disturbing one or more acres whereas the Phase II rule covers construction sites between one and five acres in size. Other states also have soil and erosion programs in place that are similar to Phase II (including CZARA states with primary enforcement). Therefore, to transfer Paterson et al.'s results to estimate the potential benefits of the Phase II rule, EPA calculated the percentage of Phase II construction starts that are not covered by a state program or CZARA.

Nonurban households were not surveyed by Paterson et al. (1993) and EPA has no information on the WTP of these households. However, it is likely that these households also value soil and erosion control programs. One variable that may indicate potential differences in WTP is income. However, the per capita incomes of the urban residents surveyed by Paterson et al. reflect the range of incomes throughout the State. Thus, EPA does not believe that the value to urban residents would be significantly different from that of nonurban residents. Therefore, EPA estimated the aggregate WTP for all households.

If construction site erosion rates are higher for North Carolina than for other areas of the country, the WTP values to prevent erosion from migrating off-site may be greater in North Carolina as well. However, it is likely that erosion rates differ within North Carolina, so there is no one figure to use for comparison. Likewise, storm water erosion rates elsewhere differ across a

[9]EPA is similarly unable to quantify water quality impacts of the Phase II rule because damage functions are not available to estimate how the soil erosion controls might avoid future impacts on water quality. Consequently, the good in the survey more closely approximates the provisions of the rule than any household benefits measure that could derived from the Carson and Mitchell (1993) water quality study.

[10]Lindsey, Paterson, and Luger (1995) note that North Carolina State officials used the results of the Paterson et al. (1993) benefit-cost analysis in educational workshops in New England to assist states considering similar construction erosion control programs.

variety of geological and climatological dimensions. The CV study developers were sensitive to this issue and developed a stratified sampling plan to include respondents from three major geological regions of the state: the coast (sandy soils), the Piedmont (clay soils), and the mountains (Paterson et al., 1993 and R. Paterson, personal communication, January, 1999). Consequently, the aggregate values represent WTP across respondents who are familiar with a variety of soil types. Therefore, EPA did not adjust WTP for households to account for differences in watersheds.

As shown in Exhibit 6–18, EPA multiplied the percentage of Phase II construction starts by the number of households and by the $25 WTP value. For example, in Virginia, 21.6% of construction starts in 1994 were on sites of between one and five acres and were not regulated to control storm water runoff under a state program or CZARA. Also, in 1997, there were approximately 2,522,096 urban households in Virginia.[11] To estimate the number of households using the WTP estimate of $25, the calculation is:

($25 adjusted WTP) × (2,522,096 households) × (21.6% Phase II starts) = $13.59 million.

EPA considers the resulting benefit estimate a high estimate because using the percentage of construction starts potentially overstates the contribution of the Phase II starts to overall soil erosion caused by construction activities. As a lower bound, EPA used shares based on site perimeter, which was chosen as a proxy for the share of eroded soils that would migrate offsite from different sizes of sites during construction. To estimate the share for each state, EPA estimated aggregate site perimeter length assuming square sites and taking the acreage midpoints for site size for all of the Phase II starts and for all starts. Exhibit 6–19 reports the site-specific assumptions used to calculate the perimeter shares. Exhibit 6–18 reports the resulting percentages, which are lower than the percentages calculated on a start basis.

Exhibit 6–18. Potential Annual WTP for the Phase II Soil and Erosion Control Program (1998 dollars)

State	Phase II Share of Starts	Phase II Share of Perimeter	1998 Households	Benefits ($ millions)	
				Low Estimate	High Estimate
Alabama	40.5%	32.7%	1,617,661	13.21	16.38
Alaska	11.7%	9.5%	228,206	0.54	0.67
Arizona	34.3%	25.9%	1,705,980	11.06	14.63
Arkansas	41.1%	32.9%	944,876	7.76	9.72
California	36.3%	27.8%	12,085,506	83.99	109.67
Colorado	39.7%	32.1%	1,457,919	11.68	14.49
Connecticut	0.0%	0.0%	1,224,666	0.00	0.00
DC	0.0%	0.0%	274,000	0.00	0.00
Delaware	0.0%	0.0%	198,114	0.00	0.00
Florida	0.0%	0.0%	5,488,369	0.00	0.00
Georgia	18.0%	11.4%	2,803,836	8.02	12.59
Hawaii	36.0%	27.3%	444,420	3.03	4.00
Idaho	41.0%	32.9%	453,270	3.73	4.65

[11]Estimates of households per state are based on the most recent estimate of population by state from 1997.

Exhibit 6–18. Potential Annual WTP for the Phase II Soil and Erosion Control Program (1998 dollars)

State	Phase II Share of Starts	Phase II Share of Perimeter	1998 Households	Benefits ($ millions)	
				Low Estimate	High Estimate
Illinois	40.1%	32.0%	4,455,374	35.68	44.64
Indiana	41.7%	34.0%	2,196,295	18.66	22.90
Iowa	42.2%	34.4%	1,068,323	9.19	11.27
Kansas	41.8%	34.1%	971,850	8.28	10.16
Kentucky	40.6%	32.7%	1,463,717	11.98	14.86
Louisiana	40.8%	33.0%	1,629,876	13.44	16.64
Maine	43.3%	35.9%	465,188	4.17	5.04
Maryland	0.0%	0.0%	1,907,973	0.00	0.00
Massachusetts	7.7%	6.1%	2,291,206	3.48	4.41
Michigan	0.0%	0.0%	3,660,634	0.00	0.00
Minnesota	43.7%	36.5%	1,754,887	16.03	19.18
Mississippi	42.1%	34.5%	1,022,660	8.81	10.78
Missouri	40.3%	32.3%	2,023,243	16.32	20.39
Montana	42.7%	34.8%	329,142	2.86	3.51
Nebraska	39.8%	31.5%	620,551	4.89	6.17
Nevada	33.7%	25.3%	628,018	3.97	5.29
New Hampshire	19.1%	12.3%	439,217	1.35	2.10
New Jersey	0.0%	0.0%	3,016,048	0.00	0.00
New Mexico	40.2%	32.6%	647,847	5.28	6.51
New York	40.0%	31.6%	6,792,969	53.65	67.93
North Carolina	0.0%	0.0%	2,780,967	0.00	0.00
North Dakota	43.1%	35.6%	240,031	2.14	2.59
Ohio	40.2%	32.1%	4,189,637	33.65	42.11
Oklahoma	41.1%	33.4%	1,242,356	10.36	12.78
Oregon	40.7%	32.6%	1,214,789	9.91	12.36
Pennsylvania	0.0%	0.0%	4,501,746	0.00	0.00
Rhode Island	0.0%	0.0%	369,824	0.00	0.00
South Carolina	0.0%	0.0%	1,408,307	0.00	0.00
South Dakota	44.1%	36.7%	276,394	2.54	3.05
Tennessee	40.1%	32.3%	2,010,561	16.24	20.16
Texas	38.2%	29.9%	7,280,651	54.49	69.51
Utah	39.8%	32.0%	771,216	6.16	7.68
Vermont	43.5%	36.1%	220,591	1.99	2.40
Virginia	21.6%	17.3%	2,522,096	10.91	13.64
Washington	38.3%	30.0%	2,101,259	15.76	20.14
West Virginia	30.8%	22.3%	680,070	3.80	5.24
Wisconsin	28.7%	20.4%	1,936,209	9.86	13.89

Exhibit 6–18. Potential Annual WTP for the Phase II Soil and Erosion Control Program (1998 dollars)

State	Phase II Share of Starts	Phase II Share of Perimeter	1998 Households	Benefits ($ millions)	
				Low Estimate	High Estimate
Wyoming	42.8%	35.3%	179,679	1.59	1.92
Total	24.8%	19.5%	100,238,225	540.45	686.02

Exhibit 6–19. Assumptions Used to Derive Perimeter Shares

Site Size Category	Average Site Size	Site Perimeter
0 to 0.5 acres	0.25 acre	417
0.5 to 1 acre	0.75 acre	723
1 to 2 acre	1.5 acre	1,022
2 to 3 acre	2.5 acre	1,320
3 to 4 acre	3.5 acre	1,562
4 to 5 acre	4.5 acre	1,771
5 to 10 acre	7.5 acres	2,286
More than 10 acres	14 acre[1]	3,124

[1] The midpoint for the open-ended size category was estimated using the housing density implied by the sample data shown in Appendix B–2.

EPA then summed the lower and upper bound results across all states. The results indicate that WTP for the erosion and sediment controls of the Phase II rule may range from $540.5 million to $686.0 million per year (Exhibit 6–18).

Small Stream Benefits

The WTP estimates derived above reflect the potential benefits of erosion and sediment control programs that protect all lakes, rivers, and streams. Because construction can be especially harmful to small stream habitat, EPA is interested in the benefits that may be attributable to improvements in small stream ecology. Information on the different proportions of waters in the United States may provide a rough approximation of, and may not fully capture, how these benefits may be attributable to small streams versus larger water bodies. However, such an exercise is complicated because lakes are measured in acres or square miles and rivers and streams are measured in miles. Therefore, EPA converted stream miles to square miles using the average width and depth of each stream order. Based on inventory data reported in state 305(b) reports and the distribution of streams by stream order (Keup, 1985), approximately 20% of all water bodies in the United States are rivers or streams and 10% of rivers and streams are classified as first order streams. First order streams are non branching and form the headwaters of riverine systems. Approximately 2% of all water bodies are first order streams, suggesting that $10.8 to $13.7 million of the total annual benefits from erosion and sediment controls may reflect a desire to protect small streams (2% × $540.5 million and 2% × $686.0 million, respectively).

6.3.5 Summary of Benefits

A summary of the potential benefits from implementing the Phase II municipal measures and erosion and sediment controls for construction sites is presented in Exhibit 6–20. Total benefits from municipal measures and construction site controls are expected to be $671.5 million to $1.1 billion per year (assuming 80% effectiveness of municipal programs), including benefits of approximately $10.8 to $13.7 million per year associated with small stream improvements. The largest portion of benefits are associated with erosion and sediment controls for construction sites.

As shown in the exhibit, some categories of benefits are not included in the WTP estimates from the research used. In particular, values for improving marine water quality (those related to commercial fishing and shell fishing and recreation, e.g. fishing) are not included in the potential benefits of the municipal minimum measures (excluding soil erosion construction sites controls).

Exhibit 6–20. Potential Annual Benefits of the Phase II Storm Water Rule (Millions of 1998 dollars)

Benefit Category	Annual WTP
Municipal Minimum Measures[1]	
Fresh Water Use and Passive Use[2]	$121.9 – $378.2
Marine Recreational Swimming	$2.1
Human Health (Marine Waters)	$7.0 – $29.9
Other Marine Use and Passive Use	+
Erosion and Sediment Controls for Construction Sites	
Fresh Water and Marine Use and Passive Use[3]	$540.5 – $686.0
Total Phase II Program	
Total Use and Passive Use (Fresh Water and Marine)	>$671.5 – >$1,096.2

+ = positive benefits expected but not monetized

[1]Based on 80% effectiveness of municipal programs.

[2]Potential annual benefits of improving fresh water impairment (Exhibit 6–9) plus potential annual benefits of avoiding future fresh water impairment (Exhibit 6–13).

[3]Based on research by Paterson et al. (1993). Although the survey's description of the benefits of reducing soil erosion from construction sites included reduced dredging, avoided flooding, and water storage capacity benefits, these benefit categories may not be fully incorporated in the WTP values. Small streams may account for over 2% of total benefits.

6.3.6 Sensitivity Analysis

As with the cost analysis, the analysis of benefits is subject to uncertainty. EPA conducted a sensitivity analysis to evaluate the impact of key assumptions on the final benefit estimates.

EPA, in its efforts to establish a baseline for water quality impairment attributable to Phase II sources, may have overestimated the extent to which the 305(b) impairment data characterizes unassessed waters. Since 305(b) data is gathered and reported by individual states, the method for deciding which waters to assess will vary from state to state. If some states choose to

monitor only those waters that are likely to be impaired instead of a random sample of waters, then the reported percentage of impaired waters will not be characteristic of the unassessed waters. To determine the sensitivity of benefit estimates to the assumption that waters represented by the 305(b) data characterizes all waters, EPA estimated benefits assuming that only 50% of the unassessed waters are similarly impaired. As Exhibit 6–21 shows, this assumption reduces overall benefits by 8% to 12%.

Exhibit 6–21. Results of Sensitivity Analysis

Assumption[1]	Estimated Total National Benefits (1998 dollars)
Original estimates	$671.5–$1,096.2
Impairment for 305(b) assessed waters applied to 50% of unassessed waters	$619.2–$964.5
Percentage change from original estimates	–8% to –12%

[1] EPA expects that the municipal program will achieve at least an 80% effectiveness.

6.4 Limitations and Uncertainties Associated with the Benefits Analyses

EPA's benefit analysis used two different approaches to estimate potential benefits of the Phase II rule. The first approach used the NWPCAM to simulate the effect of the Phase II municipal minimum measures and soil erosion control provisions on water quality at the local level. Benefits, including benefits accruing to local and nonlocal populations, were estimated to be $1.6 billion per year based on a benefits transfer of WTP values from Carson and Mitchell (1993). The second approach estimated benefits for the municipal minimum measures and the soil erosion control provisions separately. The municipal minimum measures benefit analysis was primarily based on national water quality assessment data in the 305(b) report and Carson and Mitchell's (1993) WTP values for changes in national fresh water quality, although some marine benefits were also estimated. The soil erosion control benefit analysis was based on construction start activity and a WTP value for a similar program in North Carolina. Total benefits for the second approach are estimated to range from $671.5 million to $1,096.2 million per year.

Key limitations and uncertainties associated with the above estimates are summarized by analytical approach in Exhibit 6–22. Among the most important of these limitations is the inability to monetize some categories of benefits, which may underestimate potential benefits. There is also uncertainty associated with the applicability of the WTP values used to estimate benefits of the rule, and with many details of the modeling approach. Some assumptions made to address uncertainty may tend over estimate benefits and others may tend to under estimate benefits. The net effect is unknown.

Exhibit 6–22. Key Limitations and Uncertainties in the Benefits Analysis

Factor	Impact on Benefits Estimates	Comments
National Water Pollution Control Assessment Model Benefits Analysis		
The estimates of potential benefits do not include benefits from improvements to marine waters.	–	Uses of marine waters (e.g., commercial fishing and shellfishing, recreational fishing, and swimming) are highly valued. The model does not include marine water, nor do the WTP values reflect household benefits associated with improved marine water quality.
The WTP estimates were assigned to "local" waters on the basis of changes to local water quality rather than statewide water quality.	+	Survey respondents assigned two thirds of their total valuation for water quality improvements to improvements in in-state waters. By assigning this share to improvements in local waters, the analysis may have overstated WTP for these improvements.
The small stream analysis may have overstated improvements to small streams.	+	Because small streams were modeled only as conduits from construction sites to RF1 waters, both the baseline level of pollution and the extent of improvement due to Phase II controls may have been overstated.
The estimated number of Phase II construction sites used in the model is 8% higher than the number used in the rest of the economic analysis.	+	This may slightly overstate the benefit estimate relative to the cost estimate.
National Water Quality Assessment Benefits Analysis		
The estimates of potential benefits from the municipal minimum measures do not include some categories of potential benefits from improvements to marine waters.	–	Uses of marine waters (e.g., commercial fishing and shellfishing, and recreational fishing) are highly valued. Individuals also likely hold passive use values for marine waters. However, the extent to which marine waters will be improved by the Phase II rule is unknown.
The estimates of potential benefits from erosion and sediment controls for construction sites may not fully capture the value of the flood control, water storage, and reduced dredging benefits.	–	Paterson et al. (1993) suggest that existence value motivated survey respondents' WTP. Thus, their results may not fully capture the total program value.
The WTP values for the soil erosion control provision may overstate household WTP.	+	Paterson et al. (1993) had a 44% response rate to their mail survey; those not responding may have been less concerned about construction site run-off than those who did respond.
Carson and Mitchell's survey mentioned limited examples of passive use benefits for fresh waters, therefore it is not clear whether their results fully reflect these values.	+/–	EPA did, however, adjust for changes in attitudes towards spending for pollution control.
Estimates of the potential benefits from the	+/–	Municipal programs may be more or less

Paterson et al.'s survey was conducted prior to recommendations developed by the NOAA Panel on Contingent Valuation.	+/–	Paterson et al. (1993) followed methods, recommendations, and technical advice as published and provided by experts in the fields of water resource economics and nonmarket valuation.
Survey respondents in Paterson et al.'s study were not informed of the full costs of the state program.	+/–	Additional information regarding total program costs may have influenced WTP.
Nationally, WTP for erosion and sediment controls may differ from that of North Carolina households. WTP of nonurban households may also differ from that of urban households.	+/–	EPA examined income data (a factor likely influencing WTP) and found that the median incomes for the urban areas surveyed by Paterson et al. are representative of the range of incomes across NC counties. EPA also found that the median income of NC ranks 31 among all states and, therefore, concluded that no adjustment for income differences was necessary.
Overall Impact on Benefits Estimates for either analysis	+/–	There is not sufficient information to assess the direction of potential bias in the analysis of benefits.

– = understates benefits

+/– = unclear impact on benefits

6.5 Conclusion

The two approaches to estimating the potential benefits of the rule generate a wide range of benefits, although both approaches show that the benefits are likely to exceed costs. The NWPCAM approach obtains a higher overall benefit estimate. In part, this is because the river reach modeling approach generates a higher estimate of water quality improvements because impairment is based on water quality parameters rather than designated use. The water quality improvements that could be obtained using the national assessment data from the 305(b) report are constrained by designated use (e.g., improving water quality to a swimmable level will not generate incremental benefits if the designated used is fishing). The WTP values are based on improving national water quality regardless of designated use, however, and the NWPCAM approach is not affected by this constraint. The NWPCAM valuation approach, however, tends to increase the estimate of benefits associated with any particular change in water quality. Consequently, part of the difference between the estimates may be caused by the benefits transfer method used.

7.0 COMPARISON OF BENEFITS AND COSTS

This chapter provides a comparison of the monetized annual benefits and costs of the Phase II storm water rule.

7.1 Total Annual Monetized Benefits

To estimate the benefits of the rule, EPA used two different approaches: (1) water quality modeling approach and (2) water quality assessment approach. Because the approaches use different methodologies, the benefits estimates are presented separately for comparison in this chapter.

National Water Quality Model

EPA monetized benefits of water quality improvements associated with the Phase II rule in the designated uses of stream and rivers in the United States using a national water quality model. The National Water Pollution Control Assessment Model (NWPCAM) estimates the aggregate annual benefits of the Phase II rule to be $1.63 billion. This estimate, however, does not include estuarine and marine water benefits because the NWPCAM cannot estimate them at this point in time.

National Water Quality Assessment

EPA developed a partial monetary estimate of expected benefits of both the minimum municipal measures and the construction components of the rule. As reported in Exhibit 6–20, the sum of these benefits ranges from $671.5 million to $1.1 billion annually. However, as noted above and in Chapter 6, this benefit range is not comprehensive because it omits several benefit categories which are difficult to monetize. For example, some of the benefits associated with water quality improvements in marine waters, although potentially significant, are not included. Furthermore, other benefits may be underestimated. The benefits associated with construction site controls, for example, may be underestimated because all beneficial aspects of construction site controls may not have been fully valued. In particular benefits associated with post-construction runoff are not included in the total benefits to be consistent with the cost analysis.

EPA expects that the benefits associated with implementation of the minimum municipal measures (excluding erosion and sediment controls for construction sites) will begin accruing approximately three years following implementation of the rule. This three year time period provides time for such measures as public outreach and education to become effective and the benefits realized. With regard to erosion and sediment controls for construction sites, EPA expects benefits to accrue immediately following implementation of the rule because the construction site controls will be immediately effective abating sediment and providing benefits.

7.2 Total Annual Monetized Costs

As described in Chapter 4, EPA estimated the annual aggregate municipal and construction compliance costs and Federal and State administrative costs for the proposed regulation to range from $847.6 to $981.3 million. EPA expects that costs will decrease over time because certain

municipal activities should be completed during the first permit cycle. These include development of construction ordinances and BMPs for new developments, development of ordinances prohibiting discharges other than storm water into the MS4s, assessment of the maintenance schedules for the storm water infrastructure, and the assessment of illicit connections to the MS4s. However, because EPA preferred to present one cost figure, the costs for these items were not eliminated for subsequent permit cycles.

7.3 Comparison of Benefits and Costs

Exhibit 7–1 provides an annual comparison of benefits and costs for a representative year in which the rule is implemented, one in which benefits from the minimum measures and construction controls are accruing. Because there is not an initial out lay of capital costs with benefits accruing in the future (i.e., benefits and costs are almost immediately at a steady state), it is not necessary to discount costs in order to account for a time differential. In addition, EPA did not vary the factors that comprise the benefits and costs to account for market changes over time. Therefore, the benefits and costs presented in Exhibit 7–1 reflect a constant and steady stream of annual benefits and costs. This method of comparing benefits and costs, described in EPA's Guidelines for Performing Regulatory Impact Analysis (1991), Appendix C, compares streams of benefits and costs to examine net benefits in each year. This is deemed equivalent to first discounting the costs and benefit streams to obtain their present values and then comparing them.

The two approaches to estimating the potential benefits of the rule generate a wide range of benefits. The water quality model approach obtains a higher overall benefit estimate event though it includes only a portion of freshwater benefits (i.e., lakes are included), and it excludes all marine benefits. Both approaches show that benefits could exceed $1 billion while costs would likely be less than $1 billion. In addition, costs are expected to decrease over time because certain components are likely to be implemented in the first permit cycle only. This increases the likelihood that actual benefits would indeed be significantly greater than the potential costs.

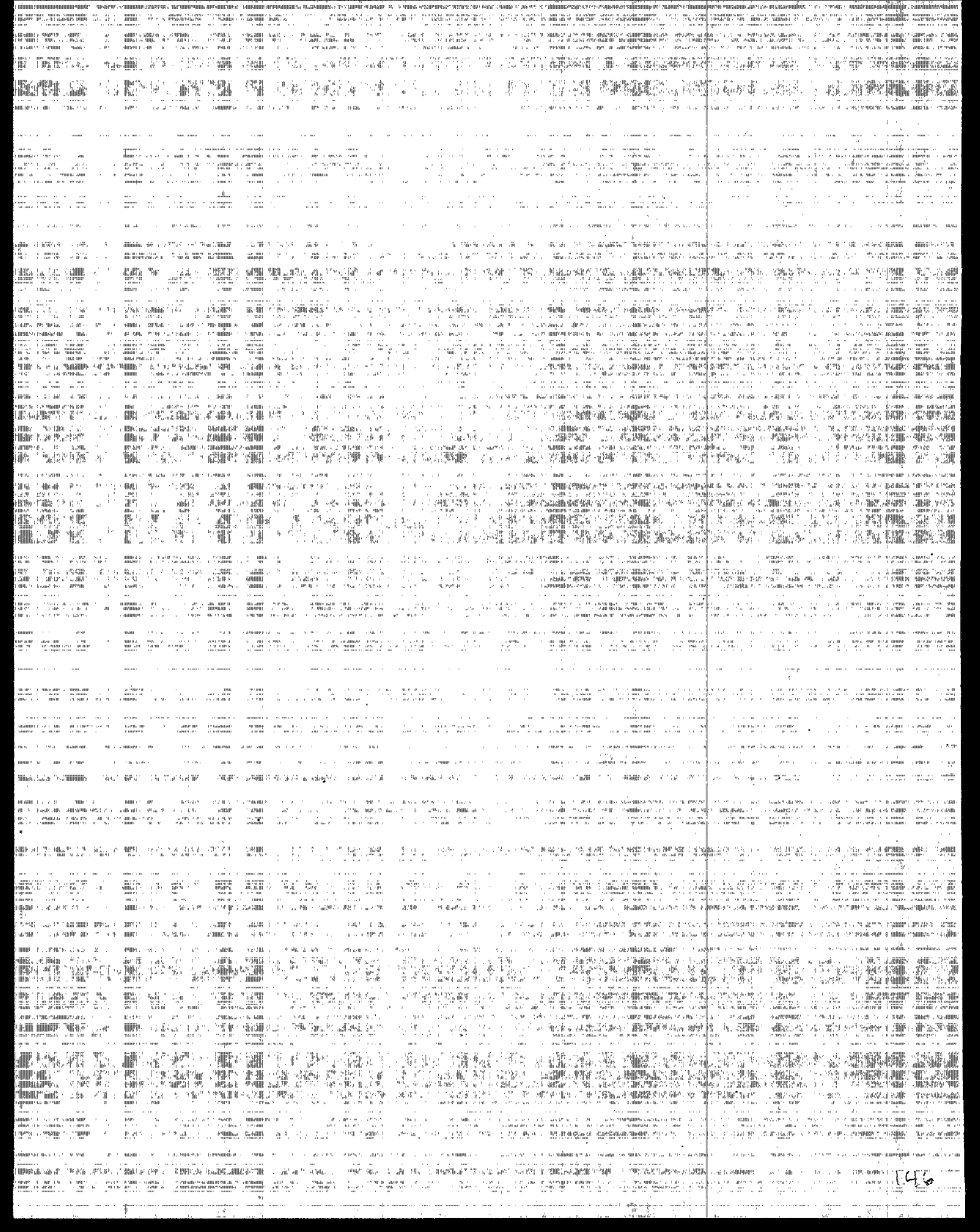
Exhibit 7–1. Comparison of Annual Benefits to Costs for the Phase II Storm Water Rule

Monetized Benefits[1]	Millions of 1998 dollars[2]
National Water Quality Model	
Total Annual Benefits	**$1,628.5**
National Water Quality Assessment	
Municipal Minimum Measures	$131.0 – $410.2
Controls for Construction Sites[c]	$540.5 – $686.0
Total Annual Benefits	**$671.5 – $1,096.2**
Costs	**Millions of 1998 dollars[2]**
Municipal Minimum Measures	$297.3
Controls for Construction Sites[3]	$545.0 – $678.7
Federal/State Administrative Costs	$5.3
Total Annual Costs	**$847.6 – $981.3**

[1]National level benefits are not inclusive of all categories of benefits that can be expected to result from the regulation.

[2]Detail may not add to total due to independent rounding.

[3] Controls evaluated include both erosion and sediment and post-construction controls.



8.0 REVISED SMALL ENTITY ASSESSMENT

This chapter updates EPA's analysis and statements with respect to three federal directives: Executive Order 12886 (Regulatory Planning and Review), including the Regulatory Flexibility Act (RFA) of 1980, as amended by the Small Business Regulatory Enforcement Fairness Act (SBREFA) of 1996; Executive Order 12898 (Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations; and the Unfunded Mandates Reform Act (UMRA) of 1995. In particular, because the cost in Chapter 4 has been revised, EPA revised the analysis presented in the initial SBREFA screening analysis, which was included in the EA for the proposed rule. Section 8.1 presents the results of the revised screening analysis. EPA will certify the final Phase II Storm Water Rule. A justification for certifying the rule is provided in the Preamble. Environmental justice issues are addressed in Section 8.2, and UMRA issues are addressed in Section 8.3.

8.1 Revised SBREFA Analysis of Impacts on Small Entities

In accordance with §402(p) of the Clean Water Act (CWA), the US Environmental Protection Agency (EPA) is finalizing a Phase II Storm Water rule. This rule is subject to the requirements of the Regulatory Flexibility Act of 1980 as amended by the Small Business Regulatory Enforcement Fairness Act of 1996. The analysis of the potential cost implications for small entities presented in the EA for the proposed rule supported the determination that the rule was not expected to have a significant impact on a substantial number of small entities. In response to comments, EPA revised its cost analysis for the soil erosion control provision of the rule. EPA also revised the per household cost estimate for the municipal minimum measures provision. EPA subsequently revised its original SBREFA screening analyses to determine the effect of the cost changes.

The RFA was enacted to increase agency awareness of the impacts of regulations (and their alternatives) on small entities, to allow for public comments on regulations that affect small entities, and to encourage agency use of flexibility in regulating small entities (US EPA, 1992). SBREFA amended the RFA to strengthen its analytical and procedural requirements. Under the RFA as amended, agencies are required to prepare a final regulatory flexibility analysis (FRFA) unless the agency certifies that the final rule will not have a significant economic impact on a substantial number of small entities. EPA is including the following revisions to the original economic impact analysis for small entities in this EA, as further support for the decision to certify the final rule.

The original economic analysis of potential impacts on small entities was prepared following *EPA's Interim Guidance for Implementing the Small Business Regulatory Enforcement Fairness Act and Related Provisions of the Regulatory Flexibility Act* (US EPA, 1997a) and, where appropriate, *EPA Guidelines for Implementing the Regulatory Flexibility Act* (US EPA, 1992). This section presents mainly those portions of the analysis that have been updated.

8.1.1 Background

Storm water runoff from lands modified by human activities can harm surface water resources in two ways: (1) by changing natural hydrologic patterns (e.g., increasing peak flow levels), and (2) by elevating pollution concentrations and loadings. The National 1996 §305(b) Report found that pollution from nonpoint sources such as runoff from agricultural and urban sources, construction sites, land disposal of waste, and resource extraction was the leading cause of impaired waters (see also the Preamble to the rule). In addition, the Nationwide Urban Runoff Program found that the concentration of total suspended solids in runoff from residential and commercial sites was 239 mg/L as compared to 20 mg/L in effluent from treatment plants providing secondary treatment (see Preamble). Evidence also suggests that illicit discharges and intensive construction activities can create severe water quality problems. As described more completely in the Preamble to the proposed rule, storm water runoff continues to harm the nation's waters. The purpose of the proposed regulation is to identify storm water sources that need to be regulated to protect water quality and to regulate these sources through a comprehensive program.

Some nonpoint sources of pollution are exempt from the National Pollutant Discharge Elimination System (NPDES) program; however, urban storm water runoff is generally discharged through discrete conveyances such as municipal separate storm sewer systems, which are subject to the NPDES program. Under §402(p) of the CWA, EPA is required to implement a comprehensive approach for addressing storm water discharges. In the statute, Congress specified that this program should be developed and implemented in two phases. The first phase addresses storm water discharges that:

- were subject to a NPDES permit before February 4, 1987
- are associated with industrial activity
- are from a municipal separate storm sewer system serving a population of 250,000 or more
- are from a municipal separate storm sewer system serving a population of 100,000 or more but fewer than 250,000
- are determined to be contributing to a violation of a water quality standard or to be a significant contributor of pollutants.

The rule implements Phase II by instituting regulations for other storm water discharges. In accordance with §402(p)(6), this rule establishes a comprehensive program to regulate designated sources, and specifies that this program will be implemented as part of the NPDES permitting program. At a minimum, this program is required to establish priorities, requirements for state storm water management programs, and expeditious deadlines.

The Phase II rule will regulate:

- all construction sites disturbing between one and five acres of land
- urbanized places and counties not included in Phase I (see the Preamble for additional details on the rule requirements).

8.1.2 Small Entities Affected by Rule

EPA used the definitions of small businesses, municipalities, and not-for-profit organizations established by the Small Business Administration (SBA) and the RFA. The SBA defines small businesses based on Standard Industrial Classification (SIC) and size standards expressed either in number of employees or annual receipts in millions of dollars (13 CFR §121.20). To evaluate the economic impact on small entities involved in the construction activity affected by the rule, EPA looked at the number of building contractors considered to be small businesses. For this SIC (SIC 15), the size standard is up to $17.0 million in annual revenues. In the EA for the proposed rule, EPA reported results from a database of businesses (Dun and Bradstreet, 1997) that was used to identify small building contractors. This estimate is believed to still be a reasonably accurate estimate of the number of construction businesses that may be affected by either the soil erosion provision or the post-construction control provision of the final rule.

The RFA defines small governmental jurisdictions and organizations (US EPA, 1992). A small government is the government of a city, county, town, school district, or special district with a population of fewer than 50,000. A small organization is any not-for-profit enterprise that is independently owned and operated, and is not dominant in its field. To evaluate the potential economic impact on small municipalities, EPA looked at the unurbanized places, urbanized places, and urbanized counties with populations of fewer than 50,000 based on the 1990 Census. EPA did not identify any not for profit organizations that would be affected by the rule. The original SBREFA estimate of small municipalities included incorporated places located outside of an urbanized area, and incorporated places and counties located either fully or partially within an urbanized area. EPA has since revised this estimate to include the minor civil divisions (i.e., unincorporated towns and townships), and municipios located fully or partially within an urbanized area, and to exclude the incorporated places located outside of an urbanized area since they are not automatically covered by the rule. The number of small businesses and the revised number of municipalities affected by the rule is shown in Exhibit 8–1.

8.1.3 Compliance Requirements

This section describes the projected reporting, recordkeeping, and other compliance requirements (and compliance costs) of the proposed rule, including the estimated classes of small entities subject to the requirements and the type of skills necessary for the preparation of reports or records. This section also provides initial screening analysis of the potential impact of these requirements, and analysis of environmental justice issues. The reporting, recordkeeping, and other compliance requirements are described in Section 8.1.4. Section 8.1.5 presents the screening analysis of the potential economic impacts on the regulated small entities. Section 8.1.6 contains further financial analysis on home buyers who might be impacted.

Exhibit 8–1. Businesses and Municipalities Potentially Affected by the Phase II Storm Water Regulations

Business or Municipality	Total Number of Firms	Number of Small Entities[1]
Construction	189,453[2]	187,610[3]
Incorporated Places, Counties, and MCDs	5,040	4,425
Municipios (Puerto Rico)	39	30
Total Municipalities	5,079	4,455

[1]Small municipalities defined as municipalities with populations of fewer than 50,000; small businesses in SIC 15 defined as businesses with annual revenues of $17 million or less.
[2]Number of construction firms in SIC 15 with sales > $0 identified in Dun & Bradstreet's FACTS database. Firms in states with equivalent soil erosion control programs (CT, DC, DE, MD, MI, NC, NJ, PA, PR, and SC) were removed from the original estimate. Because additional states with equivalent programs were subsequently identified (FL, GA, NH, VI, WV, and WI), this estimate potentially overstates the number of construction firms affected by that provision. Thus far, EPA has identified that seven states (AK, DE, FL, MD, PA, RI, and SC) have equivalent programs for the post-construction runoff control provision. Consequently, this estimate includes some businesses that will not be affected by that provision and excludes some businesses that will be affected.
[3]Number of small construction firms in SIC 15 identified in Dun and Bradstreet (1997). Note that there is no way to distinguish which firms are involved in remodeling only.

Source: US EPA, 1997.

The reporting, recordkeeping, and other compliance requirements of the proposed rule are summarized in Exhibit 8–2, which also presents EPA's estimates of the cost of compliance for the affected small municipalities and construction contractors. EPA's analysis of costs did not explicitly consider the costs for small municipalities and construction sites; however, EPA expects the costs to small entities to be less than for all entities. Therefore, Exhibit 8–2 reports the average cost for construction sites and municipalities. These estimates serve as an upper bound on costs to the affected small entities. The bulk of the costs for municipalities are reported on a per capita basis, with additional fixed administrative costs reported on a per entity basis. Building contractor cost estimates are reported on a per site basis.

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Reporting Requirements

Regulated municipalities will be required to submit annual reports to the NPDES permitting authority for their first permit term (a permit term is five years). For subsequent permit terms, regulated entities must submit reports in the second and fourth years unless the permitting authority requires more frequent reports. The report must include the following elements:

- The status of compliance with permit conditions, including the status of identified Best Management Practices (BMPs) and measurable goals for each of the minimum control measures
- Results of information collected and analyzed, including monitoring data, if any, during the reporting period
- A summary of the storm water activities the regulated entity plans to undertake in the next reporting cycle
- A change in any identified measurable goals that apply to the program elements.

EPA estimates that the skill level needed for reporting is a high school education or related work experience. However, in accordance with §122.22(a)(3), reports must be signed by either a principal executive officer or ranking elected official (US EPA, 1997b).

Building contractors will be required to submit a notice of intent (NOI) to the NPDES permitting authority, and to notify the municipality of planned construction activities. EPA estimates that the skill level needed for this task is a high school education or related work experience (US EPA, 1997b).

Exhibit 8–2. Summary of Compliance Requirements and Estimated Costs of the Phase II Storm Water Rule for Small Municipalities and Building Contractors (1998 dollars)

Small Municipalities		Building Contractors	
Per household costs (mean)[1]	**$8.93**	**Administrative costs per site**	
The per household costs include the cost for: public education and outreach, public involvement, illicit connection and discharge detection and elimination, construction site sediment and erosion control program, post-construction storm water management in new development and redevelopment, pollution prevention/good housekeeping of municipal operations		Submittal of NOI	$126.50
		Notification of municipalities	$17.10
		Average SWPPP[3]	$772.25
		Retention of records	$4.51
		Notice of termination (NOT)	$17.10
		Total administrative costs	**$937.46**
Fixed Municipal Administrative costs[2]		**Soil erosion control costs per site[4]**	
Submittal of application	$161	**Size Category**	
Record keeping	$75	**1 acre site**	$1,206
Reporting	$1,289	**3 acres site**	$4,598
Total fixed costs	**$1,525**	**5 acres site**	$8,709

[1]The per household costs do not include municipal administrative costs, which are factored on a per municipality basis here. So household costs are $0.23 less than as reported in Chapter 4.
[2]Annual costs per municipality based on estimated costs over a five year period. For reporting, costs are based on the number of reports over 30 years (an average of three reports in each permit term).
[3]Storm water pollution prevention plan.
Per acre costs are average costs from model simulations across three slope assumptions (3%, 7%, and 12%) and three soil erodibility assumptions (low, medium, and high).

Recordkeeping Requirements

The proposed rule requires regulated entities to keep records required by the NPDES permit for at least three years after the permit term. The entities are required to submit their records to the NPDES permitting authority only when specifically asked to do so. The records, including the storm water management program, must be made available to the public at reasonable times during regular business hours. EPA estimates that the skill level needed for recordkeeping is a high school education or related work experience (US EPA, 1997b). Building contractors will be required to retain records of their NOIs, their storm water pollution prevention plans, and their notices of termination.

Other Requirements

The costs shown in Exhibit 8–2 not associated with reporting and recordkeeping requirements reflect the other compliance requirements of the proposed rule. Under the proposal, NPDES permit holders must develop, implement, and enforce a storm water management program designed to reduce pollutants to the maximum extent practicable (MEP) and protect water

quality. As part of this program, permit holders are required to identify and submit to their NPDES permitting authority (in either the NOI or the permit application) the best management practices (BMPs) to be implemented and the measurable goals for each storm water minimum control measure. Permit holders must also identify the person or persons responsible for implementing or coordinating the storm water program, and identify the years in which they plan to start and complete the following measures (Draft Proposed Rule, February 13, 1997):

- ***Public education and outreach***. Permit holders must implement a public education program to distribute educational materials to the community or conduct equivalent outreach activities about the impacts of storm water discharges on water bodies, and the steps to reduce storm water pollution.

- ***Public involvement and participation***. Permit holders must comply with state and local public notice requirements.

- ***Illicit discharge and elimination***. Permit holders must:

  — Demonstrate awareness of their system, using maps or other existing documents, develop a storm sewer system map (or equivalent) showing the location of major pipes, outfalls, and topography. If data already exist, show areas of concentrated activities likely to be sources of storm water pollution.

  — Effectively prohibit (to the extent allowable under state law through ordinance, order, or similar means) illicit discharges into their storm sewer systems, and implement appropriate enforcement procedures and actions.

  — Implement a plan to detect and address illicit discharges to their systems.

  — Take actions designed to inform public employees, businesses, and the general public of hazards associated with illegal discharges and improper disposal of waste.

- ***Construction site storm water discharge control.*** Permit holders must develop, implement, and enforce a program for construction sites that discharge into their separate storm sewer system. They must use an ordinance or other regulatory mechanism that controls erosion and sediment to the greatest extent practicable and allowable under state law. The program must control other waste at construction sites, such as discarded building materials, concrete truck washout, and sanitary waste. The program must include, at a minimum, requirements for construction site owners or operators to implement appropriate BMPs, provisions for preconstruction review and approval of site management plans, procedures for receiving and ensuring proper consideration of information submitted by the public, regular inspections during construction, and penalties to ensure compliance.

- ***Post-construction storm water management in new development and redevelopment.*** Permit holders must develop and implement programs to control storm water discharges into their separate storm sewer system from development and redevelopment projects using site-appropriate and cost-effective structural and nonstructural BMPs. The programs must ensure that permit holders minimize water quality impacts.

- ***Pollution prevention and good housekeeping.*** Permit holders must develop and implement a cost-effective operation and maintenance program with the goal of preventing and reducing pollutant runoff from municipal operations. If training materials are available from the NPDES authorities or from other organizations whose materials are approved by the local government, the programs must include local government employee training to prevent and reduce storm water pollution from government operations.

- Permit holders must comply with other applicable NPDES permit requirements and standard conditions established in the individual or general permit.

- ***Evaluation and assessment.*** Permit holders must evaluate program compliance and effectiveness of identified BMPs and measurable goals.

8.1.4 Revised Analysis of Potential Economic Impact

The initial SBREFA screening analysis concluded that the rule would not have a significant impact on a substantial number of small entities. Since then, the economic analysis for the rule has revised the municipal and building construction costs. To determine whether the revised cost analysis for the final rule alters this finding, EPA revised the initial screening analysis to incorporate updated costs to municipalities and building contractors.

Municipalities

EPA guidelines recommend a "revenue test" to evaluate the potential severity of economic impact on small municipalities. This test calculates total compliance cost as a percentage of total revenues. EPA used the same method to approximate municipality revenues in the revised analysis that was reported in the EA for the proposed rule. EPA approximated municipality revenues using population estimates and per capita revenue estimates from the 1992 Census of Governments. No attempt was made to escalate revenue to 1998 dollars, so revenues are most likely underestimated. For each small municipality, EPA estimated total costs by first multiplying the number of households in the municipality with the per household costs shown in Exhibit 8–2, and then adding the $1,525 fixed administrative cost. Total costs were then divided by municipal revenue to estimate the number of municipalities that had percentages greater than 1% and greater than 3%. EPA conducted this test for several per-household municipality costs in Exhibit 4–3 of Chapter 4.

The results of the revenue test and sensitivity analysis are reported in Exhibit 8–3. The results demonstrate that even if the assumption were made that per household costs for Phase II communities were equal to the 75th percentile of household costs in the Phase I sample, less than 20% of small governments affected by the rule will incur costs greater than 1%. Therefore, with respect to the mean per capita costs incurred by small municipalities, the rule can be considered not to have a significant impact on a substantial number of small municipalities.

Exhibit 8–3. Revenue Test for Small Municipalities

Per Household Cost[1]	Per Municipality Administrative Costs	Small Municipalities with Costs Greater than 1% of Revenue (%)	Small Municipalities with Costs Greater than 3% of Revenue (%)
Median: $3.96	$1525	118 (2.65%)	25 (0.56%)
Mean: $8.93	$1525	481 (10.80%)	31 (0.70%)
75th percentile: $10.17	$1525	628 (14.10%)	32 (0.72%)

[1]The per household costs have been adjusted from those reported in Chapter 4 to remove the $0.23 per household in administrative costs because those costs are assumed to be the same for each municipality. The administrative costs, which were used to generate the $0.23 per household cost, were included in the revenue test as lump sum costs for each municipality.

Small Building Contractors

US EPA (1997) guidelines recommend a "sales test" to evaluate the potential severity of economic impact of compliance costs on small businesses. This test calculates annualized compliance cost as a percentage of total sales. Because such a test was not feasible, the initial SBREFA screening analysis approximated the sales test by estimating compliance costs for three sizes of construction sites and then comparing those costs with a representative sale price for three building categories. The site size categories are one, three, and five acres and they represent the amount of disturbed land on the development site. The three building categories are: single-family homes, multi-family residences, commercial. Industrial building sites were not considered because they fall into the multi-sector general permit category. Institutional buildings were also not considered, as they are not typically built to be sold in the real estate market. These sales tests assume that all the compliance costs are incurred by the building contractor. However, as explained below, it is unlikely that the compliance costs — even if they exceeded 1% or 3% of sales for many construction businesses — would have a significant effect on these businesses because costs will be passed on to the eventual purchaser of the property.

Compliance costs were assessed on a construction development or start basis, and a construction start could include one or several buildings (particularly for single-family homes). So to compare the compliance costs with sales costs, an estimate of buildings per site size had to be made. EPA developed these estimates based upon construction data collected from 14 local jurisdictions from around the country. A detailed description of how these estimates were derived can be found in Appendix B–2. Ratios of buildings to construction starts are not based on a random national sample, so the mean number of buildings per construction start for the states affected by Phase II may vary from these ratios.

For single-family homes EPA divided the revised compliance costs per construction start by the appropriate homes-to-site ratio for each of the three sizes of construction sites. Exhibit 8–4 reports the median compliance costs per construction start (see Exhibit 8–2), and the estimated per home costs, based on the estimated number of homes per start. The average compliance cost per home ranges from approximately $400 to $650.

As a proxy for the sales test, EPA divided the revised per home costs by the 1998 median and mean home sales prices, which are $151,000 and $181,300, respectively (US Bureau of the Census, 1999). Exhibit 8–5 reports the revised per home costs as a percent of median and mean home prices. These percentages range from 0.22% to 0.43% and they are lower than values reported in the initial SBREFA screening analysis, which ranged from 0.29% to 0.87%. These results suggest that under these assumptions, the compliance costs will not exceed 1% of sales for a construction business that builds and sells typical single-family homes.

Implicit in this sales test is the assumption that the party that receives the revenue from selling the newly built homes for the construction start, is also the party who incurs the cost for compliance with Phase II; all parties subcontracted to perform work on building the houses do not incur compliance cost and payment for their work is considered part of the developer's building costs. This is in keeping with the definition for "value of construction work done" in the 1992 United States Census of Construction Industries (US Bureau of the Census, 1996).

Exhibit 8–4. Construction Start and Per-Home Compliance Costs by Site Size

Site Size (disturbed area)	Average Compliance Costs per Construction Start	Number of Homes per Site	Compliance Costs per Home
1 Acre	$2,143	5.3	$404
3 Acres	$5,535	8.5	$651
5 Acres	$9,646	20.1	$480

Exhibit 8–5. Per-Home Compliance Costs as a Percent of Median and Mean Home Sale Price

Site Size (disturbed area)	Percent of Median Home Sale Price ($151,000)	Percent of Mean Home Sale Price ($181,300)
1 Acre	0.27%	0.22%
3 Acres	0.43%	0.36%
5 Acres	0.32%	0.26%

The initial SBREFA screening analysis noted that the cost to sales ratio was expected to be higher for single family housing than for the multi-family residential or commercial developments. Therefore, it was not considered necessary to also conduct screening analyses for those types of developments.

In response to comments that the post-construction runoff control measure may have a significant economic impact on builders, EPA has considered the possible associated costs for multi-family residential or commercial developments. The post-construction runoff control measure does not directly apply to construction operations, however municipalities may choose to regulate construction developers in response to this requirement. In order to inform the public EPA conducted similar analysis to determine the potential economic impact of the combined incremental soil and erosion and post-construction runoff control costs on these developments.

There is some uncertainty surrounding the eventual impact of the post-construction runoff control costs. To begin, EPA is not directly requiring small entities to adopt specific control measures, instead EPA is requiring MS4s to develop storm water management programs that address post-construction runoff controls for new developments. This approach allows for much more flexibility in how localities and developers can address post construction runoff. Secondly, the post construction runoff control costs shown in Exhibit 8–6 are high end estimates. Many post-construction runoff controls can be incorporated directly into the site design for a new development, which often results in much lower control costs. In fact there is evidence that property values can actually be enhanced when controls are designed to increase the aesthetic value of the sites landscaping (Schueler, 1997).

Exhibit 8–6. Best Management Practice Costs per Construction Site

Soil erosion control costs per site		Structural BMP construction costs per site[1]			
Site Size		Impervious Surface Area[2]			
		Site Size	35%	65%	85%
1 acre	$1,206	1 acre	$1,716	$3,157	$5,938
3 acres	$4,598	3 acres	$3,788	$7,625	$10,037
5 acres	$8,709	5 acres	$6,636	$9,319	$11,626
		7 acres	$10,479	$18,020	$40,919

[1] Post construction runoff control costs are the total control costs detailed in Appendix B–4, minus the capitalized operation and maintenance costs. Only the construction costs of the post construction controls were relevant to this analysis because the operation and maintenance costs will most likely not be borne by construction companies. Appendix B–4 provides a complete discussion of the post construction runoff control cost analysis.
[2] It is assumed that 35% imperviousness is associated with mulit-family residential, and 85% with commercial. The 65% imperviousness is representative of multi-family with high imperviousness, commercial with low imperviousness, and sites with a combination of the two building types. These impervious levels are based on a review of local government reports on average imperviousness by land-use (See Appendix B–4).

To conduct an analysis for multi-family residential developments, EPA performed a sales test, similar to the one for single-family homes, for condominiums and apartments. The first step was to determine the average number of multi-family units per start, for each site size category using the construction start data collected from the fourteen jurisdictions mentioned previously. Unfortunately, some of the data for multi-family developments did not report the number of units to be built on the site. However, because these were multi-family developments it could be assumed that at least two units were built on each site. So, when the number of units was not

included in the data, EPA assumed there would be two units built on the site. From this data EPA was able to determine an estimate of the number of units per acre for each site size category. This estimate is should be considered a lower bound estimate, since it is very likely that the starts that did not report the number of units were building more than just two. The estimated units per acre were then multiplied by the acres for each site size to get the estimated number of units per start. Exhibit 8–7 shows the estimated number of units per acre and per start.

Exhibit 8–7. Estimated Number of Multi-Family Residencies per Start by Site Size

Site Size (disturbed area)	Estimated Number of Units / Acre	Estimated Number of Units / Start
1 Acre	9.7	10
3 Acres	18.0	54
5 Acres	6.6	33
7 Acres	7.2	50

*The large value for the number of MFR units for the three-acre site size is the result of two outliers in the construction start data. The high values may be indicative of high rise developments.

For the second step, EPA used sale prices for both a condominium and a rental apartment to represent the price of a multi-family residential unit. The initial sale price for an apartment, $47,000, was the estimated mean price of an apartment unit based upon the 1993 Property Owners & Managers Survey (US Bureau of Census, 1993). The sale price used for a condominium, $119,700, is the median sale price for a condominium reported in the 1997 Survey of Market Absorption (US Bureau of Census, 1998). Both sale prices were adjusted to 1998 dollars using a 4.6% annual inflation rate based on the average sale price of a single-family home between 1995 and 1998 (US Bureau of Census, 1999). These sale prices were multiplied by the estimated number of units per start to determine the estimated sales per site size for both condominium and apartment developments.

Exhibit 8–8 shows the resulting sales per site, along with the ratio of compliance cost to sales for each site size. These percentages range from 0.17% to 0.91% and they are based on a very conservative estimate of the number units per site. These results suggest that under these assumptions, the compliance costs will not exceed 1% of sales for a construction business that builds and sells a typical apartment or condominium development.

Exhibit 8–8. Estimated Multi-Family Residential Sales and Compliance Costs by Site Size

Site Size (disturbed area)	Compliance Costs per Site[1]	Estimated Number of Units per Site	1998 Median Price Condominium ($125,209)		1998 Mean Apartment Price ($58,496)	
			Estimated Sales per site	Compl. Cost as % of Sales	Estimated Sales per site	Compl. Cost as % of Sales
1 Acre	$4,579	10	$1,252,090	0.37%	$584,960	0.78%
3 Acres	$11,242	54	$6,761,286	0.17%	$3,158,784	0.36%
5 Acres	$17,623	33	$4,131,897	0.43%	$1,930,368	0.91%
7 Acres	$14,249	50	$6,260,450	0.23%	$2,924,800	0.49%

[1]The total compliance cost for the 1, 3, and 5-acre sites includes the soil erosions control costs and the post-construction runoff control costs, while total compliance costs for the 7-acre sites include only post-construction runoff control costs (See Exhibit 8–6).

The analysis for commercial developments differed slightly from those conducted for single-family and multi-family developments. To estimate the sales price of commercial buildings, EPA multiplied the 1998 mean price for a square foot of commercial office space, which is $145sq/ft (FDIC, 1999) by estimates of building size. To estimate the amount of office space per site, EPA used a floor area ratio (FAR) to estimate the amount of impervious surface devoted to floor area for a typical site. For commercial sites, typical floor area ratios will range from 0.25 to 0.5 (see Appendix B–2). Floor area is assumed to be a reasonable estimate of office space, even though it does not account for non-office area, since the most conservative FAR value was used. Also since the sale price of a commercial office site can be assumed to be based primarily on the amount of available office space, developers have an incentive to minimize the amount of non-office space within a building.

To calculate the square footage of floor area for each site category the FAR value of 0.25 was first multiplied by the estimated impervious surface coverage value of 65% (see Appendix B–2), then by the number of square feet per acre, and then by the number of acres in each site size category. Finally, to determine the sale price for a start in each site size category the mean price of a square foot of office by the square footage of floor area in each category.

0.25(FAR)*65%(imp.surf.)*43,560(sq/ft)*site size*$145= Estimated Sale Price of Start

Exhibit 8–9 reports both the estimated sale price of office space per site, and the ratio of compliance cost to sales price. These percentages range from 0.38% to 0.47%, and this suggests that based upon current assumptions, the compliance costs will not exceed 1% of sales. Therefore, it is assumed that a construction business that builds and sells a typical commercial office development will not incur compliance costs greater than 1% of sales.

Exhibit 8–9. Estimated Commercial Office Space Sales and Compliance Costs by Site Size

Site Size (disturbed area)	Compliance Costs per Site[1]	1998 Mean Commercial Office Price ($145 sq/ft)	
		Estimated Sales per site	Compl. Cost as % of Sales
1 Acre	$6,691	$1,539,574	0.43%
3 Acres	$14,366	$3,079,148	0.47%
5 Acres	$20,118	$4,618,721	0.44%
7 Acres	$29,470	$7,697,869	0.38%

[1]The total compliance cost for the 1, 3, and 5-acre sites includes the soil erosions control costs and the post-construction runoff control costs, while total compliance costs for the 7-acre sites include only post-construction runoff control costs (See Exhibit 8-6).

Further Financial Analysis

Regardless of whether the compliance costs constitute a 1% or greater share of small building contractor sales, EPA believes that the impact of the rule on contractors that build single family detached residences will be minimal because they are able to pass regulatory costs on to buyers (Nelson et al., 1992; and D. Mercer, National Association of Homebuilders, personal communication, April 1997). As discussed in Section 5.1.4.2 of the Economic Analysis for the proposed rule, the long run supply curve for new residential construction is assumed to be highly elastic, while the demand curve for new homes is considered to be relatively inelastic. Therefore, a change in the total cost of building a new home is expected to be born primarily by new home buyers. Since buyers are not addressed by the RFA and SBREFA, EPA is not required to evaluate the "significance" of the economic impact posed by these costs.

Comments on the initial SBREFA screening analysis state that most home buyers qualify for mortgages at the maximum payment to income ratio allowed by lenders and that a few dollar increase in monthly payments will in effect exclude potential home buyers. In particular, a 1% increase in the price of a median home would make 460,905 families ineligible to buy that home, resulting in either fewer homes or smaller homes being built, and subsequent unemployment in the construction industry. EPA believes the suggestion that most home buyers qualify for mortgages at the maximum payment to income ratio allowed by lenders is an overstatement. The typical payment to income ratio used by lenders is that monthly payments cannot exceed gross monthly income (i.e., pretax income) by more than 28%(MSN, 1999). According to results from the Chicago Title Corporation's 1998 Annual Survey of Recent Home Buyers, the average monthly payment as a percentage of after-tax income was 32.3% for 1998 home buyers (Chicago Title Corporation, 1999). A typical American family pays 35.4% of their gross income in taxes (Tax Foundation, 1999). Using this percentage to adjust the results from the Recent Home Buyer Survey, in1998 the average American home buyer used 21% of their gross monthly income on their home payments.

EPA believes that the potential impact of compliance cost on the median home price overstated. EPA's revised cost analysis for single family detached homes shows that the potential cost impacts are well below 1% of the median home price (see Exhibit 8–5). Furthermore, this cost increase will affect a very small share of the overall housing market. Over the past three years,

the percentage of homes sold that were newly built was 21.6% (Chicago Title Corporation, 1999). Of newly built homes only 12% are estimated to be in developments affected by Phase II Storm Water Rule (see Appendix B–3). So only 2.6% of all homes sold are likely to incur the cost increase.

8.2 Environmental Justice

Executive Order 12898 established a presidential policy for incorporating environmental justice into Federal agency missions by directing agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations. For example, to assist in identifying the need for ensuring protection of populations who principally rely on fish or wildlife for subsistence, the EO directs agencies, whenever practicable and appropriate, to collect, maintain, and analyze information on the consumption patterns of those populations, and to communicate to the public the risks of those consumption patterns.

As described in the above sections, the Phase II proposed rule addresses construction sites and municipal storm water sewer systems that have not been covered under Phase I. In addition, the CZARA addresses nonpoint sources (e.g., storm water runoff) located in the coastal zone. Finally, smaller communities outside of the coastal zone that may not be covered by either the Phase I or Phase II rules can be addressed by nonpoint source programs under the CWA. Therefore, with the promulgation of the Phase II rule, EPA's regulation of storm water runoff should be fairly comprehensive.

Environmental justice concerns for the regulation of storm water discharges may lie in the level of control resulting from the different regulations. In comparison to the Phase I rule, the Phase II rule has fewer requirements and offers substantial flexibility in meeting those requirements, particularly for small entities. (The Phase II rule addresses smaller municipalities and construction sites compared to Phase I, and a subset of these are defined as small entities by the Small Business Administration as noted in Section 8.1.) Thus, to the extent that fewer requirements and more flexibility results in less pollutant reduction, Phase II may result in disproportionate environmental impacts on small communities. However, small communities may not be disproportionately minority or low income.

Evaluation of the impact of the proposed Phase II rule on minority and low income populations would require information on the location of these populations with respect to waters receiving discharges regulated under the rule. This would most likely prove difficult because:

- Upstream water quality may affect downstream populations (such that the location of the affected municipalities and construction sites alone is not sufficient)

- The same water body may be affected by discharges regulated under both Phase I and Phase II (because different size communities can be located along the waterbody and its tributaries).

This information was not available for this analysis. In addition, the water quality impacts of the proposed rule may vary considerably because permitting authorities have considerable flexibility in implementation, such as the ability to require permits for storm water sewer systems outside urbanized areas.

8.3 Unfunded Mandates

Title II of the Unfunded Mandates Reform Act of 1995 (Public Law 04-4; UMRA) establishes requirements for Federal agencies to assess the effects of their regulatory actions on State, local, and tribal governments as well as the private sector. Under section 202(a)(1)n of UMRA, EPA must generally prepare a written statement, including a cost-benefit analysis, for proposed and final regulations that "includes any Federal mandate that may result in the expenditure by State, local, and tribal governments, in the aggregate or by the private sector" of annual costs in excess of $100 million.[1] As a general matter, a federal mandate includes Federal Regulations that impose enforceable duties on State, local, and tribal governments, or on the private sector (Katzen, 1995). Significant regulatory actions require Office of Management and Budget review and the preparation of a Regulatory Impact Assessment that compares the costs and benefits of the action.

The rule is anticipated to cost both the public sector and the private sector more than $100 million/year for the time period analyzed. In particular, the Economic Analysis (EA) addresses:

- Section 202(a)(1) — authoring legislation (see EA Chapter 1 and the Preamble to the rule)
- Section 202(a)(2) — a qualitative and quantitative assessment of the anticipated costs and benefits of the regulation (see EA chapters 4 through 7 and accompanying appendices)
- Section 202(a)(3)(A) — accurate estimates of future compliance costs (as reasonably feasible; see EA chapter 4)
- Section 202(a)(3)(B) — disproportionate effects on particular segments of the private sector (see this chapter)
- Section 202(a)(3)(B) — disproportionate effects on local communities (see this chapter)
- Section 205(a) — least burdensome option or explanation required (see the Preamble to the rule)

[1]The $100 million in annual costs is the same threshold that identifies a "significant regulatory action" in Executive Order 12866.

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Pursuant to UMRA section 203, before an agency establishes any regulatory requirements that may significantly or uniquely affect small governments, including Tribal governments, it must have developed a small governments agency plan. The plan must provide for notifying potentially affected small governments, enabling officials of affected small governments to have meaningful and timely input in the development of regulatory proposals with significant Federal intergovernmental mandates, and informing, educating, an advising small governments on compliance with the regulatory requirements. The Preamble to the final rule summarizes the extent of EPA's consultation with stakeholders including industry, environmental groups, states, local, and Tribal governments. The Preamble and comment-response document contain responses to their comments collected during the public comment period for the proposed and subsequent Notices of Data Availability (UMRA sections 202(a)(5) and 204).

Pursuant to section 205(a)(1)–(2), EPA has selected the "least costly, most cost-effective or least burdensome alternative" consistent with the requirements of the CWA for reasons discussed in the Preamble to this rule. A cost comparison in the EA for the proposed rule showed that high costs for alternative options (except the no action option) all exceeded $3.0 billion per year, which is substantially greater than the $803 million cost estimate provided in Chapter 4. Under the CWA §402(p)(6), EPA is required to design a regulatory program to control contaminated discharges associated with storm water runoff. This rule addresses contaminated storm water discharges from sources that were not included in the Phase I rule: small municipal separate storm sewer systems and construction activities at small construction sites (sites disturbing greater than or equal to one acre and less than five acres).

9.0 NO EXPOSURE

The storm water Phase II rule includes a no exposure exclusion for Phase I regulated industrial facilities that have the potential to reduce the total compliance costs. "No exposure" means all industrial materials or activities are protected by a storm resistant shelter so that the materials are not exposed to rain, snow, snowmelt, or runoff. This chapter estimates the number of Phase I industrial facilities that may be able to qualify for the no exposure exclusion and the net cost savings that will result. Section 9.1 provides background and an explanation of the Phase II rule's no exposure exclusion provision. Section 9.2 discusses the methodology and estimates the cost savings from the no exposure provision for facilities currently regulated under Phase I. Section 9.3 estimates the compliance costs associated with the no exposure provision. Section 9.4 summarizes the findings, Section 9.5 identifies state and federal costs and Section 9.6 identifies data limitations and assumptions used to estimate the net cost savings of the no exposure provision.

9.1 Background

In the 1990 storm water regulations, EPA identified eleven categories of industrial activities in the definition of "storm water discharge associated with industrial activity"(40 CFR §122.26(b)(14)(I)-(xi)). See Exhibit 9–1 for a description of each category. All operators of industrial facilities with activities identified in these categories are required to obtain an NPDES storm water permit to discharge, except those facilities that are included in the "light industry" category (xi). These facilities were exempt from the requirement to obtain an NPDES permit if their industrial materials and/or activities were not "exposed" to storm water (see 40 CFR §122.26(b)(14) [introductory text]). The Agency had reasoned that most of the activity at these types of facilities takes place indoors and that emissions from stacks, use of unhoused manufacturing equipment, outside material storage or disposal, and generation of large amounts of dust or particles would be atypical (55 FR 48008, November 16, 1990).

In 1992, the Ninth Circuit court remanded to EPA for further rulemaking, the portion of the definition of "storm water discharge associated with industrial activity" that excluded the light industry in category (xi) when industrial materials and/or activities were not exposed to storm water. See *NRDC v. EPA*, 966 F.2d 1292, 1305 (9th Cir. 1992). The Ninth Circuit determined that the exemption was arbitrary and capricious for two reasons. First, the court found that EPA had not established a record to support its assumption that light industry that was not exposed to storm water was not "associated with industrial activity," particularly when other types of industry not exposed to storm water remained "associated with industrial activity." Second, the court concluded that the exemption impermissibly "altered the statutory scheme" for permitting because the exemption relied on the unverified judgement of the light industrial facility operator to determine non-applicability of the permit application requirements. In other words, the court was critical that the operator would determine for itself that there was no exposure and then simply not apply for a permit without any further action. Without a basis for ensuring the effective operation of the permitting scheme—either that facilities would self-report actual exposure or that EPA would be required to inspect and monitor such facilities—the court vacated and remanded the rule to EPA for further rulemaking. The Phase II rule responds to that remand.

Under the Phase II rule, the Agency responds to both of the bases for the court's remand. In response to the first basis, the exemption from permitting based on "no exposure" now applies to all industrial categories listed in the definition of "storm water discharge associated with industrial activity," except construction (category (x)) and industrial facilities individually designated by the NPDES permitting authority. This assures that discharges from different types of industrial facilities are equally regulated based on their propensity to be contaminated. In response to the second basis for the court's remand, the permitting exclusion is "conditional." The operator responsible for a point source discharge from a "no exposure" industrial source must meet the conditions of the exclusion, and then complete, sign and submit a written certification to the NPDES permitting authority for tracking and accountability purposes. If a condition of no exposure is not maintained, the operator must immediately obtain coverage under an NPDES storm water permit. In other words, the operator is not fully exempt from the regulations, but rather only conditionally excluded for as long as they have no exposure of materials and activities to storm water.

EPA deleted the sentence regarding "no exposure" for the category (xi) facilities in 40 CFR §122.26(b)(14)[introductory text] and added a new section, §122.26(g), titled "Conditional Exclusion for No Exposure of Industrial Activities and Materials to Storm Water." As mentioned above, this provision applies to all categories of industrial activity covered by the Phase I program that can claim a condition of no exposure, except discharges from construction and from individually designated sources.

In order to obtain the no exposure exclusion, the discharger of an otherwise regulated facility must submit a written no exposure certification that incorporates the Yes/No questions of §122.26(g)(4) of the Phase II rule to the NPDES permitting authority once every five years (see EPA's No Exposure Certification Form in Appendix D–1). Based on recommendations of the FACA Committee, the certification requires only a minimal amount of information from the facility. All no exposure certifications must be signed in accordance with the signatory requirements of 40 CFR §122.22. The no exposure certification is non-transferable. In the event that the facility operator changes, the new discharger must submit a new no exposure certification. The NPDES permitting authority is expected to maintain a simple database to record the information included in the no exposure certifications and track the facilities.

In addition to the written certification, the facility must allow the NPDES permitting authority or operator of a municipal separate storm sewer system (where there is a storm water discharge to the municipal system) to inspect the facility and to make such inspection reports publicly available upon request. Also, upon request and where applicable, the facility must submit a copy of the no exposure certification to the operator of a municipal separate storm sewer system.

Exhibit 9–1. Industrial Facilities That Must Submit Applications for Storm Water Permits (Phase I)

40 CFR 122.26(b)(14) Subpart	Description
(i)	Facilities subject to storm water effluent limitations guidelines, new source performance standards, or toxic pollutant effluent standards under 40 CFR, Subchapter N [except facilities which are exempt under category (xi)].
(ii)	Facilities classified as: SIC 24 (except 2434) ..... Lumber and Wood Products SIC 26 (except 265 and 267) .... Paper and Allied Products SIC 28 (except 283 and 285) .... Chemicals and Allied Products SIC 29 ..... Petroleum and Coal Products SIC 311 ..... Leather Tanning and Finishing SIC 32 (except 323) ..... Stone, Clay and Glass Products SIC 33 ..... Primary Metal Industries SIC 3441 ..... Fabricated Structural Metal SIC 373 ..... Ship and Boat Building and Repairing
(iii)	Facilities classified as SIC 10 through 14, including active or inactive mining operations and oil and gas exploration, production, processing, or treatment operations, or transmission facilities that discharge storm water contaminated by contact with, or that has come into contact with, any overburden, raw material, intermediate products, finished products, byproducts, or waste products located on the site of such operations. SIC 10 ..... Metal Mining SIC 11 ..... Anthracite Mining SIC 12 ..... Coal Mining SIC 13 ..... Oil and Gas Extraction SIC 14 ..... Nonmetallic Minerals, except Fuels
(iv)	Hazardous waste treatment, storage, or disposal facilities, including those that are operating under interim status or a permit under subtitle C of RCRA
(v)	Landfills, land application sites, and open dumps that receive or have received any industrial wastes (waste that is received from any of the facilities described under this subsection) including those that are subject to regulation under subtitle D of RCRA
(vi)	Facilities involved in the recycling of materials, including metal scrap yards, battery reclaimers, salvage yards, and automobile junkyards, including but limited to those classified as Standard Industrial Classification 5015 and 5093
(vii)	Steam electric power generating facilities, including coal handling sites
(viii)	Transportation facilities which have vehicle maintenance shops, equipment cleaning operations, or airport de-icing operations. Only those portions of the facility that are either involved in vehicle maintenance (including vehicle rehabilitation, mechanical repairs, painting, fueling, and lubrication), equipment cleaning operations, or airport de-icing operations, or which are otherwise listed in another category are included: SIC 40 ..... Railroad Transportation SIC 41 ..... Local and Suburban Transit SIC 42 (except 4221–45) ..... Motor Freight and Warehousing SIC 43 ..... US Postal Service SIC 44 ..... Water Transportation SIC 45 ..... Transportation by Air SIC 5171 ..... Petroleum Bulk Stations and Terminals

Exhibit 9–1. Industrial Facilities That Must Submit Applications for Storm Water Permits (Phase I) (Continued)

40 CFR 122.26(b)(14) Subpart	Description
(ix)	Treatment works treating domestic sewage or any other sewage sludge or wastewater treatment device or system, used in the storage treatment, recycling, and reclamation of municipal or domestic sewage, including land dedicated to the disposal of sewage sludge that are located within the confines of the facility, with a design flow of 1.0 MGD or more, or required to have an approved pretreatment program under 40 CFR part 403. Not included are farm lands, domestic gardens or lands used for sludge management where sludge is beneficially reused and which are not physically located in the confines of the facility, or areas that are in compliance with section 405 of the CWA.
(x)	Construction activity including clearing, grading and excavation activities except: operations that result in the disturbance of less than five acres of total land area which are not part of a larger common plan of development or sale
(xi)	Facilities under the following SICs [which are not otherwise included in categories (ii)-(x)], including only storm water discharges where material handling equipment or activities, raw materials, intermediate products, final products, waste materials, byproducts, or industrial machinery are exposed to storm water. SIC 20 ..... Food and Kindred Products SIC 21 ..... Tobacco Products SIC 22 ..... Textile Mill Products SIC 23 ..... Apparel and Other Textile Products SIC 2434 ..... Wood Kitchen Cabinets SIC 25 ..... Furniture and Fixtures SIC 265 ..... Paperboard Containers and Boxes SIC 267 ..... Converted Paper and Paper Board Products (except containers and boxes) SIC 27 ..... Printing and Publishing SIC 283 ..... Drugs SIC 285 ..... Paints, Varnishes, Lacquer, Enamels SIC 30 ..... Rubber and Miscellaneous Plastics Products SIC 31 (except 311) ..... Leather and Leather Products SIC 323 ..... Products of Purchased Glass SIC 34 (except 3441) ..... Fabricated Metal Products SIC 35 ..... Industrial Machinery and Equipment, except Electrical SIC 36 ..... Electronic and other Electric Equipment SIC 37 (except 373) ..... Transportation Equipment SIC 38 ..... Instruments and Related Products SIC 39 ..... Miscellaneous Manufacturing Industries SIC 4221 ..... Farm Products Warehousing and Storage SIC 4222 ..... Refrigerated Warehousing and Storage SIC 4225 ..... General Warehousing and Storage

Source: Federal Register, Vol. 55, No. 222, p. 48065, November 16, 1990.

9.2 No Exposure Cost Savings

In order to estimate the potential cost savings that may result from adoption of the no exposure provision it is necessary to estimate the number of currently regulated Phase I industrial facilities that may be eligible for the exclusion and to estimate the avoided costs. EPA's approach for estimating no exposure cost savings involved:

- Identifying the total number of establishments in the United States that have a narrative description or a SIC code identified in §122.26(b)(14)(I)-(ix) and (xi).
- Estimating the total number of establishments that are currently required to have a storm water permit.
- Determining the percentage, and number, of facilities for each industrial category in §122.26(b)(14) that have industrial activities or materials exposed to storm water.
- Allocating the industrial facilities in the 10 industrial categories to the 30 sectors in the modified multi-sector general permit for storm water discharges.
- Developing minimum and maximum unit compliance costs for all facilities covered by the multi-sector general permit (includes costs for visual monitoring, analytical monitoring, development and implementation of a storm water pollution prevention plan, submitting an NOI, notifying the local municipality, and recordkeeping).
- Applying the unit compliance costs for each sector to the number of facilities that may potentially qualify for the no exposure exclusion.
- Developing cost estimates for completion of the no exposure certification form.
- Estimating the increase in compliance costs for category xi facilities which currently do nothing if they have no exposure but will be required to certify no exposure after promulgation of the no exposure provision.
- Obtaining net compliance cost savings for the no exposure provision by subtracting compliance cost increases from avoided costs.

This section addresses only facilities that are currently regulated under the Phase I industrial program, including those category (xi) facilities that have industrial equipment or materials exposed to storm water and did not qualify for the original no exposure exemption. The following sections discuss each of the steps mentioned above.

9.2.1 Number of Facilities Eligible for the No Exposure Provision

Identifying the number of facilities eligible for the no exposure exclusion is problematic because there are no data sources indicating the number of facilities that have storm water discharges associated with industrial activity. Therefore, it is necessary to develop an estimate of this number. There are a number of steps involved in developing such an estimate. The first step is to identify the total number of establishments that have narrative descriptions or a SIC code identified in §§122.26(b)(14)(I)-(ix) and (xi), without concern for whether or not the facility has exposure of industrial activities or materials to storm water. This step identifies the maximum number of facilities or industrial activities that have the potential to meet the definition of storm water associated with an industrial activity.[1] There are approximately 587,099 facilities in the United States that meet the narrative description or have a SIC code identified in §§122.26(b)(14)(I)-(ix) and (xi).[2]

The next step is to estimate the number of facilities from the total of 587,099 that have a "storm water discharge associated with industrial activity," as defined by §122.26(b)(14). Eight states provided EPA with either an estimate, or actual data regarding the number of Phase I industrial establishments that meet the definition of a storm water discharge associated with an industrial activity within their state.[3] These estimates assume that every facility in categories I-ix with a storm water discharge now require a storm water permit, and only those facilities in category xi with exposure and discharge will require a permit. Exhibit 9–2 indicates the potential number of facilities within these states that are defined by categories (I) through (ix) and (xi) in §122.26(b)(14), the number of facilities estimated by the state storm water representative to have a discharge meeting the definition of a "storm water discharge associated with an industrial activity,"and the percentage of all facilities that have a discharge meeting the definition of "storm water discharge associated with an industrial activity."

[1] The term "storm water associated with industrial activity" is defined in 40 CFR §122.26(b)(14).

[2] US Department of Commerce, Census Bureau. 1996. *County Business Patterns: United States*; Edison Electric Institute, 1995; US EPA, 1997. *Preliminary Biennial RCRA Hazardous Waste Report: Based on 1995 Data*; and US EPA, 1995. *Municipal Solid Waste Fact Book.* This number does not include: abandoned and inactive landfills, mine sites, and oil and gas sites; vehicle maintenance activities at rail yards and the US Postal Service; and wastewater treatment facilities with a design flow of 1million gallons per day (MGD) or greater.

[3] The NPDES authorized States contacted are: Arkansas, Illinois, Michigan, New York, South Carolina, Tennessee, Virginia, and West Virginia. Other states were contacted but the information was not available, therefore, they were not requested to provide this information to EPA.

Exhibit 9–2. Total Facilities and Estimated Number of Regulated Industrial Facilities in Selected States

State	Total Number of Facilities[1]	Estimated Number of Regulated Facilities[2]	Percentage[3]
Arkansas	5,282	2,500	47%
Illinois	22,135	11,000	50%
Michigan	18,648	6,000	32%
New York	31,732	10,000	32%
South Carolina	5,936	4,500	76%
Tennessee	9,688	5,780	60%
Virginia	8,775	3,200	36%
West Virginia	3,319	3,000	90%
TOTAL	105,515	45,980	Weighted Average = 44%

[1]Total number of facilities that are defined by categories (I) through (ix) and (xi) in 40 CFR §122.26(b)(14). The source of information includes: for facilities identified with SIC codes US Department of Commerce, Census Bureau, 1996. *County Business Patterns for 1994*; for steam electric facilities Edison Electric Institute, 1995; for hazardous waste facilities US EPA, 1997. *Preliminary Biennial RCRA Hazardous Waste Report: Based on 1995 Data*; and for landfills US EPA, 1995. *Municipal Solid Waste Fact Book.* Note: This number does not include: abandoned and inactive mine sites, landfills, and oil and gas wells; vehicle maintenance activities at rail yards and US Postal Service centers; and wastewater treatment facilities with a design flow of 1 MGD or greater.

[2]Total number of facilities in the second column that meet the definition of "storm water discharge associated with industrial activity" in 40 CFR §122.26(b)(14), because they discharge to waters of the United States, therefore, must obtain a NPDES storm water permit. *Source:* Personal communication with State Storm Water representatives on April 23, 1997.

[3]The percentage of the total number of facilities in the second column that meet the definition of "storm water discharge associated with industrial activity" and must obtain an NPDES storm water permit.

The percentage of facilities that meet the definition of storm water discharge associated with industrial activity ranged from a high of 90% to a low of 32% in the states contacted. The weighted average is approximately 44% for (I-ix) categories. EPA estimates the number of category (xi) light industrial facilities that meet the definition of "storm water discharge with industrial activity" to be approximately 8%.[4] These figures, 44% and 8%, were used in the analysis.

[4] EPA determined the number of NOIs submitted to the NOI tracking center for facilities meeting the definition of "storm water discharge with industrial activity" for facilities characterized as category xi facilities. In the non-NPDES authorized states the owners/operators of 3,701 light industrial establishments submitted NOIs to the tracking center. The Dun and Bradstreet's FACTS database estimates that there are 65,091 light industrial establishments in the non-NPDES authorized states. The number of NOIs compared to the total number of establishments is approximately 6%. EPA also estimates that nationwide the rate of compliance for storm water permits is approximately two-thirds. Therefore, when taking into consideration noncompliance, EPA estimates the percentage of light industrial establishments that require storm water permits to be approximately 8% of the total number of establishments.

9.2.2 Industrial Facilities With and Without Exposure

Because each category of industrial facilities conducts different activities and follows different materials use and storage practices, the level of exposure of these activities and materials will vary. Exhibit 9–3 provides an estimate of the number of facilities with and without exposure for each industrial category. Exhibit 9–3 indicates that approximately 76,438 of the 152,677 facilities in the United States that meet the regulatory definition of "storm water discharge associated with industrial activity" have exposure and, therefore, must obtain a Phase I storm permit. Exhibit 9–3 also indicates that approximately 76,239 facilities that meet the regulatory definition of "storm water discharge associated with industrial activity" may have no exposure conditions at their site and will be eligible to take advantage of the no exposure provision.

9.2.3 Industrial Compliance Cost Savings

Industrial facilities currently regulated under the Phase I storm water program are required to obtain permit coverage. Under the permit, they are required to develop and implement a storm water pollution prevention plan and conduct visual and analytical monitoring of their storm water discharges. The no exposure provision provides a potential cost saving to those facilities that can certify that a condition of no exposure exists at their facility because they will no longer be required to meet the annual permitting requirements. The annual cost savings for an industrial facility was estimated to be equivalent to the annual compliance cost for an industrial facility meeting the conditions of the multi-sector general permit. EPA estimates that very few industrial facilities have applied and received an individual storm water permit and, therefore, estimated the cost savings based on the compliance costs for the multi-sector general permit.[5]

Storm Water Pollution Prevention Plan Costs

High and low cost estimates for development of the multi-sector general permit storm water pollution prevention plan were published on September 29, 1995 (60 FR 51108). The cost estimates have been inflated to 1998 dollars using the Consumer Price Index and are shown in Exhibits 9–4 and 9–5. Exhibit 9–4 presents the estimated per facility start up, annual, and total low and high industrial compliance costs for development, implementation, and maintenance of the storm water pollution prevention plan. Exhibit 9–5 indicates the additional costs that Emergency Planning and Community Right-to-Know (EPCRA) facilities would incur.[6]

The multi-sector general permit requires permittees to conduct a number of activities during the start-up years of the initial permit that are not required in years four and five of the first permit and all years in subsequent permits. Activities such as plan preparation and start-up costs are not imposed in years four and five, and subsequent terms, because the annual pollution prevention activities are intended to maintain or modify the storm water pollution prevention plan as

[5]The multi-sector general permit was chosen as the benchmark because EPA does not plan on re-issuing the baseline general permit for industrial facilities. The multi-sector general permit is being modified to incorporate those industrial establishments that were not previously included in the multi-sector general permit.

[6]The multi-sector general permit has additional conditions for EPCRA facilities. For this reason, Exhibit 9–5 indicates the compliance costs only applicable to EPCRA facilities, however, these costs are in addition to those indicated in Exhibit 9–4.

Exhibit 9–3. Estimated Number of Regulated Industrial Facilities With and Without Exposure

Phase I Industrial Category	Total Number of Facilities in the US [1]	Number of Facilities Requiring a Permit [2]	Percent of Facilities with Exposure [3]	Number of Facilities with Exposure	Percent of Facilities with No Exposure [3]	Number of Facilities with No Exposure
(i) Effluent Guidelines	NA[4]	NA[4]	NA[4]	NA[4]	NA[4]	NA[4]
(ii) Manufacturing	78,757	34,653	50%	17,327	50%	17,327
(iii) Mining[5]	27,166	11,953	100%	11,953	0%	0
(iv) Hazardous Waste Treatment and Storage	1,787	786	30%	236	70%	550
(i) Landfills[5]	3,581	1,576	100%	1,576	0%	0
(vi) Automobile and Scrap Recyclers	16,171	7,115	100%	7,115	0%	0
(vii) Steam Electric	993	437	50%	218	50%	218
(viii) Vehicle Maintenance[6]	165,182	72,680	20%	14,536	80%	58,144
(ix) Wastewater Treatment Facilities	NA[4]	NA[4]	90%	NA[4]	10%	NA[4]
(xi) Light Industrial[7]	293,462	23,477	100%	23,477	0%	0
TOTAL	**587,099**	**152,677**		**76,438**		**76,239**

[1]US Department of Commerce, Census Bureau. 1996. *County Business Patterns: United States*; Edison Electric Institute, 1995; US EPA, 1997. *Preliminary Biennial RCRA Hazardous Waste Report: Based on 1995 Data*; and US EPA, 1995. *Municipal Solid Waste Fact Book.* This number does not include: abandoned and inactive landfills, mine sites, and oil and gas sites; vehicle maintenance activities at rail yards and the US Postal Service; and wastewater treatment facilities with a design flow of 1 million gallons per day (MGD) or greater.

[2] Based on 44% of total number of facilities in US. The 44% is an average obtained from Exhibit 9–2.

[3]The percentage estimates are based on best professional judgement of EPA Phase I storm water staff—Bill Swietlik, US EPA, Office of Water Permits Division.

[4]NA = Not Available.

[5]The exact number of abandoned and inactive mine sites, oil and gas sites, and landfills is unknown.

[6]The exact number of vehicle maintenance activities will be greater than the number indicated because information is not available for the number of rail yards and US Postal Service facilities that conduct vehicle maintenance activities. Also, the number of manufacturing facilities that have co-located vehicle maintenance activities in unknown. Likewise, the number of Federal, State, and local government facilities conducting vehicle maintenance is unknown.

[7]Based on data received by the NOI Tracking center, EPA determined that NOIs for light industrial facilities represented 6% of the total number of light industrial facilities in the non-NPDES authorized States. EPA estimates that the compliance rate for the storm water program is 60%. When taking into consideration the compliance rate, EPA estimates that 8% of all light industrial establishments require Phase I storm water permits.

necessary. The cost savings for an existing industrial facility are only the annual costs, but cost savings for facilities that become operational after promulgation of the Phase II rule will include both start-up and annual costs. This analysis, however, does not attempt to estimate the cost savings for new facilities.

Exhibit 9–4. Estimated Industrial Pollution Prevention Costs for All Regulated Facilities (1998 dollars)

Requirements for All Facilities	Low Costs			High Costs		
	Start-Up Costs	Annual Costs	Total Costs	Start-Up Costs	Annual Costs	Total Costs
Plan Preparation	$1,758		$1,758	$88,214		$88,214
Plan Implementation	$105	$340	$1,805	$41,006	$10,855	$95,281
Comprehensive Site Compliance and Evaluation/Plan Revision		$310	$1,550		$10,281	$51,405
Reportable Quantities				$9,847		$9,847
Subtotal	$1,863	$650	$5,113	$139,067	$21,136	$244,746

Source: Multi-sector Storm Water General Permit (60 FR 51108)
Notes: Numbers may not total because of rounding.
Since permit lasts for 5 years, total costs = (annual costs X five years) + first year costs.

Exhibit 9–5. Estimated Incremental Industrial Pollution Prevention Costs for EPCRA Facilities (1998 dollars)

Requirements for EPCRA Facilities	Estimated Costs		
	Start-Up Costs	Annual Costs	Total Costs
Plan Preparation			
Liquid Storage Area	$12,974		$12,974
Material Storage Area	$649		$649
Loading Areas	$24,326		$24,326
Process Areas	$12,963		$12,963
Drainage/Runoff	$8,978		$8,978
Housekeeping/Maintenance		$6,901	$34,505
Facility Security	$3,754		$3,754
Employee Training		$1,625	$8,125
Toxicity Reduction		$3,517	$17,585
Subtotal	$63,642	$12,043	$123,854

Source: Multi-sector General Permit (60 FR 51108)
Notes: Numbers may not total because of rounding. Also, costs are in addition to costs indicated in Exhibit 9–4.
Since permit lasts for five years, total costs = (annual costs X five years) + first year costs.

Exhibit 9–6. Estimated Annual Cost Savings per Facility (1998 dollars)

Facility	Existing Facility	Operational Facility After Promulgation of Phase II Rule
Non-EPCRA facility	$650-$21,136 [1]	$1,023-$48,949 [3]
EPCRA facility	$12,693-$33,179 [2]	$25,794-$73,720 [4]

[1]Based on annual costs in Exhibit 9–4.
[2]Based on annual costs in Exhibit 9–4 plus annual costs in Exhibit 9–5
{i.e. : ($650 +$12,043 = $12,693) and ($21,136+$12,043 = $33,179) }
[3]Based on first time costs divided by 5 years plus annual costs in Exhibit 9–4;
{i.e. : (1863/5) + 650 = 1,023 and (139,067/5) + 21,136 = 48,949}
[4]Based on first time costs divided by 5 years plus annual costs in Exhibit 9–5 and figure from above.
{i.e. : (63,642/5) + 12,043 +1,023 = 25,794 and (63,642/5) +12,043 + 48,949 = 73,720}

The percent of facilities that required to meet EPCRA requirements is unknown; this analysis assumes that 25% of facilities qualifying for the no exposure exemption must meet EPCRA requirements. Based on this assumption of 25% EPCRA and 75% non-EPCRA, a weighted average using annual costs information from Exhibit 9–4 and Exhibit 9–5 determined the low and high range of estimated cost savings.[7]

Exhibit 9–7. Adjusted Annual Cost Savings per Facility (1998 dollars)

Low	High
$3,661	$24,147

Monitoring Costs

The lack of required monitoring will result in a second cost savings for industrial facilities that qualify for the no exposure exclusion. The multi-sector general permit includes both visual and analytical monitoring requirements. The visual monitoring requirements must be conducted each quarter year by all facilities. Analytical monitoring must be conducted during years two and four of the multi-sector general permit. EPA estimates that it will take 30 minutes to collect and visually inspect a storm water sample and to log the observation. EPA also estimates that it will take 30 minutes to collect, via a grab sample, and package each storm water sample for shipment to an outside laboratory for analysis. The average hourly wage for private sector employees (including overhead and administrative costs) is estimated to be $44.35, in 1998 dollars.[8] Therefore, the average cost to collect and package, or visually inspect and record, a storm water sample is estimated to be $22.17, in 1998 dollars. The multi-sector general permit includes analytical monitoring of storm water samples for many of the industrial sectors and subsectors.

[7]For the low estimate, 25% (650 + 12,043) + 75% (650) = 3,661.
For the high estimate, 25% (21,136 + 12,043) + 75% (21,136) = 24,147.

[8]This figure is based on the average hourly compensation for all employees in the manufacturing sector (SIC codes 20 through 39) and includes 50% for overhead, 67% for fringe, and 15% for inflation. The source of the number of employees is US Department of Commerce, Bureau of the Census. 1995. *1993 Annual Survey of Manufactures: Statistics for Industry Groups and Industries*, M93(AS)-1. Table 2, page 1-8.

Exhibit D–2–1 in Appendix D provides estimated unit costs for the parameters identified in the monitoring section of the multi-sector general permit. Exhibit D–2–2 indicates the monitoring requirements and estimated costs for each subsector in the multi-sector general permit. Since the number of outfalls will vary from site to site, it has been assumed that each industrial facility will have four outfalls. The multi-sector general permit requires industrial permittees to conduct four sampling events during years two and four of the permit. Therefore the total number of samples collected during the life of the five year permit is 32.[9]

Notice of Intent Costs

The operators of Phase I industrial facilities are required to submit a notice of intent (NOI) under a NPDES general permit to obtain coverage of storm water discharges associated with industrial activity. In 1992, EPA estimated the cost for the operator to complete an NOI to be approximately $16.25, in 1998 dollars.[10] Since the submittal of the NOI is a one-time expense, an annual cost can be estimated by dividing the one-time cost by the life of the permit, which is typically five years. Therefore, the annual cost is estimated to be approximately $3.25, in 1998 dollars.

Costs for Notification of Municipalities

Under the modified multi-sector general permit, operators of industrial facilities that discharge into a local municipal separate storm sewer system (MS4) are required to notify the MS4 operator (typically a municipality) that they are applying for a NPDES storm water permit. In 1992, EPA estimated the cost of municipal notification at approximately $16.25, in1998 dollars.[11] Notifying the local municipality is a one-time expense an annual cost can be estimated by dividing the one-time cost by the life of a five-year permit. The annual cost is estimated to be approximately $3.25 in 1998 dollars.

Recordkeeping Costs

The operator of an industrial facility is required to retain all data, plans, reports, and inspections required under the permit for three years from the date of permit expiration. It is estimated that the cost for recordkeeping is approximately $457, in 1998 dollars for a five year permit, or $91, in 1998 dollars annually.[12]

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[9] The number of samples collected during the life of the five year permit can be calculated by:
[NUMBER OF YEARS SAMPLES REQUIRED] x [NUMBER OF OUTFALLS] x [QUARTERS IN A YEAR]
OR 2 x 4 x 4 = 32.

[10] The Cadmus Group, Incorporated. February 21, 1992. *Information Collection Request for the Revisions to the National Pollutant Discharge Elimination System: Storm Water Implementation.* Prepared for US EPA Office of Wastewater Enforcement and Compliance.

[11] The Cadmus Group, Incorporated. February 21, 1992. *Information Collection Request for the Revisions to the National Pollutant Discharge Elimination System: Storm Water Implementation.* Prepared for US EPA Office of Wastewater Enforcement and Compliance.

[12] It is estimated that over the five-year multi-sector permit the industrial facility will spend five hours for recordkeeping activities at $43.67 per hour. For these recordkeeping activities it will be necessary for the industrial facility to purchase one two- drawer vertical file cabinet for $208 and hanging folders for $25. The total cost over the five-year permit is approximately

9.2.4 Total Industrial Cost Savings

Exhibit D–2–3 in Appendix D indicates the estimated number of industrial facilities in each subsector (under the multi-sector general permit) that may qualify for the no exposure exemption and the cost savings associated with each subsector. The per facility per subsector annual costs were summed over visual monitoring costs, analytical monitoring costs, submittal of NOI costs, municipality notification costs, recordkeeping costs and the respective low and high pollution prevention plan costs. This estimate is then multiplied by the number of facilities with no exposure in each subsector to obtain the annual low and high range cost savings for each subsector. It is estimated that a total of 76,239 facilities, currently regulated by the Phase I industrial storm water program, will qualify for the no exposure conditional exclusion. This will result in an annual cost savings ranging from $318,825,521 to $1,865,642,987 in 1998 dollars. This range is extremely large due to the large annual cost range associated with storm water pollution prevention plans (per-facility annual costs range from $3,661 to $24,147), as shown in Exhibit 9–7.

9.3 No Exposure Certification Cost

Under the Phase II rule, industrial facilities currently regulated and permitted under §122.26(b)(14)(I) through (ix), but have no exposure of activities or materials to storm water, will be eligible for the no exposure exclusion. The operators of facilities that seek to obtain the no exposure exclusion must provide written certification to the NPDES permitting authority that no exposure conditions exist. In addition, operators of facilities that meet the SIC code definition of §122.26(b)(14)(xi), but are not currently covered by a permit because their industrial activities and materials are not exposed to storm water, will now need to certify that no exposure conditions exist at their industrial site. Therefore, to determine the net cost savings it is necessary to estimate the certification cost.

Through an informal poll, it was estimated that it would take 45 minutes to complete EPA's no exposure certification form (see Appendix D–1).[13] Similar to a permit application, the certification form must be re-submitted every five years. The average hourly wage for private sector employees (including overhead and G&A) is estimated to be $44.35, in 1998 dollars.[14] Therefore, the average cost to complete the no exposure certification form is estimated to be $33.26, in 1998 dollars.

$450, in 1997 dollars.

[13]An informal poll of professionals knowledgeable of the industrial activities conducted by storm water permittees and the storm water program was conducted. The average time to complete EPA's no exposure certification form was 45 minutes.

[14]This figure is based on the average hourly compensation for all employees in the manufacturing sector (SIC codes 20 through 39) and includes 50% for overhead, 67% for fringe, and 15% for inflation. The source of the number of employees is US Department of Commerce, Bureau of the Census. 1995. *1993 Annual Survey of Manufactures: Statistics for Industry Groups and Industries*, M93(AS)-1. Table 2, page 1–8.

The number of currently permitted facilities in categories (I) through (ix) with no exposure is estimated to be approximately 76,239.[15] The number of existing category (xi) industrial facilities with no exposure that will now be required to submit a no exposure certification form to the NPDES permitting authority is estimated to be approximately 105,646.[16] The summation of these two figures results in 181,885 as the total number of facilities that will complete the notice of certification.

The total cost to complete the no exposure certification form can be estimated by:

[LABOR COST] x [NUMBER OF FACILITIES] = TOTAL COST

where:

LABOR COST	=	$33.26, in 1998 dollars. (three-fourths of the average hourly wage of $44.35 for private sector employees in the manufacturing sector to complete the no exposure certification form in 45 minutes).
NUMBER OF FACILITIES	=	181,885 (Number of facilities from categories (I) through (ix) and (xi) that have no exposure of their activities and materials to storm water.)

Using the above formula, the total cost to complete the no certification form is approximately $6,049,495. By dividing the total cost by five (the term of the certification), the estimated annual cost to complete the no certification form is $1,209,899.

9.4 Net Compliance Cost Savings

The net impact of the no exposure exclusion is an annual net compliance cost savings ranging from $317,615,622 to $1,864,433,088. Annual net compliance cost savings reflects the annual cost savings for all facilities projected to qualify for the no exposure exemption less the estimated total annual cost for all facilities to complete the no exposure certification form.

9.5 State and Federal Costs

Once the no exposure provision is promulgated, the costs for federal and state NPDES permitting authorities will increase. The NPDES permitting authorities will need to make a certification

[15] See Exhibit 9–3. The total includes industrial categories (I) through (ix) of 40 CFR §122.26(b)(14).

[16] The total number of light industrial facilities in the US is estimated to be 293,462 and the total number of light industrial facilities regulated by the Phase I storm water regulation is estimated to be 23,477 from Exhibit 9–3. The exact number of light industrial facilities with a discharge to waters of the US is unknown. If it is assumed that 44% of all light industrial facilities have discharges to waters of the US (44% is equivalent to the average developed in Exhibit 9–2) and 23,477 light facilities require Phase I industrial storm water permits because they meet the regulatory definition of §122.26(b)(14)(xi) then the number of category xi facilities that will need to certify no exposure conditions is approximately 105,646, that is, (293,462 x 0.44 – 23,477).

form available to the regulated community, and then record and review the no exposure certification forms submitted. However, since EPA has already included a certification form in the Phase II rule package, the cost for a NPDES permitting authority to develop a form was not included in this analysis. The increased cost is based simply on significant number of industrial facilities that are expected to certify to no exposure.

9.5.1 Total State Costs

The NPDES-authorized states and territories will be responsible for implementing the no exposure provision. This will require the states to record and review the no exposure certification forms submitted by industrial facilities. It is estimated that a total of 181,885 industrial facilities have no exposure and will submit a no exposure certification form. Multiplying the ratio of NPDES-authorized states and territories (44) to the total NPDES jurisdictions (53) by 181,885 results in a total of 150,999 facilities possibly seeking the no exposure exclusion in NPDES-authorized states and territories. Exhibit 9–8 presents the cost to implement the no exposure provision in NPDES-authorized states and territories. The annual cost is expected to be approximately $811,000.

Exhibit 9–8. State Costs to Implement the Industrial No Exposure Provision (1998 dollars)

	Estimate
Number of Establishments Certifying No Exposure[1]	150,999
State Cost to Process Each Certification Form[2]	$26.87
Total State Costs (Over 5 years)[3]	$4,057,343
Total State Costs (Annual)[4]	$811,469

[1]The estimated number of industrial facilities (categories (I) through (ix) and (ix)) eligible for the no exposure exclusion was calculated by multiplying the ratio of NPDES-authorized States (44) to total NPDES jurisdictions (53) by 181,885, which is the estimated number of facilities eligible for the no exposure exclusion.
[2]The average hourly wage for State employees was determined by the US Dept. of Labor Employment Cost Indexes and Levels 1975–1995; Bulletin 2466, Oct.1995. The hourly wage includes overhead expenditures and is in 1998 dollars.
[3]Total state costs are reported over five years in this row. Five years represents the life of the certification. In subsequent permit cycles the costs to process the certification forms may increase because additional facilities will constructed (which are not included in this analysis) and other facilities will change their existing practices to make themselves eligible for the no exposure exclusion.
[4]The annual cost was derived by dividing the Total State Costs by five. Similar to a permit, the certification form has a five-year term.

9.5.2 Total Federal Costs

EPA will be responsible for implementing the no exposure provision in the nine non NPDES-authorized states and territories. As the NPDES permitting authority in these nine areas, EPA will have to record and review the no exposure certification forms submitted by industrial facilities. It is estimated that a total of 181,885 industrial facilities have no exposure and will submit a no exposure certification form. Multiplying the ratio of non-authorized states and territories (9) to the total NPDES jurisdictions (53) by 181,885 results in a total of 30,886 facilities possibly seeking the no exposure exclusion in non-authorized states and territories. Exhibit 9–9 presents the cost for EPA to implement the no exposure provision in non-authorized states and territories. The annual cost is expected to be approximately $175,000.

Exhibit 9–9. Federal Costs to Implement the Industrial No Exposure Provision (1998 dollars)

	Estimate
Number of Establishments Certifying No Exposure[1]	30,886
EPA Cost to Process Each Certification Form[2]	$28.37
Total EPA Costs (Over 5 years)[3]	$876,236
Total EPA Costs (Annual)[4]	$175,247

[1]The estimated number of industrial facilities (categories (I) through (ix) and (ix)) eligible for the no exposure exclusion was calculated by multiplying the ratio of non NPDES-authorized states (nine) to total NPDES jurisdictions (53) by 181,885, which is the estimated number of facilities eligible for the no exposure exclusion.

[2]The average hourly wage for federal employees, including overhead costs was determined by the US Office of Personnel Management, 1998 schedule.

[3]Total EPA Costs are reported over five years in this row. Five years represents the life of the certification. In subsequent permit cycles the total costs to process the certification forms may increase because additional facilities will be constructed (which are not included in this analysis) and other facilities will change their existing practices to make themselves eligible for the no exposure exclusion.

[4]The annual cost was derived by dividing the Total EPA Costs by five. Similar to a permit, the certification form has a five-year term.

9.6 Data Limitations

There are a number of data limitations that hindered the no exposure provision analysis in this chapter. These limitations include:

- There are no data sources indicating the number of industrial facilities that should be covered by the Phase I program, therefore, the baseline needed to be estimated and in some cases reliable data could not be collected.
- The number of facilities do not include abandoned or inactive mines, landfills, and oil and gas sites on both public and private lands.
- By estimating the universe of regulated facilities with data from *County Business Patterns* there is the potential to under estimate the number of facilities, and industrial activities, regulated. For example, some facilities may need to meet permit requirements for more than 1 industrial sector. This is true for large industrial facilities, such as a newsprint mill, which

may have to meet permit conditions for newsprint manufacturing, vehicle maintenance, railroads, steam electric generation, and on-site landfills. The method used to estimate the number of establishments would only count this as one facility in this analysis, but in reality this facility would have five different permit conditions reflecting each of the above industrial activities.

- By relying on the *County Business Patterns* there is the potential to over estimate the number of industrial establishments is some SIC codes and under estimate in others. The *County Business Patterns* records locations where commercial transactions occur not where the industrial activity occurs. For example, the *County Business Patterns* indicates that there are over 100 facilities identified by SIC code 45 occurring in the District of Columbia. SIC code 45 represents transportation by air, but in reality, the District of Columbia does not have a single commercial airport within its jurisdiction. Similarly, the *County Business Patterns* do not report data for the thousands of active oil and gas exploration, production, processing, or transmission sites. These two help indicate the difficulty in estimating the number of facilities regulated under the Phase I program.

- The potential number of industrial facilities requiring storm water permits may be overstated because there was no attempt to eliminate industrial facilities that may discharge storm water to combined sewers. Storm water discharges to combined sewers are exempt from storm water permitting requirements. The exact number of industrial facilities with storm water discharges to combined sewer systems is unknown.

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Appendix A

Literature Related to the Potential Impacts of Storm Water Discharges

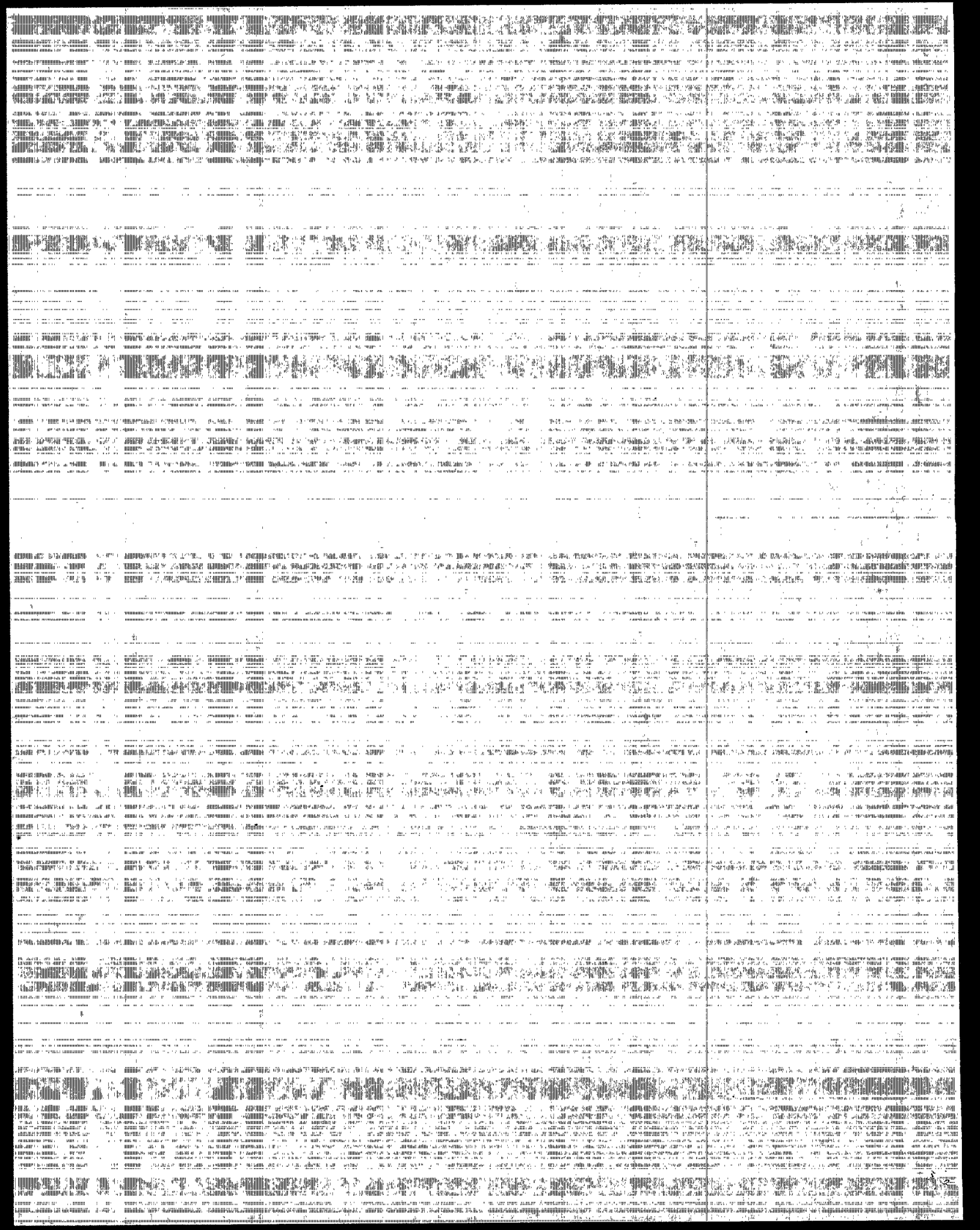


Exhibit A–1. Literature Related to the Potential Impacts of Storm Water Discharges

Study	Description	Results
Jones et al. (1997)	Macroinvertebrate and fish communities were used to assess the ability of urban BMPs to mitigate Storm water impacts in a suburban watershed. A total of eight practices were assessed including wet ponds, dry ponds, a retrofitted culvert, and a riparian park. The study area is Neabsco Creek in Prince William County, VA., located in a rapid growing suburban jurisdiction in the Washington D.C., metro area. The area has undergone substantial development in the past 20 years and has been accompanied by the use of BMPs to control Storm water impacts. The reference site is Quantico Creek, also in Prince William County, whose watershed is occupied by a unit of the National Park System and the Quantico Marine Base. The watershed is almost entirely forested.	Alterations in the stream macroinvertebrate community in the suburban Neabsco watershed were clear at all sampling stations even when EPA Rapid Bioassessment Protocol (RBP) index values were near reference levels. Taxa richness was consistently lower in the suburban streams particularly in the key indicator groups: stoneflies, mayflies, and non-hydropsychid caddisflies. In general, the data suggest that appropriately designed and properly sited BMPs can provide some mitigation of Storm water impacts on stream communities. However, no BMPs were able to restore the full complement of macroinvertebrate families found in the reference watershed. The resulting communities reflect a fundamental alteration in stream biotic diversity, structure, and function.
Barret et al. (1996)	Examined the impact of highway construction on Danz Creek, Travis County, TX, an intermittent stream that flows in a natural channel and through the construction corridor.	A review of literature shows that, in general, changes in water quality are the result of an increase in suspended sediments discharged from construction sites. The higher suspended solids levels result in reduced diversity and density of fauna in the affected area. Fourteen samples from ten storms were collected at each of two monitoring sites. The greatest differences between upstream and downstream concentrations are shown by suspended solids, turbidity, iron, and zinc. Although accumulation of sediment in the creek occurred during this period, by the end of the study period the creek below the highway had returned to preconstruction conditions. Even though the effects on Danz Creek were temporary, there is concern regarding the effects of construction on the water quality in the Edwards Limestone aquifer. The Danz Creek lies on the recharge zone and therefore, higher concentrations of suspended solids could be expected to enter the aquifer during the period when runoff from the construction site occurred.

Exhibit A–1. Literature Related to the Potential Impacts of Storm Water Discharges

Study	Description	Results
Masterson and Bannerman (1994)	Study to determine the impacts of Storm water runoff on five urban streams in Milwaukee County, Wisconsin. The authors analyzed storm sewer outfall, stream water quality, bottom sediment, whole crayfish tissue, semipermeable polymeric membrane devices (SPMDs), benthic macroinvertebrate surveys and habitat.	Study results show that the urban streams are not meeting their biological potential and recreational classifications as designated by the WDNR. Levels of suspended solids, bacteria, heavy metals, oil and grease, and PAHs were detected in Storm water discharges and stream water that exceeded water quality criteria. Urban streams exhibited a significantly lower diversity of fish species and a majority of the organisms are pollutant tolerant species of fish and macroinvertebrates. Benthic macroinvertebrate bioassessment scores indicated moderate to severe impairment. The study also found a correlation between the extent of urban land use and biological degradation and limited recreational uses. Three of the five streams studied have 100 % urban land use and were the most degraded. Two of the streams have approximately a 50 % urban and non-urban land use and supported a healthier population of aquatic organisms. The reference site supported the most abundant and diverse fish and invertebrate community in accordance with its 100 % non-urban location. Furthermore, high PAH and heavy metal concentrations (lead, in particular) were found in urban whole crayfish tissue samples. SPMD results confirmed that pollutants that tend to bioaccumulate (lipophilic pollutants such as lead, PAH, pesticides, zinc) are discharging into the streams.
Barret et al. (1993)	A review and evaluation of literature pertaining to the quantity and control of pollution from highway runoff and construction.	Highway construction may cause changes in turbidity, suspended solids concentration, and color of receiving waters. The extent and persistence of the changes varies from site to site. However, turbidity and suspended solids concentrations are much greater after construction begins. When construction impacts on stream quality are detected, they are usually transitory. Prevention of erosion during construction is important to minimize the effects on receiving waters. Vegetative stabilization is the most effective method for reducing construction impacts.

Exhibit A–1. Literature Related to the Potential Impacts of Storm Water Discharges

Study	Description	Results
Lopes and Fossum (1995)	The chemistry and toxicity of urban Storm water, streamflow, and bed material in the Phoenix, AZ area were characterized to determine if urban Storm water could degrade the quality of streams. The objectives were to characterize the chemistry and acute toxicity of Storm water from drainage basins with urban and undeveloped land use and of streamflow from the Salt River; identify the phases of Storm water (oil, grease, suspended solids, dissolved trace metals, and dissolved organic compounds) that are causing the toxic effect; and characterize the chemistry and acute toxicity of bed material from drainage basins with urban and undeveloped land use and ephemeral streams that receive urban runoff.	First-flush samples from urban drainage basins appeared to be more toxic than flow-weighted composite samples, and Storm water was more harmful to fathead minnows than to water fleas. The most toxic Storm water samples were collected from the drainage basins with residential and commercial land use, and the toxicity probably was due to surfactants and other constituents leached from asphalt and resealant. Toxicity was generally due to organic constituents. In urban drainage basins, bed-material samples collected from areas where Storm water accumulates appeared to be more toxic than from areas where Storm water does not accumulate.
Campbell (1994)	Storm water treatment ponds in the Orlando, FL area were studied to determine if fish that live these ponds contained significant concentrations of cadmium, nickel, copper, lead, and zinc. The study examined fish with different foraging strategies to determine if such differences affect heavy metal concentrations in the fish. The fish studied included the redear sunfish, a bottom feeder; largemouth bass, a predator at the top of the fish food chain; and bluegill sunfish, an omnivore. The Storm water ponds were associated with shopping center, apartment complex, and road construction projects. Wading birds were observed feeding in all selected storm water ponds. Natural lakes and ponds that did not receive any road or urban runoff were used as controls.	Significant concentrations of heavy metals were observed in the fish living in Storm water ponds, especially in the bottom-feeder, the redear sunfish. Redear sunfish collected from Storm water ponds contained mean cadmium, nickel, copper, lead, and zinc concentrations that were significantly higher than those from control sites. The effect on wading birds and other wildlife that are feeding on the fish living in Storm water ponds is unknown and was beyond the scope of the study. The authors suggest that, due to the results of the study, attracting wildlife to these ponds be discouraged.

Exhibit A–1. Literature Related to the Potential Impacts of Storm Water Discharges

Study	Description	Results
Sturm and Kirby (1991)	Studies focused on an evaluation of current design criteria and BMPs for controlling sediment in runoff from construction sites in response to legislation which established an effluent limit on turbidity. Grab samples were collected at the inlet to and outlet from sediment basins, and in the receiving stream at points upstream and downstream of the basin discharge point for several rainfall events. Samples were analyzed for suspended solids and turbidity. The turbidity standard for Georgia states that "discharges of Storm water runoff shall not exceed 50 NTU higher than the turbidity level of the receiving stream immediately upstream." The standard is 60 NTUs for roadway drainage construction sites.	The studies determined that the relationship between increases in suspended solids and turbidity as a measurement of water quality impairment varies with the soil type and the magnitude of the suspended sediment concentration. The probability of meeting the turbidity discharge standard was dependent on rainfall characteristics, the hydrologic condition and size of the watershed, soil properties and soil conservation measures, and sediment basin design. Results also suggested that an improvement in the design criteria for sediment basins would be to re-define the surface loading rate and to specify lower allowable values for solid with high percentages of clay.
Marsh (1993)	The objectives were to determine the biotoxicity of the nonpoint source runoff into the receiving waters of Jefferson County, KY and to determine whether there is a dilution factor in the toxicity of Storm water during the course of a storm. Over the course of one year, samples from six sites were analyzed for organic and inorganic compounds, pesticides, nutrients, dissolved solids, dissolved oxygen, turbidity, alkalinity, conductivity, hardness, pH, and temperature. The toxicity of the water was determined by bioassay of fathead minnows.	The study found that the contents of Storm water runoff from the Greater Louisville area were as varied as the sites where samples were collected and varied dramatically within a site from storm to storm. There were toxins in the runoff and sometimes the concentrations were exceedingly high. Pesticides, hydrocarbons, organic and inorganic compounds, low DO, high turbidity, and too many nutrients contributed to toxicity, but they were each a function of season, antecedent dry periods, and land uses. However, mortality in the bioassay was most affected by low DO concentrations in the runoff.
Lemly (1982)	Examined the water quality, substrate composition, and benthic insect populations in differently polluted zones of a small, southern Appalachian trout stream. Sediments in the Cullowhee Creek, NC were received from a feeder stream draining portions of the watershed disturbed by logging, residential construction, and livestock pastures.	Zones receiving sedimentation exhibited significantly degraded water quality with respect to bed load and pH at the substrate. These polluted zones also exhibited an extreme reduction in the abundance and diversity of filter feeding insects due to indirect effects of sedimentation which caused disruption of feeding and general habitat destruction. Addition of nitrates and phosphate, in association with sedimentation, resulted in growth of a filamentous bacterium which adversely affected insects.

Exhibit A–1. Literature Related to the Potential Impacts of Storm Water Discharges

Study	Description	Results
Gardner (1981)	Studied the effect of turbidity on the feeding rates of bluegills in a laboratory setting.	Found, under controlled circumstances, that turbidity significantly affected feeding rates. The experiment tested three levels of turbidity (60, 120, and 190 NTU) and found that feeding rates at the most turbid level declined by almost 50% as compared to the clearest level. The authors concluded that the reduction of feeding rates may occur in natural systems subject to periods of high concentrations of suspended sediments. The range of turbidity used in the study encompasses that found in North Carolina and may be typical of many southeastern US lakes and streams. In addition, turbidity in streams from watershed disturbed by construction or logging could exceed these levels.
Field and Pitt (1990)	Two studies examined the effects of urban runoff on aquatic organisms. One study examined Coyote Creek in San Jose, CA, a small stream only a few meters wide and less than a meter deep that drains a watershed of about 80,000 ha. Upstream flows are quite clean and downstream urban flows are highly variable and polluted. Another study compared two streams in Bellevue, WA, Kersey Creek an urban stream, and Bear Creek, a rural stream.	Both studies found significant impairment to aquatic life beneficial uses, but the possible causes were quite different. In Coyote Creek, impairment was attributed to major accumulation of toxic sediments. Kersey Creek suffered from increased flows, altered channel morphology and food availability, low DO concentrations, and various organic and metallic priority pollutants. The studies reveal that the effects of storm-induced discharges on aquatic, receiving-water organisms and other beneficial water uses is site-specific. Previous attempts to identify urban storm runoff problems using available data have not been conclusive because of differences in sampling procedures and the practice of pooling data from various sites. The long-term aquatic effects of urban runoff are probably more important than short-term effects associated with specific events. Further, long-term effects may only be expressed at great distances downstream from discharge location, or in accumulating areas (such as lakes).

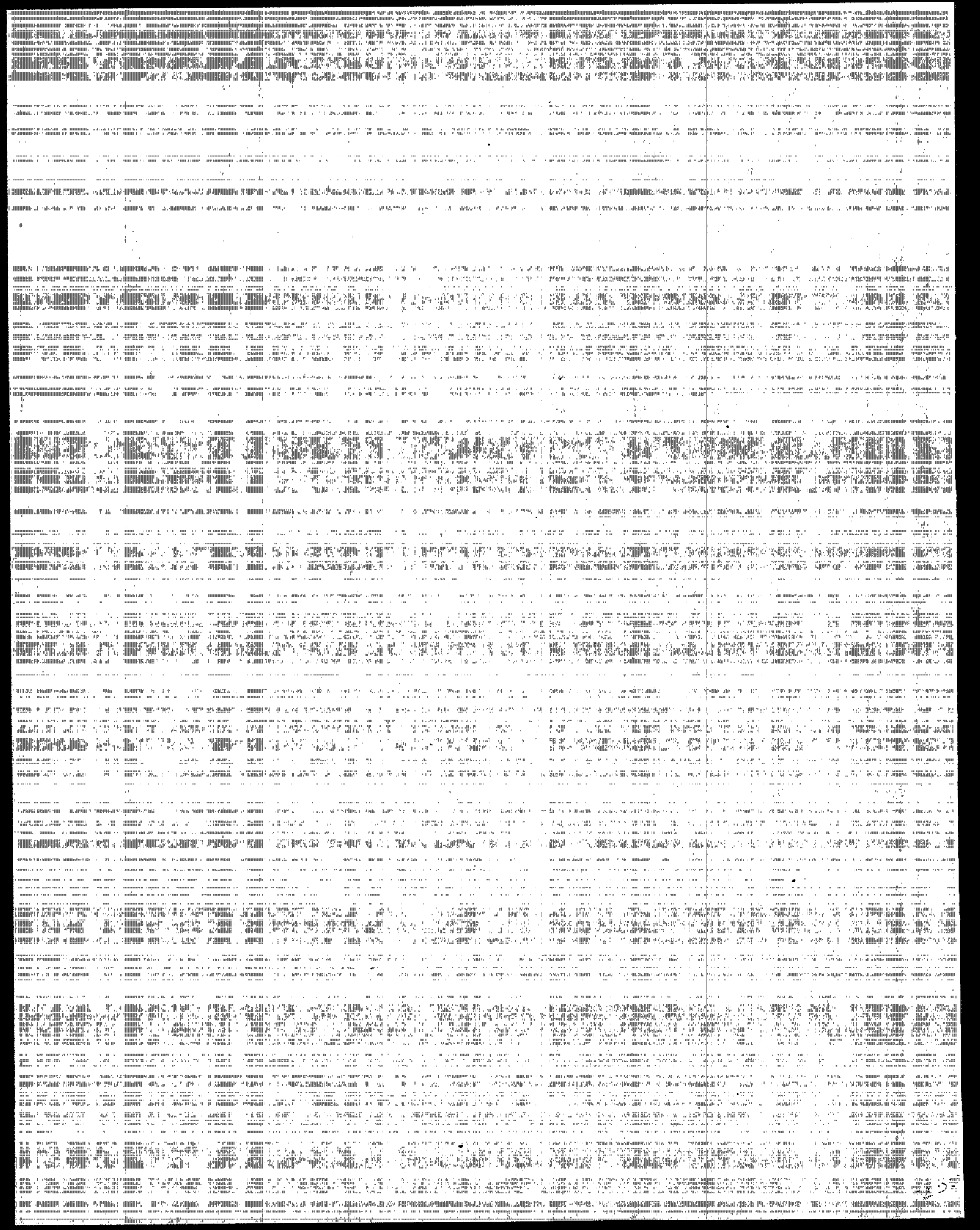
Exhibit A–1. Literature Related to the Potential Impacts of Storm Water Discharges

Study	Description	Results
Steinman and McIntire (1990)	Describes the responses of periphyton communities to disturbances that change local environmental conditions and biological properties of the system in question. The disturbances examined in the paper are floods, desiccation, organic nutrient enrichment, and toxic pollutants.	A survey of the literature reveals that periphyton recovery patterns can be influenced strongly by site and disturbance type. For example, local environmental conditions, such as nutrient concentration, light level, grazing pressure, substrate size and composition, propagule abundance and source, sediment load, and stream order, grade, and channel geomorphology all can affect the recovery rates of periphyton. In addition, periphyton communities appear to take longer to recover from exposure to toxic metals than other disturbance types, perhaps because these metal remain in the system a relatively long time. Periphyton communities are crucial to stream ecosystem recovery because they serve as an important food resource for many invertebrates. Hence, if periphyton recovery is slow following a disturbance, other biological components in streams also may be slow to recover.

Appendix B

Data and Methods Associated with the Municipal, Construction, and Post-Construction Programs

Appendix B–1	**Narrative Explanations of Evaluated Costs and Municipal Cost Data**
Appendix B–2	**Revised Construction Start Methodology**
Appendix B–3	**Model Construction Site Plans**
Appendix B–4	**Post-Construction Runoff Control Analysis**
Appendix B–5	**Federal and State Administrative Costs**



Appendix B-1

Municipal Cost Questions and Results from the NAFSMA Storm Water Phase II Survey

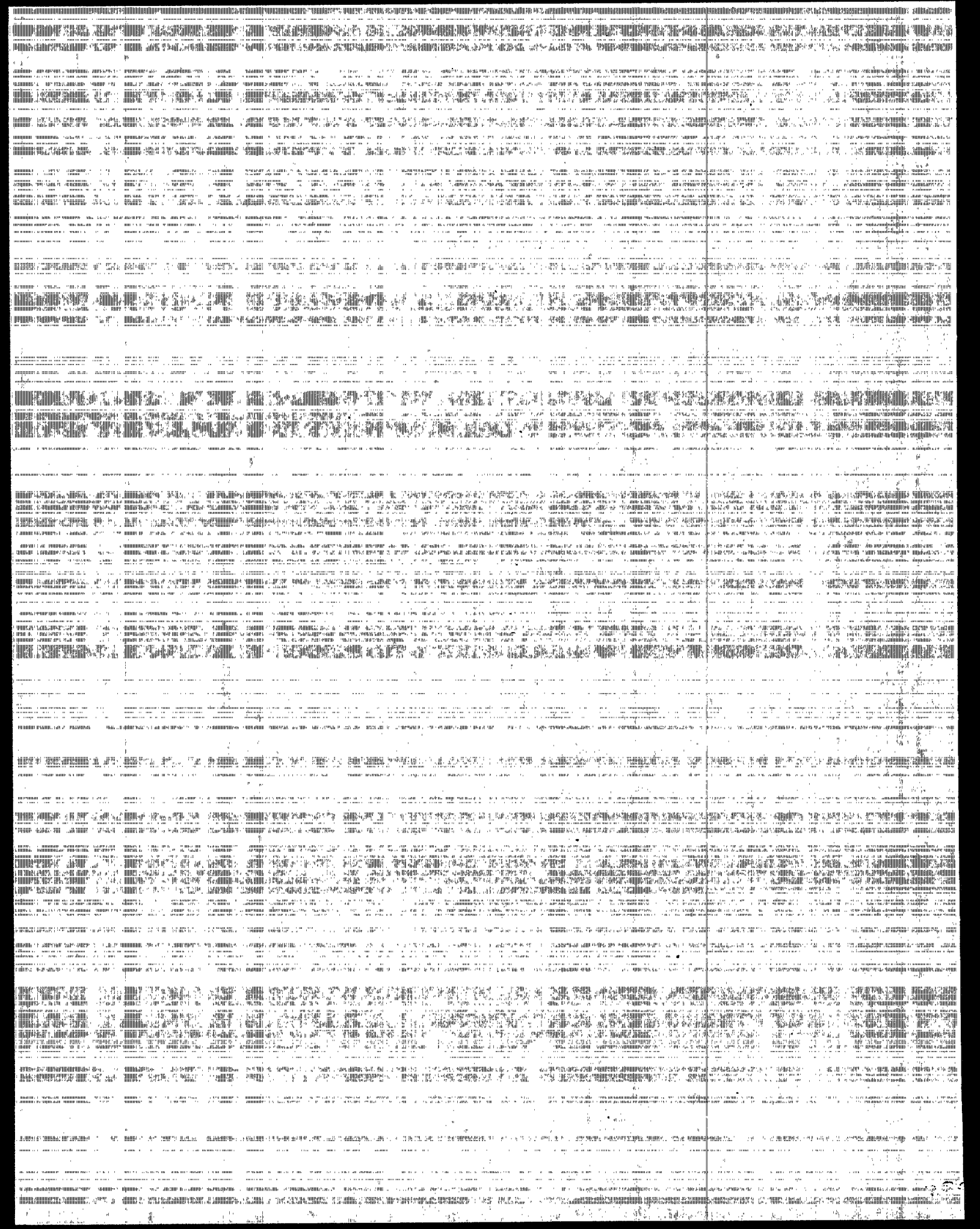


Exhibit B-1a
NAFSMA Storm Water Phase II Survey

National Association of Flood and Stormwater Management Agencies
1299 Pennsylvania Ave NW, Eighth Floor West ω Washington, DC 20004 ω Tel: (202) 218-4122 ω Fax: (202) 842-0621

NAFSMA Storm Water Phase II Survey

The first six of the following questions correspond directly to the six "minimum measures" required by the proposed January 9, 1998 stormwater phase II regulation (63 FR 1536-1643). Completing these questions will give you an overview of the requirements your jurisdiction will likely face upon adoption of the final rules, and will give you a preliminary assessment of whether you are already meeting most of the requirements or will have to initiate new, locally funded activities. The additional questions will enable NAFSMA to evaluate how to best serve you and other Phase II communities.

Please fax (202) 842-0621 or mail the survey to Bill Morrissey at NAFSMA's National Office by Monday, August 31, 1998

Best contact person in your local government for Phase II information

Name:_____

Address:_____

City/State/Zip_____

Phone_____ Fax_____

Email_____

1. Do you have a public education/outreach program that distributes educational materials to the community about the impacts of storm water discharges on water quality and the steps to be taken to reduce pollutants in stormwater? Y N

   If yes, which of the following are included in your program, and what is the approximate annual cost? (Circle all appropriate letters)

A. Limiting the use and runoff of lawn and garden chemicals $_____
B. Promotion of "adopt a stream" and similar programs $_____
C. Promotion of storm drain stenciling $_____
D. Education of commercial, industrial, and institutional entities on storm water pollution $_____
E. Targeting of diverse communities, such as minority, disadvantaged, and children $_____
F. Informing public employees, businesses and the general public of hazards associated with illegal discharges and improper disposal of waste $_____
G. Other_____ $_____

   Approximate total annual cost: $_____

2. Are you required by State law and/or local ordinance to notify and/or involve your citizens in projects or programs that may effect local rivers, streams, lakes, or other types of water bodies? Y N

   - Do you have citizens advisory board that would advise elected officials or staff on new public works or water quality programs or activities? Y N

3. Do you have a storm sewer map for your jurisdiction that shows the location of major pipes, outfalls? Y N

   - If no, do you have an estimate of the cost to prepare such a map? $_____
   - Are you familiar with how to acquire such a map? Y N
   - Do you have a map or other data source that identifies areas of concentrated activity likely to be a source of storm water pollution, such as hazardous waste facilities, waste transfer stations, and

municipal "industrial" facilities, such as vehicle maintenance operations, transportation facilities (Bus garages [indoor/outdoor], light rail, commuter van pools, etc).? Y N

- If no, do you have an estimate of the cost to prepare such information? $_____

- Do you have a program to detect and address illicit discharges, including illegal dumping, to your storm water system? Y N

- If yes, what is the approximate annual cost of this program? $_____

4. Do you have an erosion/sediment control program for construction activities involving one or more acres? Y N

- Do you regulate or impose sediment control requirements on construction activities, management of construction waste (including human) and debris at construction sites? Y N

Note: Such a program must use an ordinance or other regulatory mechanism that requires the control of erosion and sediment to the maximum extent practicable and allowable under State or Tribal law. The program must control other waste at the construction site that may adversely impact water quality, such as discarded building materials, concrete truck washout and sanitary waste. The program must include, at a minimum, requirements for construction site owners or operators to implement appropriate best management practices (BMP), provisions for pre-construction review of site management plans, procedures for receipt and consideration of information submitted by the public, regular inspections during construction, and penalties to insure compliance.

- If yes, what is the approximate annual cost of this program? $_____

5. Do you have a program to permanently address storm water runoff from new development and redevelopment projects that result in land disturbance of one or more acres? Y N

Note: Such a program must include a plan to implement site-appropriate and cost-effective structural and non-structural best management practices (BMP's), and ensure adequate long-term operation and maintenance of such BMP's. The program must ensure that controls are in place that would prevent or minimize water quality impacts. Examples of non-structural BMP's include policies and ordinances that result in protection of natural resources and prevention of runoff, such as growth limits, protection of wetlands and riparian areas, minimizing impervious areas, maintaining open space, and minimizing disturbance of soils and vegetation. Examples of structural BMP's include detention ponds, filtration practices such as grassed swales and sand filters, and infiltration practices such as porous pavement.

- If yes, what is the approximate annual cost of this program? $_____

6. Do you have a program to prevent or reduce pollutant runoff from municipal operations? Y N

Note: Such a program must include local government employee training to prevent and reduce storm water pollution from government operations, such as park and open space maintenance, fleet maintenance, transportation facilities, planning, building oversight, and storm water system maintenance.

- If yes, what is the approximate annual cost of this program? $_____

7. Are you aware that by August 7, 2001 municipalities less than 100,000 population that own or operate an "industrial facility are required to submit a NPDES permit application for storm water discharges? Y N

Note: Municipalities less than 100,000 were exempted by a provision in ISTEA in 1991 from having to permit facilities they own or operate with "storm water discharges associated with industrial activity" except for airports, power plants, and uncontrolled sanitary landfills. Regulations effective August 7, 1995 extended this exemption for six years. "Industrial" facilities that a small municipality might own or operate that are exempted until 8/7/2001 include: vehicle maintenance shops, asphalt and concrete batch plants, sand and gravel mines, municipal solid waste landfills or transfer stations, hazardous waste landfills and land-application sites, hazardous-waste recycling facilities, municipal wastewater treatment plants over 1 MGD, and municipal construction sites (including new road projects) over 5 acres.

- Are You aware that if You own or operate an airport, power plant, or uncontrolled sanitary landfill, you were required to submit a storm water permit application by October 1, 1994? Y N

Note: Uncontrolled sanitary landfills are active or closed landfills or open dumps that do not meet the runoff control requirements for solid waste facilities defined in RCRA.

8. What is the area served by your storm water system, measured in square miles? _____ square miles

   ♣ What is the area of your jurisdiction, if different from above? _____ square miles

9. What is the population of your jurisdiction? _____

10. Is there an adjoining or overlapping city or county that already has a stormwater program permitted by the State or EPA that may agree to:

    a) operate a joint stormwater program for both your cities;
    b) operate selected parts of the program jointly for both your cities;
    c) provide you with assistance in developing and implementing your program:
    d) talk to you about the program;
    e) none of the above;
    f) don't know;

11. What portions of the storm water sewer system in your jurisdiction do you currently regulate, maintain, and replace when obsolete? **(Check all that apply)**

Portion of System	Regulate	Maintain	Replace
Jurisdiction owned properties	o	o	o
Jurisdiction maintained streets/roadways	o	o	o
Adopted easements on private property	o	o	o
All streams, ditches and storm drains that...	o	o	o

(check statement below that matches your defintion of storm drain)

___ serve more than one property
___ contain runoff from a public street or property
___have a drainage of_____ acres
___ other_____

12. How are your current storm water system operations, maintenance, repair, rehabilitation, and replacement activities funded? (Circle all letters that apply)

A.	Your city's/agency's general revenues	_____ percent
B.	A separate storm water system fee or tax	_____ percent
C.	A combined water utility fee or tax	_____ percent
D.	A dedicated street maintenance revenue	_____ percent
E.	A regional storm water management agency	_____ percent
F.	Other _____	_____ percent

13. How do you expect to pay for this new program? **(Circle all letters that apply)**

G.	Your city's/agency's general revenues	_____ percent
H.	A separate storm water system fee or tax	_____ percent
I.	A combined water utility fee or tax	_____ percent
J.	A dedicated street maintenance revenue	_____ percent
K.	A regional storm water management agency	_____ percent
L.	Other _____	_____ percent

14. How do you expect to prepare the required permit application when the time comes?

A. Existing staff
B. Hire new permanent staff
C. Hire new temporary staff
D. Consultant
E. Do not know

15. Prior to receiving this package, were you notified that you would soon be required to have a stormwater pollution control program? Y N

If yes, what has been your primary source of information? (Circle all letters that apply)

A. National League of Cities
B. National Association of Counties
C. American Public Works Association
D. National Association of Flood and Stormwater Management Agencies
E. US Environmental Protection Agency
F. State
G. Magazines/publications
H. Other _____

16. How can NAFSMA and other organizations best assist you in meeting Phase II storm water requirements?

A. Workshops and seminars on the regulations
B. Sharing activities of other jurisdictions
C. Written materials through the mail
D. Web page updates
E. Other _____
F. Other _____

Survey Completed By (If different than contact): _____

For questions concerning the survey please contact Bill Morrissey in NAFSMA's Washington Office.

Phone: (202)218-4122 E-Mail: Morrisseyw@carmengrp.com

Please return the survey to Bill Morrissey via mail or either fax number:

Bill Morrissey
NAFSMA
1299 Pennsylvania Ave, Eighth Floor West
Washington, DC 20004

Fax: (202)842-0621 or (202)785-5277

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NAFSMA assigned an ID number to each city and county that responded to their survey. Of the 121 respondents, 56 were able to provide cost information about their storm water programs. Exhibit B-1b presents the cost information reported by the 56 respondents.

Exhibit B–1b. NAFSMA Raw Data Used in the Economic Analysis
Annual Costs Reported

ID#	Question 1 Public Ed/ Outreach ($)	Question 3 Illicit Discharges ($)	Question 4 Erosion/Sed Control ($)	Question 5 Development ($)	Question 6 Muni Runoff ($)	Question 9 Population ($)
1		5,000				4,900
2			40,000	40,000		40,000
4			30,000	30,000		30,000
5					2,000	45,000
6			5,000	5,000		12,500
8	27,500	50,000	35,000	20,000	15,000	23,500
11	600					4,406
13				25,000		23,500
14	2,000	2,000				150,000
15	30,000					30,000
20		5,000	5,000	5,000	2,500	10,000
22				100,000		15,000
25		100,000		100,000		50,600
27	2,000		4,000	5,000	2,000	3,300
28		100,000				100,000
31	3,000		10,000	7,500		88,000
33		30,000	20,000	10,000		37,000
35	3,000		40,000	50,000		13,000
36			1,040			23,000
37				40,000		65,000
40		35,000		10,000		45,000
41			5,000	5,000		29,800
44			10,000	10,000		72,000
46	400		500	1,200		15,396
47	50,000		7,000	3,000	7,000	120,000
50	114,000					50,000
52			75,000	75,000	500,000	25,000
55	1,000					33,000
56	10,000	6,000				68,000
58	1,000			5,000		100,000
60	200	10,000	15,000	5,000	5,000	35,000
63		5,000	2,000		3,500	4,200
64		75,000			10,000	33,000
65					300,000	90,000

Exhibit B–1b. NAFSMA Raw Data Used in the Economic Analysis

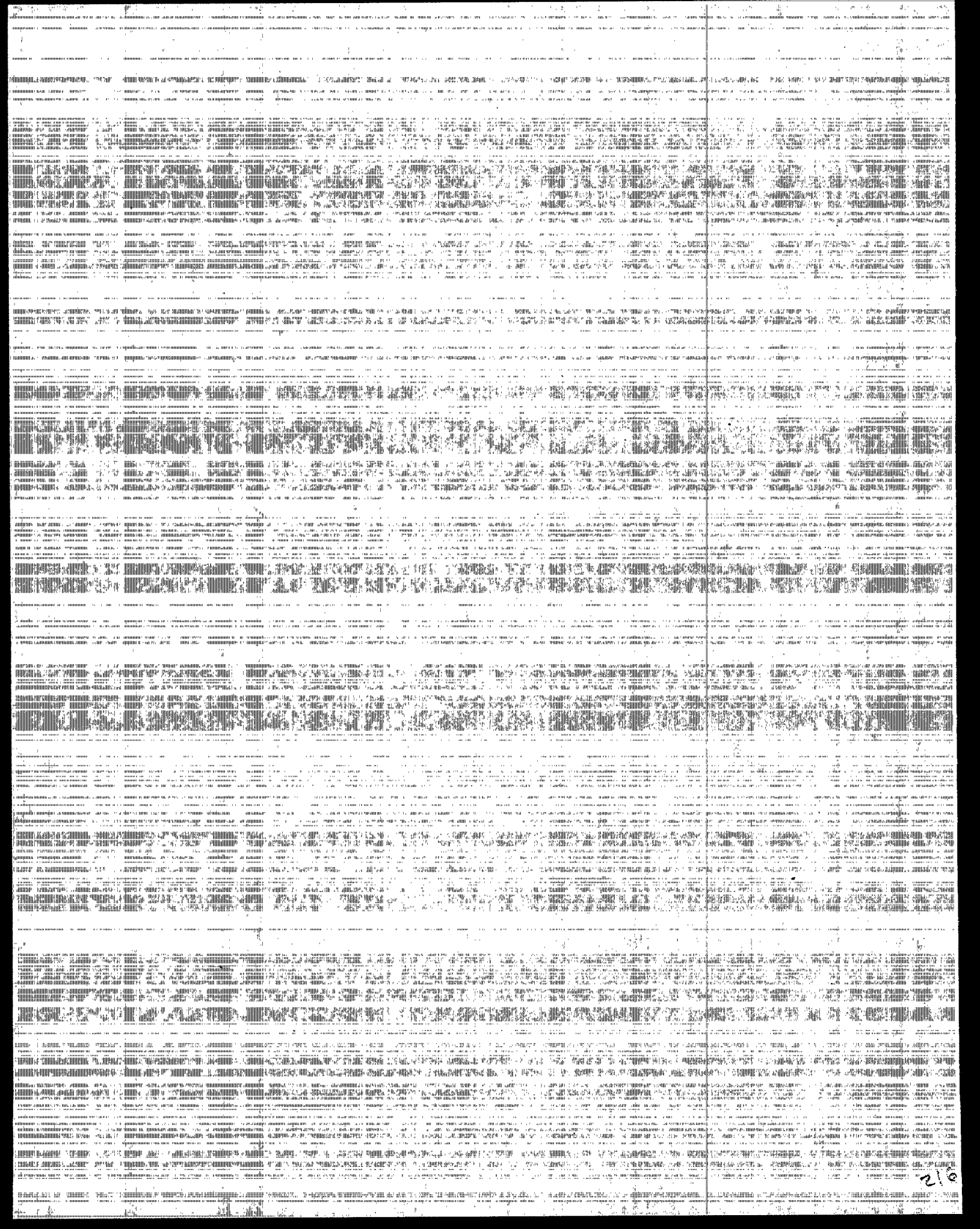
Annual Costs Reported

ID#	Question 1 Public Ed/ Outreach ($)	Question 3 Illicit Discharges ($)	Question 4 Erosion/Sed Control ($)	Question 5 Development ($)	Question 6 Muni Runoff ($)	Question 9 Population ($)
66				30,000		80,000
67				150,000		118,000
71			1,000			5,200
76	18,700	30,000	45,000	15,000	500	167,854
77	5,350		1,000			27,300
79			75,000	75,000		78,000
80			9,000	9,000		19,000
99		1,000	15,000	18,000	1,000	16,000
106	3,650	4,000	7,000	1,000		14,000
108				30,000		65,000
109		2,000	10,000	50,000	5,000	99,000
113	5,000	500	2,000	2,500	500	17,500
122			3,000	8,000	1,000	26,000
123	2,000		25,000			43,000
133	6,100	25,000	5,000	5,000	10,000	105,000
136	152,000	15,000	15,000		50,000	250,000
137			30,000	50,000	30,000	84,105
138			5,000	5,000	1,000	1,000
139				90,000	200,000	43,000
141			35,000			85,000
144	40		10,000	10,000		100,000
147			8,000			12,000
% Resp:	18%	16%	29%	30%	16%	

Exhibit B-1c.
Average and Percentile Costs for Five Phase II Minimum Control Measures
(Per Household Costs, $1998)

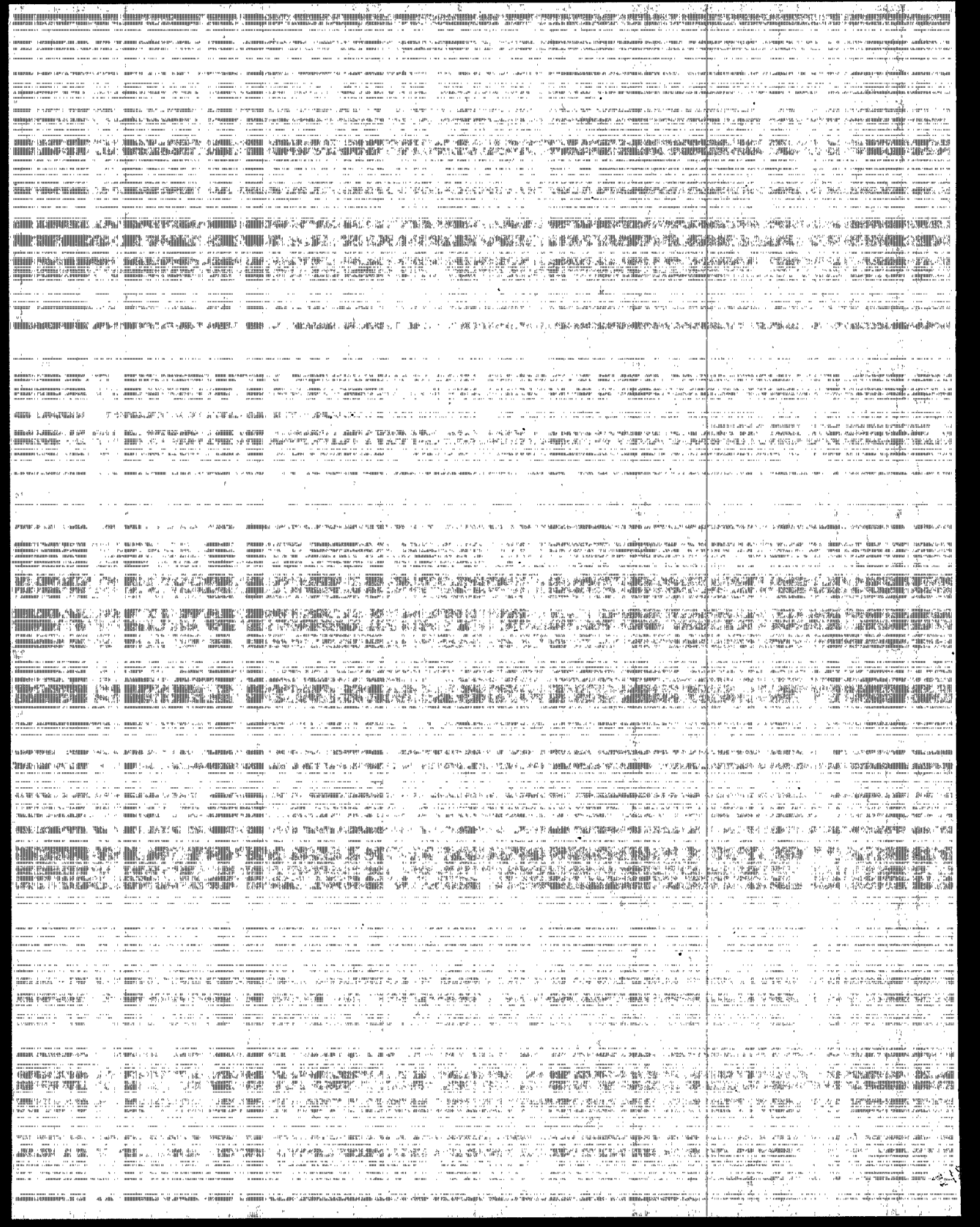
	Public Education/ Outreach	Illicit Discharges	Erosion/ Sediment Control	Development	Municipal Runoff[1]	Totals: All Categories
Mean Cost	$0.91	$1.78	$1.84	$2.64	$1.75	$8.93
Minimum	$0	$0.03	$0.09	$0.07	$0.01	$0.19
25%	$0.08	$0.20	$0.30	$0.37	$0.14	$1.09
50%	$0.37	$0.75	$1.08	$1.24	$0.52	$3.96
75%	$1.01	$2.65	$2.10	$2.79	$1.63	$10.17
95%	$3.04	$5.61	$7.92	$10.68	$9.08	$36.34
Maximum	$5.97	$5.95	$13.10	$17.47	$12.19	$54.68

Source: NAFSMA Phase II Survey Raw Data Report, 1998
[1]These estimates removed the effect of one disproportionately huge "outlier" (almost 15 times the mean cost for all other municipalities and 4 times greater than the next highest per capita cost) in one municipality's (respondent number 52) estimate of its annual municipal runoff control costs.



Appendix B–2

Construction Start Methodology



Appendix B–2.
Construction Start Methodology

This appendix describes the methodology used to estimate the number of construction sites potentially incurring incremental costs of the Phase II Storm Water rule. In determining the universe of construction starts, a correlation was made between the information obtained from the fourteen municipalities on construction starts per disturbed area and data obtained from the national building permits. The methodology consisted of ten steps. The appendix discusses each step in detail. Note that the exhibits referenced in the text are presented at the end of the appendix.

Step One. EPA obtained data files from the United States Bureau of the Census indicating the number of building permits issued by each building permit-issuing authority in the United States. Data files were obtained for the years 1980–1995. The Census Bureau stopped collecting nonresidential building permit information in 1995, which precluded the use of 1995 data in this analysis.

The data files, covering 1980 to 1994, group the building permits into the following categories:

- Residential housekeeping buildings (single-family buildings, two-family buildings, three- and four-family buildings, and five or more family buildings, residential non-housekeeping buildings, nonresidential buildings)

- Residential non-housekeeping buildings (hotels, motels, tourist cabins, lodges, dormitories, rooming houses, and fraternity houses)

- Nonresidential buildings (amusement, social, and recreational buildings; churches and other religious buildings; industrial buildings; parking garages; service stations; hospitals; office, bank, and professional buildings; public works and utilities buildings; schools and other educational buildings; stores and customer services; jails and reformatories; and structures other than buildings, such as marinas, boat houses, dog pounds, boardwalks, and outdoor stadiums)

- Additions, alterations, and conversions of nonresidential and non-housekeeping residential buildings (excluding "installation" permits issued to cover electrical, plumbing, heating, and air-conditioning)

- Additions of residential garages and carports

- Demolition and razing of buildings.

Step Two. EPA summarized the data for building permits issued in 1994 in the 50 states, the District of Columbia, the Virgin Islands, and Puerto Rico.

Step Three. EPA removed building permit categories with a 400 and 600 series designation. The building permits issued for Category 400 include additions, alterations, and conversions to

residential and nonresidential buildings, and additions of residential garages and carports. These structures typically disturb less than ½ acre of land or involve internal renovations. Category 600 includes the demolition and razing of buildings, which may not disturb land. If land-disturbing activities were to occur following demolition or razing, these activities should be included in the storm water permit application for the new construction activity.

Step Four. EPA selected 1994 as the base year for developing construction cost estimates because it was the year of most recent data on building permits issued in the United States. The cost analysis, however, used 1998 as its base year and the number of construction starts was escalated from 1994 to 1998 using an average annual growth rate of 1.3%, which reflects the average growth rate in permits during prior years.

Step Five. EPA grouped building permits into similar types of buildings and activities. The following equivalents were developed based on commonly used zoning code descriptions and the Census Bureau's definition of building categories:

- code 101 represents single-family detached homes;
- codes 103, 104, and 105 represent other "attached" homes (e.g., apartments, townhouses, condominiums);
- codes 213, 214, 318, 321, 322, 324, 327, and 328 represent commercial establishments;
- code 320 represents industrial or manufacturing facilities;
- codes 319, 323, 325, and 326 represent all institutional buildings (e.g., schools, hospitals, churches, government buildings);
- code 329 represents parks and recreational facilities.

Step Six. EPA converted building permits to storm water construction starts. A storm water construction start encompasses general construction activities occurring on a given site at a given time; it is independent of the number of building starts. For example, if a contractor builds 20 single-family homes on a four-acre parcel of land, that contractor will require 20 separate building permits. The same development would be considered one storm water construction start, assuming it is part of a common plan of development or sale. Municipalities do not ordinarily maintain construction records from a "storm water construction start" perspective. Therefore, to estimate the scope of this category, it is necessary to translate building permits into storm water construction starts.

In the EA for the proposed rule, construction data collected from Prince Georges County, Maryland was used to translate building permits to storm water construction starts nationwide. For this EA, EPA has supplemented that data with data from thirteen other local government jurisdictions from around the country to develop new ratios to estimate the number of construction starts.

Exhibit B–2–1 categorizes the construction type, the number of housing developments, the number of housing units constructed, and the number of commercial, industrial, institutional, and parks and recreational units constructed by size in acres. Exhibit B–2–1 also lists the number of units per development within the single family homes category. These data are required because the assumption that one building permit equals one storm water permit does not apply to single family homes. (The derived values based on this data are designated in the equation used in step seven below as SF_D with the relevant subscript. For example, $SF_{D½}$ equates to the average number of single-family homes built on developments disturbing between zero and ½ acre.)

Step Seven. EPA developed ratios to estimate the number of building permits issued by construction type (residential, commercial, industrial, etc.) for each size category. The size category is equivalent to the land area disturbed by an individual development. Exhibit B–2–2 indicates the percentages used to estimate the type of construction by size category. For example, Exhibit B–2–2 gives a percentage value of 1.39% for Residential Detached home sites on construction sites that disturb between 0 and ½ acre. This value was derived by dividing 252 (the number of units built within this size category, shown in Exhibit B–2–1) by 18,134 (the total number of units built for all size categories of residential detached homes, also in Exhibit B–2–1), and multiplying the result by 100. Exhibit B–2–2 shows that approximately 86% of the building permits issued for single-family homes were constructed in developments disturbing more than five acres of land.

The following example uses the methodology to convert the number of building permits into storm water permits, as outlined in Steps 6 and 7 for Alabama.

Example:

In 1994 the State of Alabama issued 14,459 single-family building permits, 558 multi-family building permits, 2,543 commercial building permits, 175 industrial building permits, 233 institutional building permits, and 775 parks and recreation building permits. The following equation was used to convert these numbers to construction starts:

$$N_4 = (SF_B \div SF_{D4} \times SF_{P4}) + (MF_B \times MF_{P4}) + (C_B \times C_{P4}) + (Ind_B \times Ind_{P4}) + (Inst_B \times Inst_{P4}) + (P\&R_B \times P\&R_{P4})$$

where

N_4 = Number of construction starts between four and five acres in State X

SF_B = Number of building permits reported by the Census Bureau in State X for the construction of single-family detached homes.

SF_{D4} = Average number of single-family homes built on developments disturbing between four and five acres in the municipalities where data was collected (from Exhibit B–2–1).

SF_{P4} = Percent of single-family development plans disturbing between four and five acres of land in the municipalities visited, as compared to the total number of single-family development plans reviewed in the municipalities visited (from Exhibit B–2–2, converted to a decimal, e.g., 4.87% = 0.0487).

MF_B = Number of building permits reported by the Census Bureau in State X for multiple-family dwellings.

MF_{P4} = Percent of multi-family dwelling plans disturbing between four and five acres of land in the municipalities visited, as compared to the total number of multi-family dwelling plans reviewed in the municipalities visited (from Exhibit B–2–2, expressed in the formula as a decimal).

C_B = Number of building permits reported by the Census Bureau in State X for commercial establishments.

C_{P4} = Percent of commercial establishment plans reviewed in the municipalities visited disturbing between four and five acres of land, as compared to the total number of commercial establishment plans reviewed in the municipalities visited (from Exhibit B–2–2, converted to a decimal).

Ind_B = Number of building permits reported by the Census Bureau in State X for the construction of industrial establishments.

Ind_{P4} = Percent of industrial establishment plans reviewed in the municipalities visited disturbing between four and five acres of land, as compared to the total number of industrial establishment plans reviewed in the municipalities visited (from Exhibit B–2–2, converted to a decimal).

$Inst_B$ = Number of building permits reported by the Census Bureau in State X for the construction of institutional establishments.

$Inst_{P4}$ = Percent of institutional construction plans reviewed in the municipalities visited disturbing between four and five acres of land, as compared to the total number of institutional construction plans reviewed in the municipalities visited (from Exhibit B–2–2, converted to a decimal).

$P\&R_B$ = Number of building permits reported by the Census Bureau in State X for the construction of parks and recreational facilities.

$P\&R_{P4}$ = Percent of park and recreational facility plans reviewed in the municipalities visited disturbing between four and five acres of land, as compared to the total number of plans for parks and recreational facilities reviewed in the municipalities visited (from Exhibit B–2–2, converted to a decimal).

Using the Alabama data gives the following results:

$$N_4 = (14{,}459/(884/44) \times 0.0487) + (558 \times 0.10843) + (2{,}543 \times 0.0507) + (175 \times 0.0515) + (233 \times 0.0581) + (775 \times 0.0722)$$

$$N_4 = 35 + 61 + 129 + 9 + 14 + 56$$

$$N_4 = \underline{304}$$

This value is reported in Exhibit B–2–3 in the Alabama row under Construction Starts four to five Acres as 304 starts.

Step Eight. EPA collected and reviewed state erosion and sediment control regulations during January and February, 1997. Based on that review, EPA identified states that have erosion and sediment control requirements for sites that disturb between one and five acres (Phase II) that are

equivalent to EPA's final Phase II rule requirements. In states that regulate construction starts that disturb between one and five acres, or a subset of that acreage range (Georgia, New Hampshire, West Virginia, and Wisconsin) those starts were eliminated from the analysis because they already have sediment and erosion control requirements similar to Phase II. The following states have equivalent programs:

- Connecticut (all starts)
- Delaware (all starts)
- District of Columbia (all starts)
- Georgia (two- to five-acre starts)
- Maryland (all starts)
- Michigan (all starts)
- New Hampshire (two- to five-acre starts)
- New Jersey (all starts)
- North Carolina (all starts)
- Pennsylvania (all starts)
- Puerto Rico
- South Carolina (all starts)
- West Virginia (three- to five-acre starts)
- Wisconsin (three- to five-acre starts)

Step Nine. The Coastal Nonpoint Pollution Control Program directs municipalities in the coastal zone to require erosion and sediment controls for construction starts disturbing less than 5 acres of land. Coastal municipalities are required to have construction erosion and sediment control requirements in place before issuing Phase II permits. EPA's cost estimate includes only those states and counties that do not have enforceable policies and mechanisms for erosion and sediment controls at construction starts. EPA eliminated construction starts located in CZARA states and counties (as identified by EPA *Coastal Nonpoint Finding Status*. April 22, 1998) where CZARA is, or is expected to be, used as the primary enforcement tool. As a result, all construction starts in the states of Florida, Rhode Island and the Virgin Islands as well as starts from CZARA counties in Alaska, Massachusetts, and Virginia were excluded.

Exhibit B–2–3 indicates the number of storm water construction starts by state and size category after all equivalent programs have been removed.

Step Ten. Finally, EPA chose to examine the Phase II construction universe, as presented in Exhibit B–2–3, by climatic zones. Climatic zones reflect regional variations in rainfall intensity and amount. This step involved estimating the percentage of land area within each state corresponding to a given climatic zone and then using these percentages to determine the number of starts within each zone. The results are presented in Exhibit B–2–4. The total number of construction starts between one and five acres is 123,145. This estimate was reduced by 15% to account for waivers, resulting in slightly more than 110,223 starts. This is the number of Phase II construction starts that is used throughout the cost analysis. To determine that 21.1% of all starts may be regulated by Phase II, EPA divided the number of Phase II construction starts by the total number of permits issued nationwide (110,000/522,000 = 21.1%).

Summary

This appendix identifies the methodology used to identify the number of construction starts potentially incurring incremental costs of the Phase II Storm Water rule. The Phase II construction universe comprises 110,000 construction sites ranging from one to five acres in size.

Exhibit B–2–1. Construction Starts by Acreage and Type from Selected Municipalities

Construction Acreage	Construction Type								
	Residential Detached Homes[1]		Residential Attached Developments[2]	Commercial[3]	Industrial[4]	Institutional[3,4]	Parks and Recreational	Total Starts	Percent of Total
	Number of Developments	Number of Units Built							
> 0 acre ≤ ½ acres	194	252	23	101	22	38	15	393	14.94%
> ½ acres ≤ 1 acre	72	150	20	165	17	42	5	321	12.21%
≥1 acre ≤ 2 acres	71	375	30	230	22	55	13	421	16.01%
> 2 acres ≤ 3 acres	53	370	18	116	13	34	6	240	9.13%
> 3 acres ≤ 4 acres	60	588	21	62	13	23	4	183	6.96%
> 4 acres ≤ 5 acres	44	884	31	48	7	18	7	155	5.89%
> 5 acres ≤ 10 acres	138	3,880	56	99	22	48	21	384	14.60%
> 10 acres	223	11,636	87	125	20	52	26	533	20.27%
Total	**855**	**18,134**	**286**	**946**	**136**	**310**	**97**	**2,630**	**100%**

Sources: Austin, Texas; Baltimore County, Maryland; Cary, North Carolina; Ft. Collins, Colorado; Lacey, Washington; Loudoun County, Virginia; New Britain, Connecticut; Olympia, Washington; Prince George County, Maryland; Raleigh, North Carolina; South Bend, Indiana; Tallahassee, Florida; Tucson, Arizona, and Waukesha, Wisconsin.

[1]*Residential detached* refers to the number of developments, by size category, and the total number of single-family homes constructed in those developments. Each home represents a building permit, but only the development requires a storm water permit.

[2]*Residential attached* refers to the number of developments, by size category, and the number of units built in those apartments, townhouses, and condominium complexes. Each development represents a single building permit.

[3]For the commercial, industrial, institutional, and parks and recreational categories, each unit represents both a building permit and development.

[4]Institutional includes medical, religious, educational, and governmental structures.

[5]The total column includes the number of units built in all cases except for residential attached, where the number of developments was used.

Exhibit B–2–2. Percentage of Construction Sites by Acre Size Category

Construction Acreage	Construction Type					
	Residential Detached Homes (%)	Residential Attached Homes (%)	Commercial (%)	Industrial (%)	Institutional (%)	Park and Recreational (%)
> 0 to < 0.5 acres	1.39	8.04	10.68	16.17	12.26	15.46
0.5 to 1 acre	0.83	7.00	17.44	12.50	13.55	5.15
1 to 2 acres	2.07	10.49	24.32	16.17	17.74	13.40
2 to 3 acres	2.04	6.29	12.26	9.56	10.97	6.19
3 to 4 acres	3.24	7.34	6.55	9.56	7.42	4.12
4 to 5 acres	4.87	10.84	5.07	5.15	5.81	7.22
5 to 10 acres	21.40	19.58	10.44	16.18	15.60	21.88
> 10 acres	64.16	30.42	13.24	14.71	16.66	26.57
Total	**100**	**100**	**100**	**100**	**100**	**100**

Note: The percentages are based on the number of building permits for the commercial, industrial, institutional, and parks and recreational columns in Exhibit B–2–1, the number of developments column for other family homes, and the number of units column for single-family homes.

Exhibit B–2–3. Construction Starts by State and Acreage with Starts in States with Equivalent Erosion and Sediment Control Programs Removed

	1–2 acres	2–3 acres	3–4 acres	4–5 acres	Total (1–5 acre sites)
Alabama	908	480	322	304	2,014
Alaska	25	13	9	8	56
Arizona	1,940	997	727	907	4,570
Arkansas	737	392	273	275	1,678
California	6,669	3,368	2,269	2,722	15,028
Colorado	1,153	623	443	409	2,628
Connecticut	0	0	0	0	0
DC	0	0	0	0	0
Delaware	0	0	0	0	0
Florida	0	0	0	0	0
Georgia	2,684	0	0	0	2,684
Hawaii	563	282	190	243	1,279
Idaho	688	363	248	242	1,541
Illinois	3,005	1,565	1,044	1,035	6,649
Indiana	2,603	1,349	854	793	5,598
Iowa	1,109	575	367	341	2,392
Kansas	963	502	322	300	2,087
Kentucky	908	483	334	315	2,040
Louisiana	1,023	530	336	323	2,213
Maine	871	443	259	233	1,806
Maryland	0	0	0	0	0
Massachusetts	393	197	118	122	829
Michigan	0	0	0	0	0
Minnesota	2,433	1,254	757	650	5,094
Mississippi	732	383	246	226	1,587
Missouri	1,494	785	531	524	3,334
Montana	242	127	83	79	531
Nebraska	889	451	283	300	1,923
Nevada	1,068	549	413	537	2,567
New Hampshire	474	0	0	0	474
New Jersey	0	0	0	0	0
New Mexico	403	215	146	133	898
New York	4,847	2,443	1,519	1,645	10,453
North Carolina	0	0	0	0	0
North Dakota	229	119	77	68	493
Ohio	2,619	1,375	931	924	5,849
Oklahoma	706	367	235	221	1,529

Exhibit B–2–3. Construction Starts by State and Acreage with Starts in States with Equivalent Erosion and Sediment Control Programs Removed *(continued)*

	1–2 acres	2–3 acres	3–4 acres	4–5 acres	Total (1–5 acre sites)
Oregon	1,271	675	470	458	2,874
Pennsylvania	0	0	0	0	0
Puerto Rico	0	0	0	0	0
Rhode Island	0	0	0	0	0
South Carolina	0	0	0	0	0
South Dakota	477	246	149	132	1,004
Tennessee	1,510	799	541	511	3,362
Texas	4,571	2,371	1,601	1,715	10,259
Utah	733	393	279	266	1,671
Vermont	426	217	129	115	888
Virgin Islands	0	0	0	0	0
Virginia	1,370	717	459	412	2,957
Washington	2,034	1,065	745	802	4,646
West Virginia	562	286	0	0	848
Wisconsin	3,082	1,396	0	0	4,478
Wyoming	157	82	52	46	337
Total	58,572	28,477	17,764	18,332	123,145

Exhibit B–2–4 further refines the analysis of construction starts by correlating the total construction starts of each state with the total amount of pollutant loading. By subdividing each state by climatic zones, a relationship can be formed between the pollutant loading of each state and construction starts.

Exhibit B–2–4. Estimate of the Numbers of Phase II Storm Water Construction Starts by State and Climatic Zone

State	Climatic Zone Category	% of State Land Area	Starts 1–5 acres
Alabama	P	25	503
Alabama	N	72	1,450
Alabama	T	3	60
Alaska	W, X, Y	100	56
Arizona	D	100	4,570
Arkansas	N	40	671
Arkansas	P	60	1,007
California	A	12	1,803
California	C	40	6,011
California	D	48	7,213
Colorado	D	8	210

Exhibit B–2–4. Estimate of the Numbers of Phase II Storm Water Construction Starts by State and Climatic Zone *(continued)*

State	Climatic Zone Category	% of State Land Area	Starts 1–5 acres
Colorado	E	58	1,524
Colorado	G	27	710
Colorado	H	7	184
Connecticut	R	100	0
DC	P	100	0
Delaware	T	100	0
Florida	P	19	0
Florida	T	81	0
Georgia	N	10	268
Georgia	P	73	1,959
Georgia	T	17	456
Hawaii	V	100	1,279
Idaho	B	35	539
Idaho	D	12	185
Idaho	E	53	817
Illinois	M	100	6,649
Indiana	M	79	4,423
Indiana	N	21	1,176
Iowa	M	100	2,392
Kansas	H	81	1,690
Kansas	M	19	396
Kentucky	N	91	1,856
Kentucky	P	9	184
Louisiana	P	69	1,527
Louisiana	T	31	686
Maine	R	100	1,806
Maryland	N	41	0
Maryland	P	27	0
Maryland	T	32	0
Massachusetts	R	100	829
Michigan	K	65	0
Michigan	M	35	0
Minnesota	F	10	509
Minnesota	K	56	2,853
Minnesota	M	34	1,732
Mississippi	P	97	1,539
Mississippi	T	3	48

Exhibit B–2–4. Estimate of the Numbers of Phase II Storm Water Construction Starts by State and Climatic Zone *(continued)*

State	Climatic Zone Category	% of State Land Area	Starts 1–5 acres
Missouri	M	47	1,567
Missouri	N	46	1,534
Missouri	P	7	233
Montana	E	66	350
Montana	G	34	180
Nebraska	M	20	385
Nebraska	G	43	827
Nebraska	H	37	712
Nevada	D	100	2,567
New Hampshire	R	100	474
New Jersey	R	100	0
New Mexico	D	57	512
New Mexico	E	14	126
New Mexico	G	29	260
New York	R	100	10,453
North Carolina	N	16	0
North Carolina	P	57	0
North Carolina	T	27	0
North Dakota	G	6	30
North Dakota	F	94	463
Ohio	M	42	2,457
Ohio	N	31	1,813
Ohio	R	27	1,579
Oklahoma	H	68	1,040
Oklahoma	M	8	122
Oklahoma	N	19	290
Oklahoma	P	5	76
Oregon	A	37	1,063
Oregon	B	24	690
Oregon	D	27	776
Oregon	E	12	345
Pennsylvania	N	74	0
Pennsylvania	R	26	0
Puerto Rico	Z	100	0
Rhode Island	R	100	0
South Carolina	P	64	0

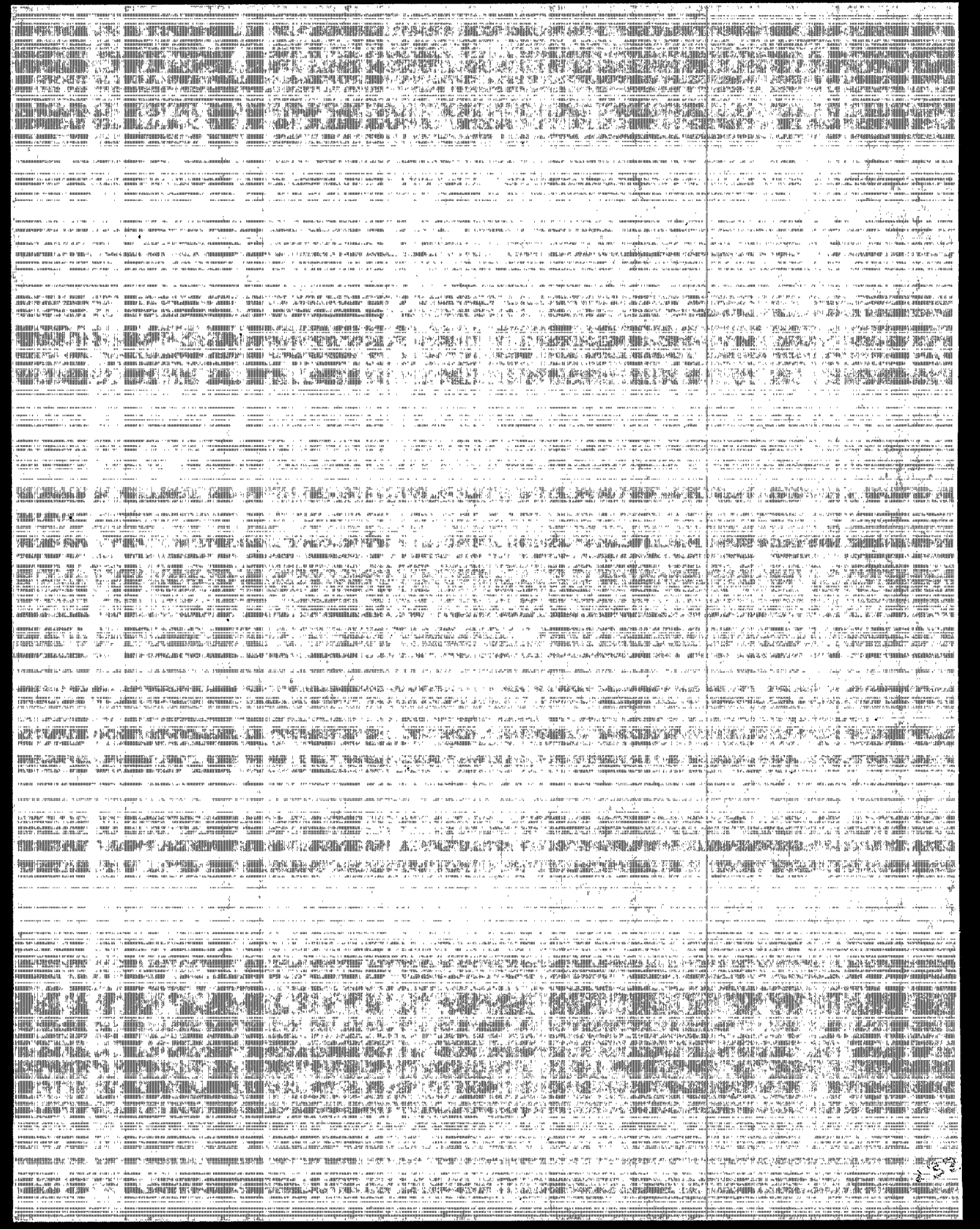
Exhibit B–2–4. Estimate of the Numbers of Phase II Storm Water Construction Starts by State and Climatic Zone *(continued)*

State	Climatic Zone Category	% of State Land Area	Starts 1–5 acres
South Carolina	T	36	0
South Dakota	F	35	351
South Dakota	G	50	502
South Dakota	M	15	151
Tennessee	N	76	2,555
Tennessee	P	24	807
Texas	D	11	1,128
Texas	H	44	4,514
Texas	I	27	2,770
Texas	P	11	1,128
Texas	T	7	718
Utah	D	67	1,120
Utah	E	33	552
Vermont	R	100	888
Virgin Islands	Z	100	0
Virginia	N	40	1,183
Virginia	P	46	1,360
Virginia	T	14	414
Washington	A	30	1,394
Washington	B	56	2,602
Washington	E	14	650
West Virginia	N	100	848
Wisconsin	K	63	2,821
Wisconsin	M	37	1,657
Wyoming	D	27	91
Wyoming	E	43	145
Wyoming	G	30	101
Total Starts—1994			123,145
Estimate of Total Starts[1]—1998			129,675
Estimate of Total Starts Adjusted for Phase II Waiver Provision			110,223

[1]Based on data collected from the US Bureau of the Census the annual growth rate for the number of building permits issued from 1980 to 1994 was 1.3%. This growth rate is used to estimate 1998 construction starts from the 1994 baseline. However, EPA recognizes the growth rate for construction starts fluctuates yearly and does not necessarily increase each year.

Appendix B–3

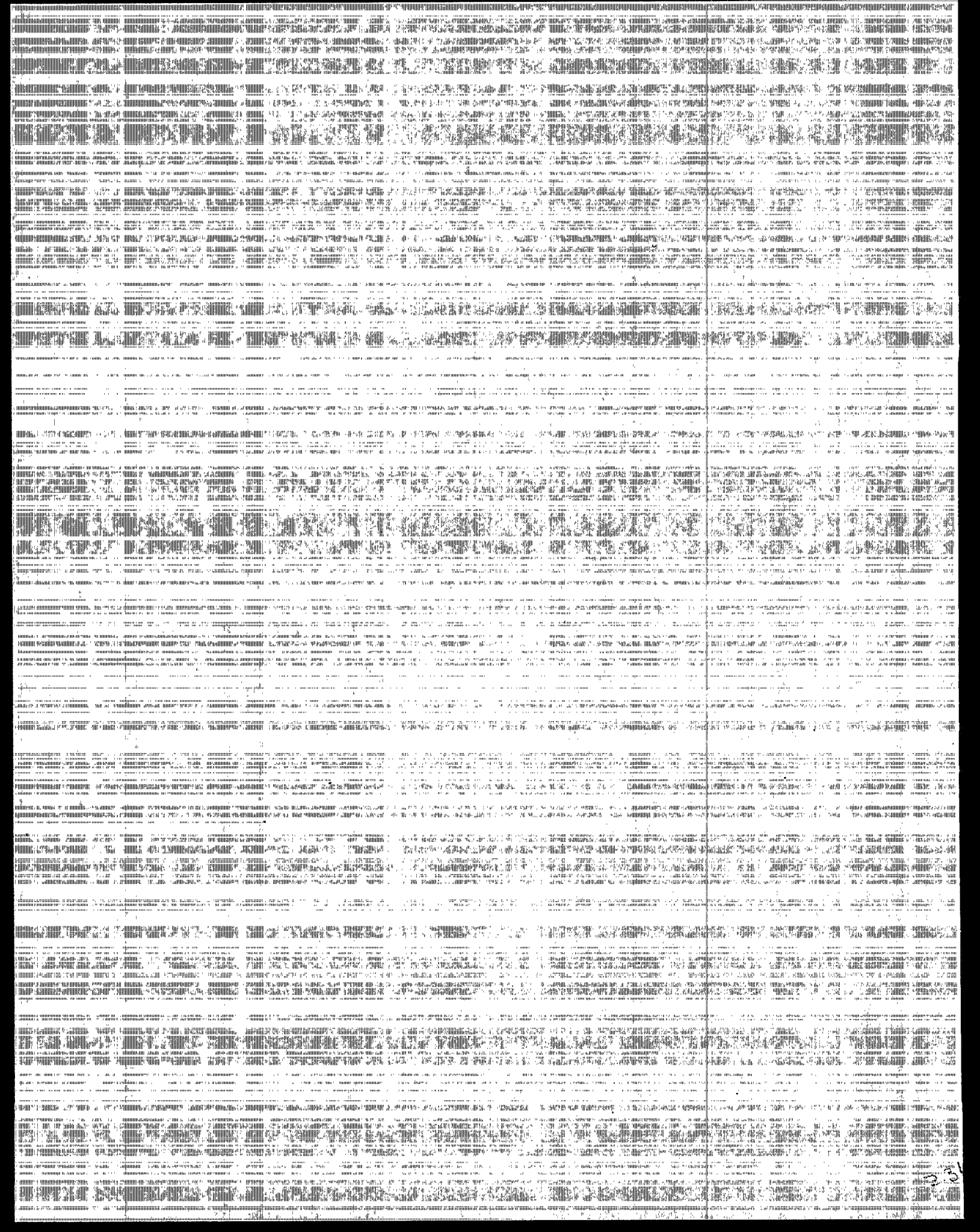
Model Construction Site Plans



Drawing Assumptions

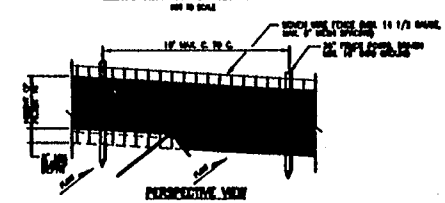
Detailed drawings of the model sites (i.e., site plans) and the assumed BMPs that could be used under the Phase II rule are found in the following pages. In developing the BMP mix for each model site, certain simplifying assumptions were needed. EPA assumed the following would apply to each site:

- The project area will remain completely denuded for six months.
- The site slopes uniformly from north to south.
- No structures, swales, or other drainage features will impede the flow of storm water from the northern part of the site to the southern part.
- No run-on will occur from surrounding areas.
- 25' wide streets are located on the north and east sides of the site.
- A stream flows along the south side of the site.
- A 30' vegetated buffer is maintained between the site and the stream.
- Sediment traps will be designed to a volume of 1,800 cubic feet/acre.
- All BMPs will be properly installed and maintained.
- An existing 4' wide swale runs along the east side between the project site and the street. This assumption was made because erosion and sediment control plans typically need to control runoff to and from various existing drainage structures. Although the site slopes north to south, a designer should assume that a considerable amount of sediment will enter the swale due to the constantly changing drainage patterns of a construction site.

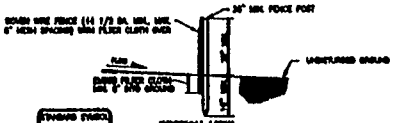


ITEM (a)
SILT FENCE DETAILS

NOT TO SCALE



PERSPECTIVE VIEW



SECTION VIEW

CONSTRUCTION SPECIFICATIONS

1. WOVEN WIRE FENCE TO BE FASTENED SECURELY TO FENCE POSTS WITH WIRE TIES OR STAPLES.
2. FILTER CLOTH TO BE FASTENED SECURELY TO WOVEN WIRE FENCE WITH TIES SPACED EVERY 14" AT TOP AND MID SECTION.
3. WHEN TWO SECTIONS OF FILTER CLOTH ADJOIN EACH OTHER THEY SHALL BE OVERLAPPED BY SIX INCHES AND FOLDED.
4. MAINTENANCE SHALL BE PERFORMED AS NEEDED AND SEDIMENT REMOVED WHEN "BULGES" DEVELOP IN THE SILT FENCE.

POSTS: WOOD, WITH 1.00 lb/ft TYPE OR 2" HARDWOOD

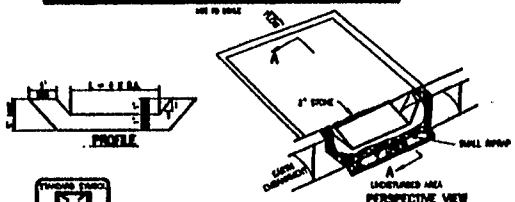
FENCE: WOVEN WIRE, 14 1/2 GA. 6" MESH SPACING

FILTER CLOTH: FILTER X, MIRAFI 100X, STABLINKA T140N OR APPROVED EQUAL

PREFABRICATED UNIT: GEOFAB, ENVIROFENCE, OR APPROVED EQUAL

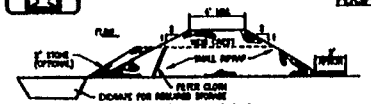
ITEM (g)
STONE OUTLET SEDIMENT TRAP: ST-V

NOT TO SCALE



PROFILE

PERSPECTIVE VIEW



CROSS SECTION A-A

OPTION A ONE FOOT LAYER OF 2" STONE MAY BE PLACED ON THE UPSTREAM SIDE OF THE RIPRAP IN PLACE OF THE EMBEDDED FILTER CLOTH.

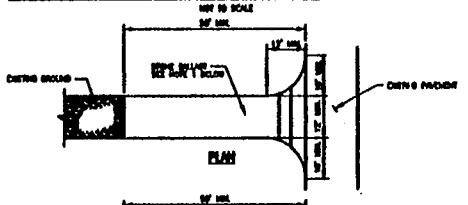
CONSTRUCTION SPECIFICATIONS FOR ST-V

1. AREA UNDER EMBANKMENT SHALL BE CLEARED, GRUBBED AND STRIPPED OF ANY VEGETATION AND ROOT MAT. THE POOL AREA SHALL BE CLEARED.
2. THE FILL MATERIAL FOR THE EMBANKMENT SHALL BE FREE OF ROOTS AND OTHER WOODY VEGETATION AS WELL AS OVER-SIZED STONES, FROZEN, ORGANIC MATERIAL OR SPOILS SELECTIONABLE MATERIAL. THE EMBANKMENT SHALL BE COMPACTED BY TRAVERSING WITH EQUIPMENT WHILE IT IS BEING CONSTRUCTED.
3. ALL CUT AND FILL SLOPES SHALL BE 2:1 OR FLATTER.
4. THE STONE USED IN THE OUTLET SHALL BE SMALL RIPRAP 4"-8" ALONG WITH A 1" THICKNESS OF 2" AGGREGATE PLACED ON THE UP-GRADE SIDE OF THE SMALL RIPRAP OR EMBEDDED FILTER CLOTH IN THE RIPRAP.
5. SEDIMENT SHALL BE REMOVED AND TRAP RESTORED TO ITS ORIGINAL DIMENSIONS WHEN THE SEDIMENT HAS ACCUMULATED TO 1/2 THE DESIGN DEPTH OF THE TRAP.
6. THE STRUCTURE SHALL BE INSPECTED AFTER EACH RAIN AND REPAIRS MADE AS NEEDED.
7. CONSTRUCTION OPERATIONS SHALL BE CARRIED OUT IN SUCH A MANNER THAT EROSION AND WATER POLLUTION IS MINIMIZED.
8. THE STRUCTURE SHALL BE REMOVED AND THE AREA STABILIZED WHEN THE DRAINAGE AREA HAS BEEN PROPERLY STABILIZED.

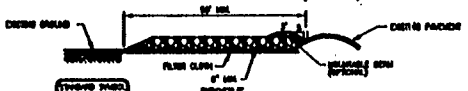
NOTE: MAXIMUM DRAINAGE AREA = 5 acres

ITEM (d)
STABILIZED CONSTRUCTION ENTRANCE DETAILS

NOT TO SCALE



PLAN



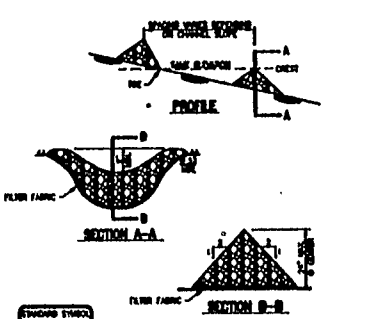
PROFILE

CONSTRUCTION SPECIFICATIONS

1. STONE SIZE - USE 2" STONE, OR RECLAIMED OR RECYCLED CONCRETE EQUIVALENT.
2. LENGTH - NOT LESS THAN 50 FEET (EXCEPT ON A SINGLE RESIDENCE LOT WHERE A 30 FOOT MINIMUM LENGTH WOULD APPLY).
3. THICKNESS - NOT LESS THAN 6 INCHES.
4. WIDTH - TWELVE (12) FOOT MINIMUM, BUT NOT LESS THAN THE FULL WIDTH AT POINTS WHERE ACCESS OR EGRESS OCCURS. TWENTY-FOUR (24) FOOT IF SINGLE DWELLING TO SITE.
5. FILTER CLOTH - WILL BE PLACED OVER THE ENTIRE AREA PRIOR TO PLACING OF STONE.
6. SURFACE WATER - ALL SURFACE WATER FLOWING OR DIVERTED TOWARD CONSTRUCTION ENTRANCES SHALL BE PIPED ACROSS THE ENTRANCE. IF PIPING IS IMPRACTICAL, A MOUNTABLE BERM WITH 5:1 SLOPES WILL BE PERMITTED.
7. MAINTENANCE - THE ENTRANCE SHALL BE MAINTAINED IN A CONDITION WHICH WILL PREVENT TRACKING OR FLOWING OF SEDIMENT ONTO PUBLIC RIGHTS-OF-WAY. ALL SEDIMENT SPILLED, DROPPED, WASHED OR TRACKED ONTO PUBLIC RIGHTS-OF-WAY MUST BE REMOVED IMMEDIATELY.
8. WHEN WASHING IS REQUIRED, IT SHALL BE DONE ON AN AREA STABILIZED WITH STONE AND WHICH DRAINS INTO AN APPROVED SEDIMENT TRAPPING DEVICE.
9. PERIODIC INSPECTION AND NEEDED MAINTENANCE SHALL BE PROVIDED AFTER EACH RAIN.

ITEM (e)
CHECK DAM DETAILS

NOT TO SCALE



PROFILE

SECTION A-A

SECTION B-B

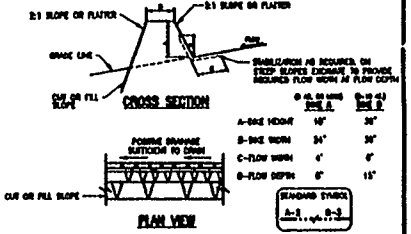
CONSTRUCTION SPECIFICATIONS

1. STONE SHALL BE PLACE ON A FILTER FABRIC FOUNDATION TO THE LINES, GRADES AND LOCATIONS SHOWN IN THE PLAN.
2. THE SPACING OF CHECK DAMS TO ASSURE THAT THE ELEVATION OF THE CREST OF THE DOWNSTREAM DAM IS AT THE SAME ELEVATION OF THE TOE OF THE UPSTREAM DAM.
3. EXTEND THE STONE A MINIMUM OF 1.0 FEET BEYOND THE DITCH BANKS TO PREVENT CUTTING AROUND THE DAMS.
4. PROTECT THE CHANNEL DOWNSTREAM OF THE LOWEST CHECK DAM FROM SCOUR AND ERODION WITH STONE OR LINER AS APPROPRIATE.
5. ENSURE THAT CHANNEL APPURTENANCES SUCH AS CULVERT ENTRANCES BELOW CHECK DAMS ARE NOT SUBJECT TO DAMAGE OR BLOCKAGE FROM DISPLACED STONES.

NOTE: MAXIMUM DRAINAGE AREA 5 ACRES.

ITEM (f)
EARTH DIKE DETAILS

NOT TO SCALE



CROSS SECTION

	@ ds as shown Dia A	@ ds as shown Dia B
A-DIKE HEIGHT	18"	30"
B-DIKE WIDTH	24"	36"
C-FLOW WIDTH	4'	6'
D-FLOW DEPTH	8"	15"

PLAN VIEW

CONSTRUCTION SPECIFICATIONS

1. ALL DIKES SHALL BE COMPACTED BY EARTH-MOVING EQUIPMENT.
2. ALL DIKES SHALL HAVE POSITIVE DRAINAGE TO AN OUTLET.
3. THE DIKES MAY BE USED AND SIDE SLOPES BE FLATTER IF DESIRED TO FACILITATE CROSSING BY CONSTRUCTION TRAFFIC.
4. FIELD LOCATION SHOULD BE ADJUSTED AS NEEDED TO UTILIZE A STABILIZED OUTLET.
5. EARTH DIKES SHALL HAVE AN OUTLET THAT FUNCTIONS WITH A MINIMUM OF EROSION. RUNOFF SHALL BE CONVEYED TO A SEDIMENT TRAPPING DEVICE SUCH AS A SEDIMENT TRAP OR SEDIMENT BASIN WHERE DIRECT SIDE CHANNEL OR THE DRAINAGE AREA ABOVE THE DIKE ARE NOT ADEQUATELY STABILIZED.
6. STABILIZATION SHALL BE AS IN ACCORDANCE WITH STANDARD SPECIFICATIONS FOR SEED AND STRAW MULCH IF NOT IN VEGETATIVE SEASON, THE FLOW CHANNEL AS PER THE CHART BELOW.

FLOW CHANNEL STABILIZATION

SEQUENCE	GRADE	DIKE A	DIKE B
1	0.5-2.0%	SEED AND STRAW MULCH	SEED AND STRAW MULCH
2	2.1-5.0%	SEED AND STRAW MULCH	SEED, MULCH, AND 30 CHECKLOCK STAR 3' STAKE
3	5.1-8.0%	SEED WITH AGRI OR SOD, 4" DEEP	LINED RIP-RAP 6-8"
4	8.1-10%	LINED RIP-RAP 6-8"	DOWNCOMB SCHEM

A. STONE TO BE 2 INCH STONE, OR RECYCLED CONCRETE EQUIVALENT, IN A LAYER AT LEAST 3 INCHES IN THICKNESS AND BE PRESSED INTO THE SOIL WITH CONSTRUCTION EQUIPMENT.

B. RIP-RAP TO BE 4-8 INCHES IN A LAYER AT LEAST 8 INCHES THICKNESS AND PRESSED INTO THE SOIL.

C. APPROVED EQUIVALENTS CAN BE SUBSTITUTED FOR ANY OF THE ABOVE MATERIALS.

7. PERIODIC INSPECTION AND REQUIRED MAINTENANCE MUST BE PROVIDED AFTER EACH RAIN EVENT.

NOTE:
PRINT REDUCED TO 11" X 17" & IS NOT HALF SCALE. PLEASE COMPENSATE TO DETERMINE PROPER WORKING SCALE BEFORE PROCEEDING.

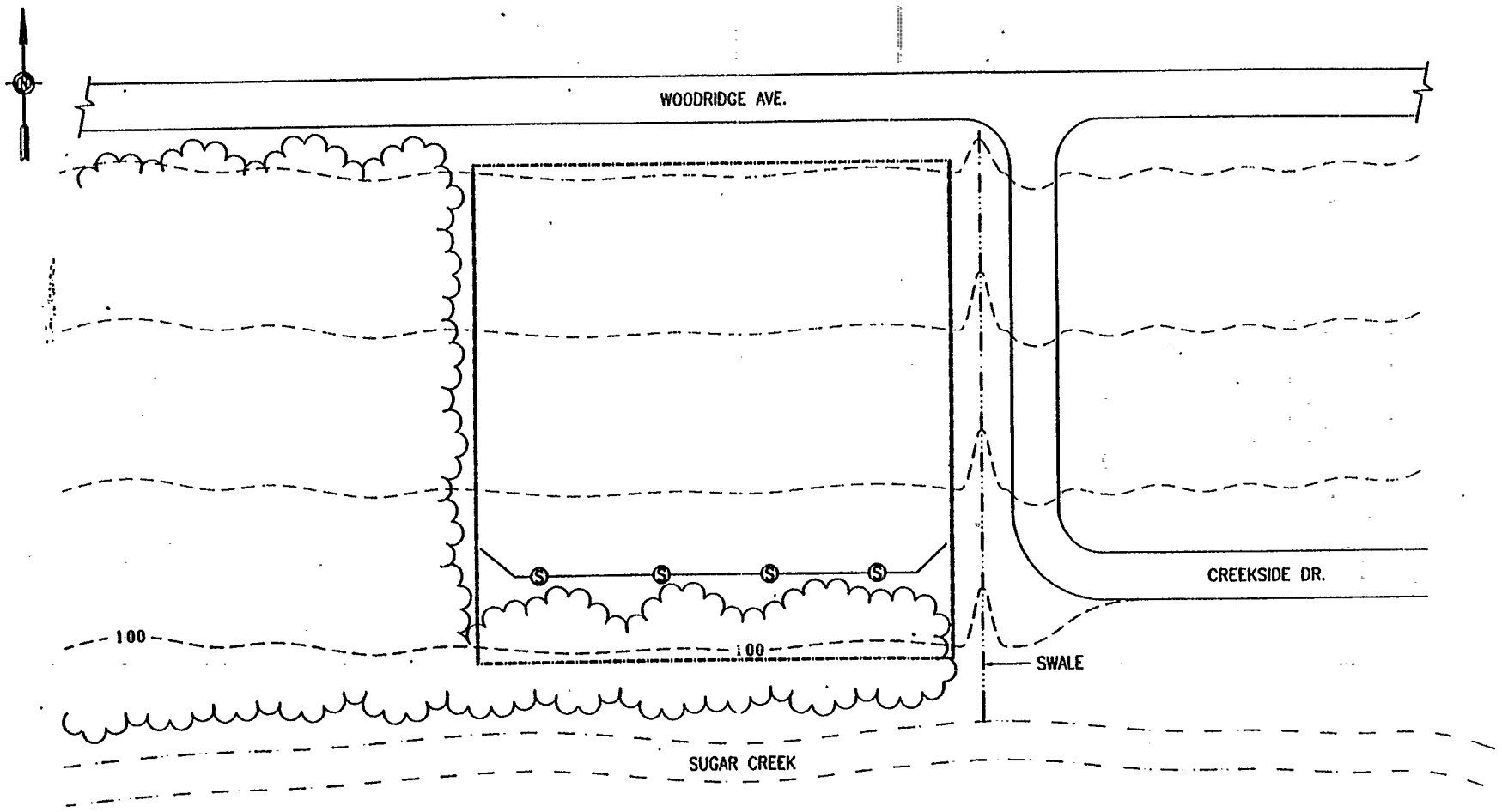
DETAILS SOURCED NEW YORK GUIDELINES FOR URBAN EROSION AND SEDIMENT CONTROL

Professional Seal

ENVIRONMENTAL PROTECTION AGENCY

EROSION AND SEDIMENTATION CONTROL DETAILS — dwg. no. 01

drawn	MS/DS/DS	scale	NONE
project no.	01-1301-00-3000-320	file no.	03000-11-0
approved			
date			



LEGEND

- 2' CONTOUR
- 100 10' CONTOUR
- CONTRACT LIMITS
- CREEK
- TREE LINE

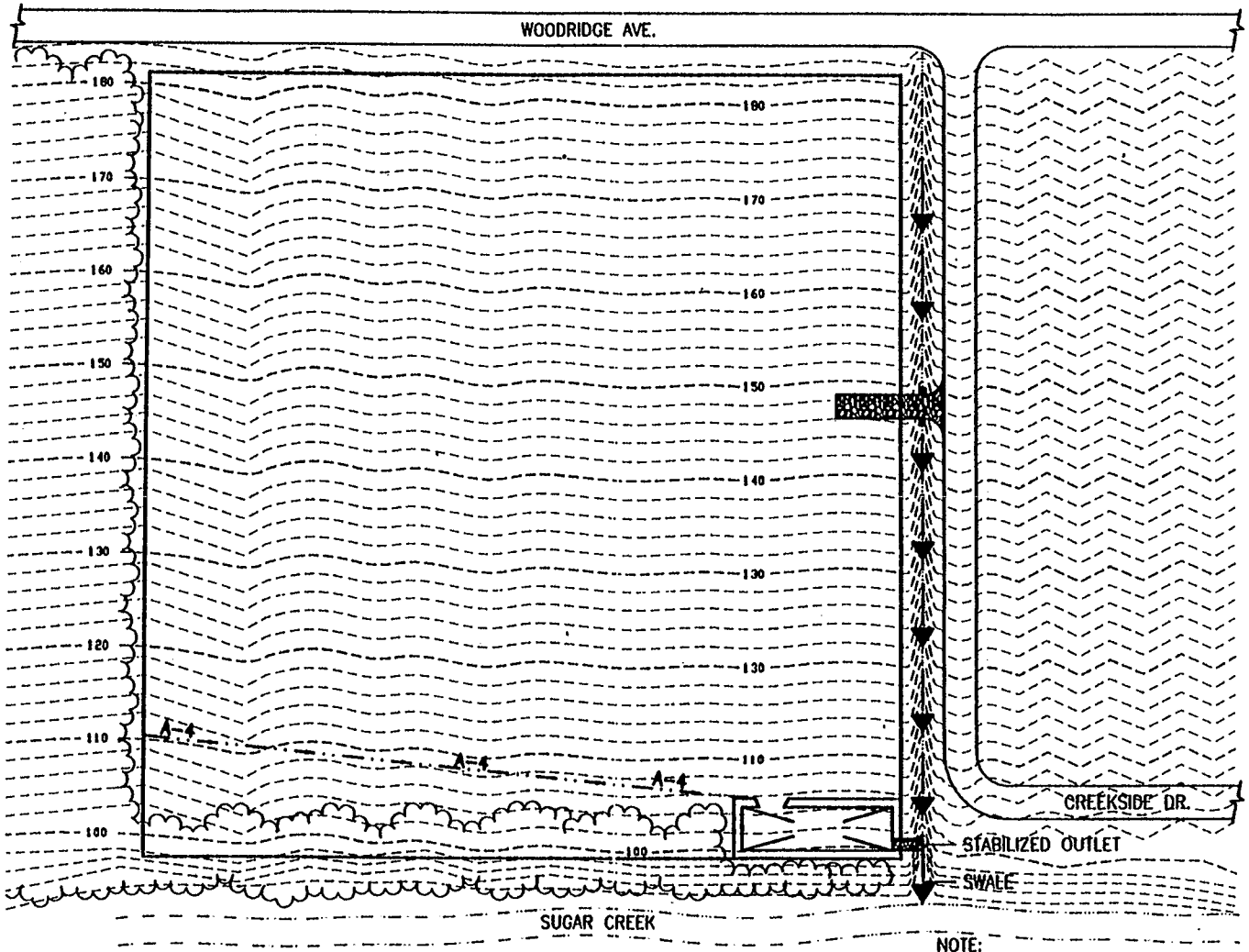
NOTE:
PRINT REDUCED TO 11" X 17" & IS NOT HALF SCALE. PLEASE COMPENSATE TO DETERMINE PROPER WORKING SCALE BEFORE PROCEEDING.

SCALE IN FEET

ENVIRONMENTAL PROTECTION AGENCY

SMALL CONSTRUCTION SITE
TYPICAL PLAN 1 ACRE SITE
3% SLOPE LOW SOIL ERODIBILITY

01



LEGEND

- 2' CONTOUR
- 10' CONTOUR
- CONTRACT LIMITS
- CREEK
- A-1 EARTHEN DIKE
- SEDIMENT TRAP
- STABILIZED CONSTRUCTION ENTRANCE

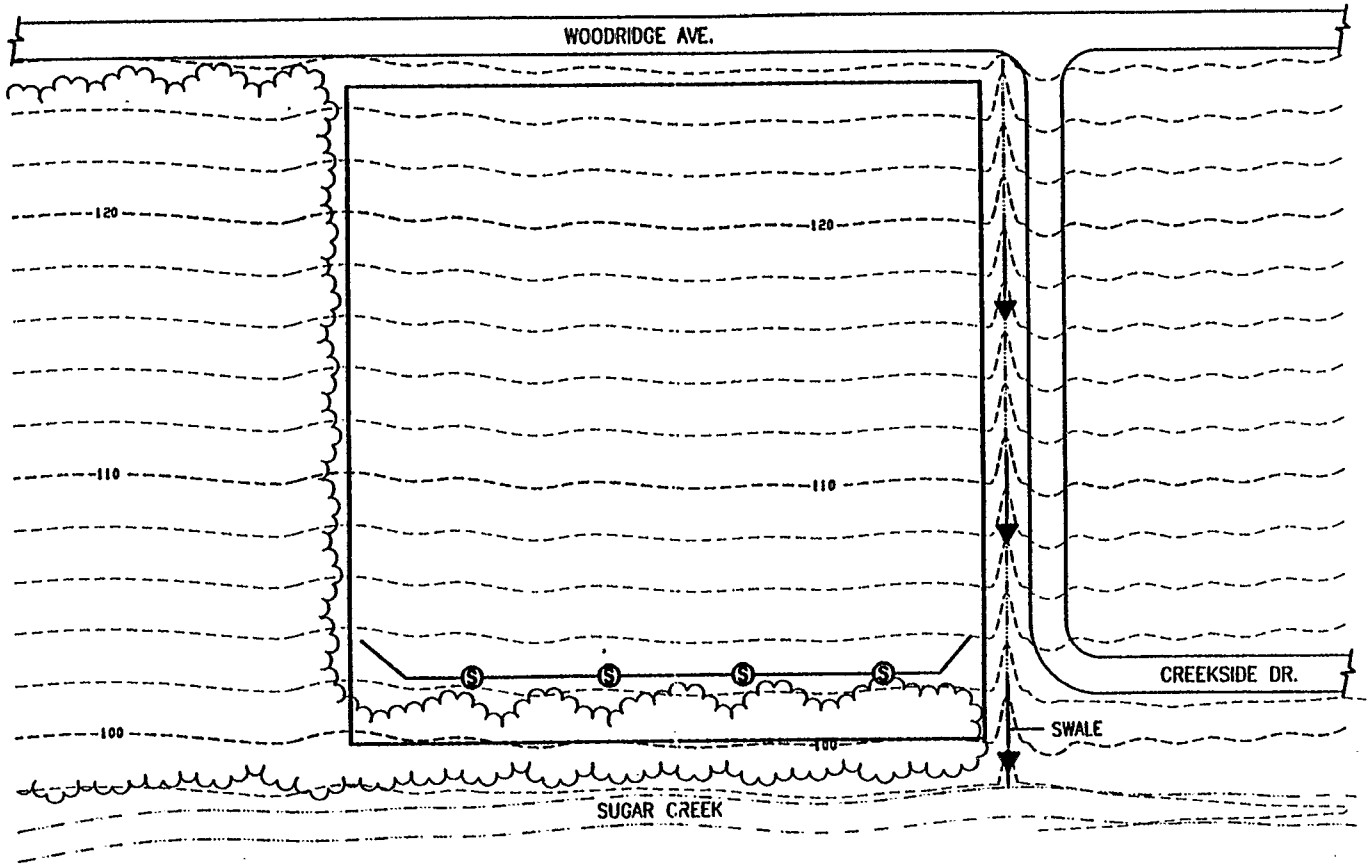
NOTE: SEED AND MULCH ALL DISTURBANCE AFTER INITIAL CLEARING AND GRUBBING.

NOTE:
PRINT REDUCED TO 11" X 17" & IS NOT HALF SCALE. PLEASE COMPENSATE TO DETERMINE PROPER WORKING SCALE BEFORE PROCEEDING.

ENVIRONMENTAL PROTECTION AGENCY

SMALL CONSTRUCTION SITE
TYPICAL PLAN 5 ACRE SITE
16% SLOPE HIGH SOIL ERODIBILITY

36



NOTE: SEED AND MULCH CRITICAL AREAS AREAS DURING CONSTRUCTION.

NOTE:
PRINT REDUCED TO 11" X 17" & IS NOT HALF SCALE. PLEASE COMPENSATE TO DETERMINE PROPER WORKING SCALE BEFORE PROCEEDING.

LEGEND

- 2' CONTOUR
- 100 10' CONTOUR
- CONTRACT LIMITS
- CREEK
- TREE LINE
- S SILT FENCE
- STONE CHECK DAM

ENVIRONMENTAL PROTECTION AGENCY

SMALL CONSTRUCTION SITE
TYPICAL PLAN 3 ACRE SITE
7% SLOPE MODERATE SOIL ERODIBILITY

17

Appendix B–4

Post-Construction Runoff Control Cost Analysis

Overview

This appendix describes the methodology used to estimate BMP installation costs attributable to the Phase II Storm Water rule's post-construction municipal minimum measure. Specifically, the costing exercise estimates the costs associated with constructing BMPs that attempt to maintain predevelopment runoff conditions on post-construction sites. The measure affects sites on which land disturbance is greater than or equal to one acre and that discharge into a regulated MS4. However, sites that disturb more than ten acres are not included in this analysis because the Construction General Permit already imposes post-development storm water control requirements on those sites (63FR 7858) .

In estimating incremental costs attributable to this measure, EPA estimated a per-site BMP cost for 12 model sites of varying size (one, three, five and seven acres) and imperviousness (35%, 65% and 85%). This approach was based on the results of an EPA Office of Science and Technology study (Preliminary Data Summary of Urban Storm Water Best Management Practices, US EPA, Office of Science and Technology, December 1998b). EPA used the Office of Science and Technology study to develop a combination of BMPs for the model sites and calculate costs based on the amount of storm water runoff expected from sites of varying imperviousness. Based on considerations of site size constraints, total BMP costs and terrain variations, EPA calculated a weighted average BMP cost, including operation and maintenance costs, for each of the model sites.

Two additional adjustments refined the per-site cost estimate for post-construction control. First, EPA included a cost reduction associated with nonstructural practices that it anticipates will be used to comply with this measure. EPA identified per-site average cost reductions associated with redirection of rooftop runoff ("rooftop runoff credit"). Second, EPA anticipates ancillary cost savings because the new BMPs (structural and nonstructural) will also reduce peak storm water flows, allowing developers to save on construction costs when they build their sewer connections. The potential cost savings, based on estimates of reduced per-site costs for storm water conveyances, were also subtracted from the initial per-site BMP cost.

The adjusted per-site BMP cost was then multiplied by the total number of construction sites that are located in Phase II urbanized areas to obtain a national cost estimate.

Detailed Description of the Cost Analysis

Phase II Post-Construction Universe

EPA derived the number of construction starts affected by this measure by further refining the construction start analysis used to identify the number of starts that would be regulated under the Phase II construction program for sites nationwide. As a result, this analysis started with the data set that is described in Appendix B–2, steps one through seven. Two additional steps, described below, were performed to identify the post-construction universe.

Step One. EPA used county-level Bureau of the Census construction data as the basis for identifying the universe of construction starts affected by the post-construction minimum

measure (construction starts that disturb between one and 10 acres of land and occur in Phase II urbanized areas). EPA identified all counties that are located either entirely or partially inside urbanized areas. EPA eliminated all other nonurbanized counties from the construction start data set. For counties that are located partially inside an urbanized area, EPA assumed that construction activity is evenly distributed and, therefore, based its calculation of the number of construction starts on ratio of county land located in the urbanized area versus outside the urbanized area.

Step Two. EPA removed construction starts that were located in counties with roughly equivalent programs under CZARA in the following states: Rhode Island, Delaware, Maryland, Pennsylvania, Florida, South Carolina and Alaska. Exhibit B–4–1 summarizes the number of construction starts by acreage category that may be affected by the Phase II rule.

Exhibit B–4–1. Estimated Number of Construction Starts Potentially Affected by the Phase II Post-Construction Runoff Control Provision

Construction Starts (1998)				
Area Acreage	Multi-Family Residential (35%)	Multi-Family/ Commercial/ Institutional (65%)	Commercial (85%)	Totals
1 Acre	221	2,942	2,505	5,668
3 Acres	287	2,451	1,939	4,677
5 Acres	228	822	523	1,573
7 Acres	244	818	384	1,445
Totals	981	7,033	5,351	13,364

Per-Site Costs

Step One. EPA developed a theoretical series of representative sites to which typical best management practices could be applied. The 12 model sites varied by site size (one, three, five and seven acres) and level of imperviousness (35%, 65% and 85%). Imperviousness levels for multi-family and commercial development were established based on a review of local government reports detailing average imperviousness by land use type (see Exhibit B–4–2). To account for ranges of imperviousness reported for multi-family (35%–65%) and commercial (65%–85%) development, EPA assigned half the starts to either impervious category. For example, of the 442 multi-family one-acre starts, 221 are counted in the 35% impervious category while the other 221 are counted in the 65% impervious category. All institutional starts are counted in the 65% impervious category, reflecting the reported impervious range of 50-80%.

Exhibit B–4–2. A Summary of Impervious Surface Percentages for Commercial and Multi-Family Land Use

Reference	% Impervious
Commercial	
US Soil Conservation Service. 1975. Technical Release 55. Urban Hydrology for Small Watersheds	85
MWCOG. 1987. Controlling Urban Runoff: A Practical Manual for Planing and Designing Urban BMPs	60–80 (light com) 80–100 (heavy com)
MWCOG. 1997. Anacostia Watershed Study— draft (survey of land use and corresponding impervious surface levels in the District of Columbia, Montgomery and Prince Georges counties)	50–70(low density com) 70–80(medium density com) 80–90(med/high density com) 90–100(high density com)
Maryland Department of the Environment (Jim George and Greg Lindsey). 1991. Financing Stormwater Controls in Carroll County: A Preliminary Investigation	82

Exhibit B–4–2. A Summary of Impervious Surface Percentages for Commercial and Multi-Family Land Use

Reference	% Impervious
Commercial	
NVPDC. 1990. Evaluation of Regional BMPs in the Occoquan Watershed	90–95 (suburban shopping center/cbd)
Institutional	
MWCOG. 1997. Anacostia Watershed Study—draft (survey of land use and corresponding impervious surface levels in the District of Columbia, Montgomery and Prince Georges counties)	50–70 (schools, military installations, churches) 70–80 (schools, colleges, churches)
Multi-Family	
US Soil Conservation Service. 1975. Technical Release 55. Urban Hydrology for Small Watersheds	38 (lots ≤ 1/8 acre) 65 (lots 1/4 acre)
MWCOG. 1987. Controlling Urban Runoff: A Practical Manual for Planing and Designing Urban BMPs	35–60 (townhouse/garden apts)
Maryland Department of the Environment (Jim George and Greg Lindsey). 1991. Financing Stormwater Controls in Carroll County: A Preliminary Investigation	40–68 (garden apts/condos)
City of Olympia. 1994. Impervious Surface Reduction Study	42–56 (4–7 units/acre)
MWCOG. 1997. Anacostia Watershed Study—draft (survey of land use and corresponding impervious surface levels in the District of Columbia, Montgomery and Prince Georges counties)	30–50(row houses/garden apts) 50–70(mid-rise apt/multi-unit) 70–80(high density res)
NVPDC. 1990. Evaluation of Regional BMPs in the Occoquan Watershed	35–75(6–30 DU/Acre)

For purposes of this analysis, EPA assumed that single family residential development would be able to meet the post-construction runoff control program goal using storm water sensitive site design. Therefore, single family residential construction starts were excluded from this analysis. The Multi-Sector General Permit places post-development runoff requirements on industrial sites that are similar to the Phase II requirements for the post-construction runoff control minimum measure and, as a result, these were also excluded from this analysis (60 FR 50804).

Step Two. EPA identified five best management practices (BMPs) that developers could use to meet the municipal program requirements of the new development/redevelopment minimum measure. The following five BMPs selected for the analysis represent typical water quality BMPs: dry detention pond, infiltration trench, infiltration basin, grass swales and sand filter. EPA accounted for site constraints resulting from site size and impervious level when assigning BMPs to the model sites, then developed an average per-site BMP cost. This per-site cost was adjusted to account for potential cost reductions associated with the redirection of rooftop runoff.

BMP Installation and Maintenance Costs. Per-site costs were calculated based on estimates of water quality volume (WQv), which is the volume of water that a BMP is designed to treat.[1] Using Schueler's simple method, EPA determined water quality volume for the one-inch storm as follows (US EPA, 1998):

$$WQv = (.05 + .9I)\ A/12$$

where: WQv = Water Quality Volume (Acre-Feet)
I=Impervious Fraction in the Watershed
A=Watershed Area (Acres)

Exhibit B–4–3 summarizes the results of calculations determining water quality volume for each of the twelve model sites described above. Total volume, which includes both water quality volume and detention volume, is not used in this analysis because EPA assumed that site operators will account for detention volume where it is needed to correct for flooding hazards; the control of detention volume is not a feature of the Phase II Rule. Construction and maintenance costs depend on the size of the BMP, which depends on the water quality volume.

Exhibit B–4–3. Water Quality Volume Calculations for Twelve Model Sites

Square Acreage (A)	**1 Acre**			**3 Acres**		
Percent Impervious Cover (I)	**35**	**65**	**85**	**35**	**65**	**85**
Water Quality Volume (acre-feet) (P)(Rv)(A/12) P = 1" of rainfall Rv = 0.05 + 0.9 (I) A = Drainage Acreage	0.03	0.04	0.07	0.08	0.12	0.20
Square Acreage (A)	**5 Acres**			**7 Acres**		
Percent Impervious Cover (I)	**35**	**65**	**85**	**35**	**65**	**85**
Water Quality Volume (P)(Rv)(A/12) P = 1" of rainfall Rv = 0.05 + 0.9 (I) A = Drainage Area	0.13	0.18	0.34	0.18	0.26	0.48

EPA's cost analysis used the construction cost equations and the annual maintenance cost assumptions in *Preliminary Data Summary of Best Management Practice Cost Analysis* (EPA, 1998), which reports the findings of OST's national review of capital costs attributable to BMP design and construction. Exhibit B–4–4 summarizes construction cost equations and maintenance costs for each of the five BMPs.

[1] For example, a BMP may be designed to capture the first inch of runoff from the drainage area. Any volume of rainfall over the first inch would bypass the BMP. Therefore, water quality volume for this BMP would be one watershed inch.

Exhibit B–4–4. Descriptions of New Development and Redevelopment BMPs

BMP	Construction Cost Equation	Maintenance Costs[1]	Notes	Sources
Detention Pond	$18.5WQv^{0.70}$	5%	Ponds are a reliable best management practice.	a,b,c,d,e
Infiltration Trench	1–3ac: 4,400 5 ac: 10,400 7 ac: 3.9 WQv + 2,900	12%	Although infiltration trenches are designed to last a long time, they need to be inspected and rebuilt if they become clogged.	d,e,f
Infiltration Basin	1.3 WQv	4%	Infiltration basins are not very reliable, and tend to become clogged.	g
Swale	(15%)*(%Impervious area)*(.25$/sf)	5%	Used for smaller development, requires frequent maintenance in order to function long-term.	d
Sand Filter	4 WQv	12%	Sand filters require frequent maintenance in order to function long-term.	a,e,g

Notes:
WQv = Water Quality Volume
Sand filter volume was estimated at 4WQv, which is slightly high, to account for the relatively small drainage area.
Life = Length of time without major modifications or reconstruction

a = Brown and Schueler, 1997b
b = Wiegand, et al, 1986
c = Schueler, 1987
d = SWRPC, 1991
e = US EPA, 1993a
f = Schueler, 1997
g = Livingston, et al, 1997

[1] Presented as % of construction costs on an annual basis

As noted previously, this costing analysis utilizes a theoretical set of representative sites to which typical best management practices are assigned. For each of these representative sites, Exhibit B–4–5 shows which BMPs were used to develop an average per-site cost. Some BMPs are more likely to be used than others for different sizes of sites and different degrees of imperviousness. The selection of BMPs to use for each site was based on the following assumptions:

- To allow for variety in sites and to provide a range, a selection of three BMPs was typically provided.
- Engineers will use the most cost effective BMP provided site restrictions are not a factor.
- It is standard practice and feasible to select detention basins in the design of BMPs. Consequently, a detention basin was assigned to each of the model sites.

- Infiltration trenches are not cost effective on smaller sites with low impervious levels but may be on larger sites.

- In general, swales are used and effective on small sites with low impervious levels. Due to cost constraints, sand filters are typically used on larger sites.

Exhibit B–4–5. BMPs Used for Cost Analysis

Site Size (acres)	% Impervious	Percent Selected for BMP Design				
		Detention Basin	Infiltration Trench	Infiltration Basin	Swale	Sand Filter
1	35	40		40	20	
	65	30	30	30	10	
	85	40	40			20
3	35	40		40	20	
	65	33.3	33.3	33.3		
	85	33.3	33.3	33.3		
5	35	40		40	20	
	65	50		50		
	85	30	30	30		10
7	35	40	10	40		10
	65	45		45		10
	85	66.6				33.3

Exhibit B–4–5 also shows the weights that were assigned to each BMP to obtain a weighted average cost for each type of site. Nonuniform weights were provided when one BMP was believed to be less likely to be selected than the others. The sand filter and swale BMPs were given less weight than the other possible options to account for site constraints or limited effectiveness. The remaining weight was then distributed evenly among the other BMPs. For example, on a five-acre site with 85% impervious surface, the cost of a sand filter exceeds the combined average cost of the detention pond, infiltration trench, and infiltration basin. Because an engineer would be more likely to select the most cost effective BMP or combination of BMPs, and sand filters are used only when site constraints present no other option, EPA assigned a low weight to the sand filter (10%) and equal weights to the remaining three BMPs (30% each). By assigning nonuniform weights to the BMPs, the analysis more accurately reflects expected costs under actual development conditions.

The BMP costs shown in Exhibit B–4–6 are capital costs associated with each BMP for each size site and impervious cover. Exhibit B–4–6 does not report costs for BMPs that were not selected for a model site because of limitations related to site size and imperviousness The average

weighted cost was obtained by using the weights in Exhibit B–4–5. The total cost is the sum of the average weighted BMP and operating and maintenance (O&M) costs.

The O&M costs shown in the exhibit are present value calculations of O&M costs over ten years (i.e., two NPDES permit periods) assuming a 7% discount rate. These capitalized O&M costs are included in the cost analysis because they represent the social costs of maintaining the effectiveness of the structural BMPs installed in any year. If the BMPs were not maintained, their effectiveness would decline and the overall effectiveness of this provision of the rule would decline.

Exhibit B–4–6. Average BMP Installation Costs and O&M Costs for Model Sites

BMP	Construction Costs ($) [1,2,3]											
Acreage	1 Acre						3 Acres					
	35		65		85		35		65		85	
Percent Impervious Cover	BMP Cost	O&M Cost	BMP Cost	O&M Cost	BMP Cost	O&M Cost	BMP Cost	O&M Cost	BMP Cost	O&M Cost	BMP Cost	O&M Cost
Detention Pond	2,535	127	3,472	174	5,083	254	5,470	274	7,483	374	10,599	530
Infiltration Trench	—	—	4,400	528	4,400	528	—	—	10,400	1,248	10,400	1,248
Infiltration Basin	1,468	59	2,300	92	—	—	4,403	176	6,889	276	11,326	453
Swale	572	29	1,062	53	—	—	1,715	86	—	—	—	—
Sand Filter	—	—	—	—	12,197	1,464	—	—	—	—	—	--
Avg. Weighted Cost ($)	**1,716**	**561**	**3,158**	**1,710**	**6,232**	**4,253**	**4,292**	**1,384**	**8,257**	**4,443**	**10,775**	**5,223**
Total Cost ($)	**2,277**		**4,867**		**10,486**		**5,676**		**12,700**		**15,998**	

Exhibit B–4–6. Average BMP Construction Costs and O&M Costs for Model Sites *(continued)*

BMP	Construction Costs ($) [1,2]											
Acreage	5 Acres						7 Acres					
Percent Impervious Cover	35		65		85		35		65		85	
	BMP Cost	O&M Cost	BMP Cost	O&M Cost	BMP Cost	O&M Cost	BMP Cost	O&M Cost	BMP Cost	O&M Cost	BMP Cost	O&M Cost
Detention Pond	7,822	391	9,994	500	15,366	768	9,899	495	12,735	637	19,561	978
Infiltration Trench	—	—	10,400	1,248	10,400	1,248	33,720	4,046	—	—	—	—
Infiltration Basin	7,338	1,248	10,411	417	19,254	770	10,273	411	14,723	589	—	—
Swale	2,859	294	—	—	—	—	—	—	—	—	—	—
Sand Filter	—	—	—	—	59,242	7,109	31,610	3,793	45,300	5,436	83,635	10,036
Avg. Weighted Cost ($)	**6,636**	**2,124**	**10,269**	**5,067**	**13,506**	**5,871**	**11,441**	**5,387**	**20,220**	**11,228**	**40,919**	**28,076**
Total Cost	**8,760**		**15,336**		**19,377**		**16,828**		**31,448**		**68,996**	

Note: Costs are for construction and operation and maintenance costs.

[1]Refer to Exhibit B–4–4 for BMP construction cost equations and Exhibit B–4–3 for volumes used to calculate construction costs.

[2]Refer to Exhibit B–4–5 for weighted BMP information.

[3]Dollar costs provided in this exhibit are not intended to imply this degree of precision. Numbers can be rounded to the nearest 100.

Rooftop Runoff Credit. EPA anticipates that non-structural practices will be used whenever feasible to comply with this measure, because they are generally less costly to implement than structural measures. One simple design practice, the redirection of rooftop runoff from impervious surfaces to grassy areas, can be used as a way to reduce the need for installation of structural BMPs. In EPA's cost analysis, per-site average cost reductions associated with redirection of rooftop runoff have been calculated and subtracted from BMP installation and maintenance costs.

The steps used in calculating the rooftop runoff credit are as follows:

Multi-family sites: The calculations are based on an average density for townhouses of 10 townhouses (TH) per acre. It was assumed that the average square footage of the rooftop was 800sq. For example, to calculate a reduced impervious area for three-acre 65% multi-family sites, the following steps are used:

- 3 acre x 10TH/acre = 30TH
- 30TH x 800 sq/TH = 24,000 sq = 0.55 acre (total rooftop area of townhouse)
- 3 acre x 65% = 1.95 acre (total impervious area on site)
- 1.95 acre–0.55 acre = 1.4 acre
- 1.4 acre/3 acre = 46% rounded to 50%

Commercial/Institutional sites: Floor Area Ratio (FAR) was used to determine rooftop surface area. FAR for commercial sites ranges from 0.25–0.5. For the one–three acre sites a FAR of 0.25 was used, and for the five–seven acre sites, a FAR of 0.35 was used. It was also assumed for these calculations, a single story building, and the discharge from the roof tops will be from multiple locations along the roof. For example, to calculate a reduced impervious area for three-acre 65% commercial sites, the following steps are used:

- 3 acre x 65% = 1.95 acre (total impervious area on site)
- 3 acre x 65% x 0.25 = 0.48 acre (area of rooftop on impervious surface)
- 1.95 acre–0.48 acre =1.47 acre
- 1.47 acre/3 acre = 49% rounded to 50% (revised impervious surface area)

Results are presented in Exhibit B–4–7.

Exhibit B–4–7. Cost Reductions from Redirection of Rooftop Runoff

Average Per-Site Reduction in BMP Costs (1998 dollars)			
Area (Acreage)	**35% Impervious (Multi-Family Residential)**	**65% Impervious (Multi-Family/Commercial /Institutional)**	**85% Impervious (Commercial)**
1 Acre	$266	$425	$0
3 Acres	$674	$1,643	$0
5 Acres	$1,048	$3,058	$0
7 Acres	$2,301	$12,097	$0

Weighted Average Per-Site Costs. After incorporating the rooftop runoff credit, Exhibit B–4–8 summarizes the weighted average total per-site costs for each of the modeled sites.

Exhibit B–4–8. Summary of Per-Site Average Total Costs by Acreage and by Percent Imperviousness

Average BMP Costs (1998 dollars)			
Area (Acreage)	**35% Impervious (Multi-Family Residential)**	**65% Impervious (Multi-Family/Commercial /Institutional)**	**85% Impervious (Commercial)**
1 Acre	$2,277	$4,867	$10,486
3 Acres	$5,676	$12,698	$15,998
5 Acres	$8,760	$15,353	$19,377
7 Acres	$16,828	$31,448	$68,996

Associated Cost Savings

An ancillary benefit of the post-construction runoff provision is that the new BMPs (structural and nonstructural) will also reduce peak storm water flows that enter the storm sewer system. Consequently, developers may be able to save on construction costs when they build their sewer connections. EPA selected the option that is most closely aligned with the cost analysis, which assumes that all of the construction sites install structural BMPs that can detain water quality volume on site long enough to reduce contaminant concentrations. In effect, the BMPs in the cost analysis reduce the peak runoff that must be handled by conventional storm water conveyances. Consequently, there is an implied potential for developers to reduce the cost of these conveyances. This is the basis for the following cost-savings analysis.

The analysis assumed that reductions in peak runoff volumes generate cost savings associated with using smaller diameter pipe compared to pipe sizes that might be required without the BMPs. In the analysis, the size of pipe that would be required to transport the water quality volume with and without the use of the storm water BMP was determined for each of the twelve model sites used in the cost analysis (i.e., four acreage sizes and three impervious surface percentages). The second and third columns in Exhibit B–4–9 show the water quality volumes for the one-inch and five-inch storm events, respectively.

The standard approach for calculating the size of pipe used in a storm water/sewer drainage system is to determine the peak discharge from a given property and then use the value in Mannings equation to determine the pipe diameter. In these calculations, a water quality volume was converted to a peak discharge using Claytor and Schueler's method (1996) (columns 4 and 5 in Exhibit B–4–9) for the five-inch storm (water quality volume without a BMP) and the one-inch storm (water quality volume retained by BMP). Then, Mannings equation was used to calculate the pipe diameter required to transport runoff with the use of a BMP measure (five-inch storm minus the one-inch storm) and without a BMP measure (five-inch storm). The resulting reduction in pipe diameter was assumed to represent the size by which the storm water/sewer drainage piping could be reduced because of the implementation of the BMP (column 6 in Exhibit B–4–9).

Exhibit B–4–9. Summary of Cost Savings for Smaller Storm Water Runoff Conveyance Systems (1998 dollars)

Site	WQ Volume (acre-ft)[1]		Discharge (cfs)[2]		Reduction In Pipe Diameter (inches)[3]	Reduction In Pipe Cost ($/LF)	Linear Feet (ft)	Per-Site Cost Savings ($)	Construction Starts[4]	National Cost Savings ($)
1 acre	**1"**	**5"**	**1"**	**5"**						
35%	0.03	0.15	0.45	2.28	1	0	210	0	221	0
65%	0.05	0.26	0.80	4.22	1	0	210	0	2,492	0
85%	0.07	0.34	1.18	5.73	2	1.40	210	294	2,505	736,470
3 acres										
35%	0.09	0.46	1.18	5.99	1	1.40	360	504	287	144,900
65%	0.16	0.79	2.22	11.01	2	1.75	360	630	2,451	1,543,815
85%	0.20	1.02	3.00	15.28	1	2.05	360	738	1,939	1,430,982
5 acres										
35%	0.150	0.76	1.69	8.55	1	0	470	0	228	0
65%	0.26	1.32	3.17	16.12	2	2.05	470	964	822	792,479
85%	0.34	1.70	4.46	22.29	2	4.00	470	1,880	526	983,240
7 acres										
35%	0.21	1.06	2.13	10.78	2	1.75	550	963	244	234,369
65%	0.37	1.85	4.02	20.14	2	4.00	550	2,200	818	1,798,500
85%	0.48	2.38	5.40	26.74	2	0	550	0	384	0
Total										**7,664,755**

Notes:

[1]The water quality (WQ) volume used for each type and size of property was obtained from Appendix B–4, which used Schueler's simple method for the one-inch storm event as reported in acre-feet.

[2]The peak discharge was determined by converting the water quality volume using Claytor and Schueler's method (1996).

[3]The diameter of pipe capable of carrying the discharge calculated for the five-inch storm event and the 5-inch minus the 1-inch storm event was determined using the Manning equation ($D = [(2.16Qn)/S_o^{1/2}]^{3/8}$) with a Mannings n value of 0.015 for concrete, a slope (S) of 1%, and a discharge (Q) as determined in column 4 and 5. This pipe diameter was then converted to inches and rounded up to the next commercially available pipe size.

[4]The number of construction starts for multi-family residential (35% impervious), multi-family, commercial and institutional (65% impervious), and commercial (85% impervious) starts are from Exhibit B–4–1.

The cost savings were estimated by subtracting the unit cost of the pipe size required to transport the five-inch storm volume from the unit cost of the pipe size required to transport the five-inch storm minus the one-inch storm volume. The 1999 Means manual was used to determine the material cost per linear foot assuming the pipe was made of concrete (non-reinforced pipe, extra strength, B&S or T&G joints). The cost-savings analysis used standard pipe sizes; therefore, if the reduction in the pipe size was not sufficient to drop to the next smaller standard pipe diameter (i.e., 27-inch pipe to a 24-inch pipe), a zero cost savings was assumed. Also, the cost-savings analysis did not assume any cost savings associated with construction or maintenance activities.

Because costs are measured in dollars per linear foot, EPA needed an estimate of approximate average length of storm water drain pipe adjacent to each construction start. To calculate the pipe length, EPA assumed that the one-, three-, five- and seven-acre properties are square in shape and that the storm water drain runs along one side of the property. Therefore, the total length of piping per property was determined by taking the square root of the acreage area and converting from acres to feet (column 8 in Exhibit B–4–9).

EPA calculated cost savings per model site by multiplying three values: the cost savings per linear foot, the linear feet per site, and the number of sites. Column 9 in Exhibit B–4–9 shows the number of construction starts used to estimate BMP costs, and column 10 reports aggregate cost savings per type of model site. Total annual cost savings across all sites was estimated to be $7.7 million.[2]

National Costs

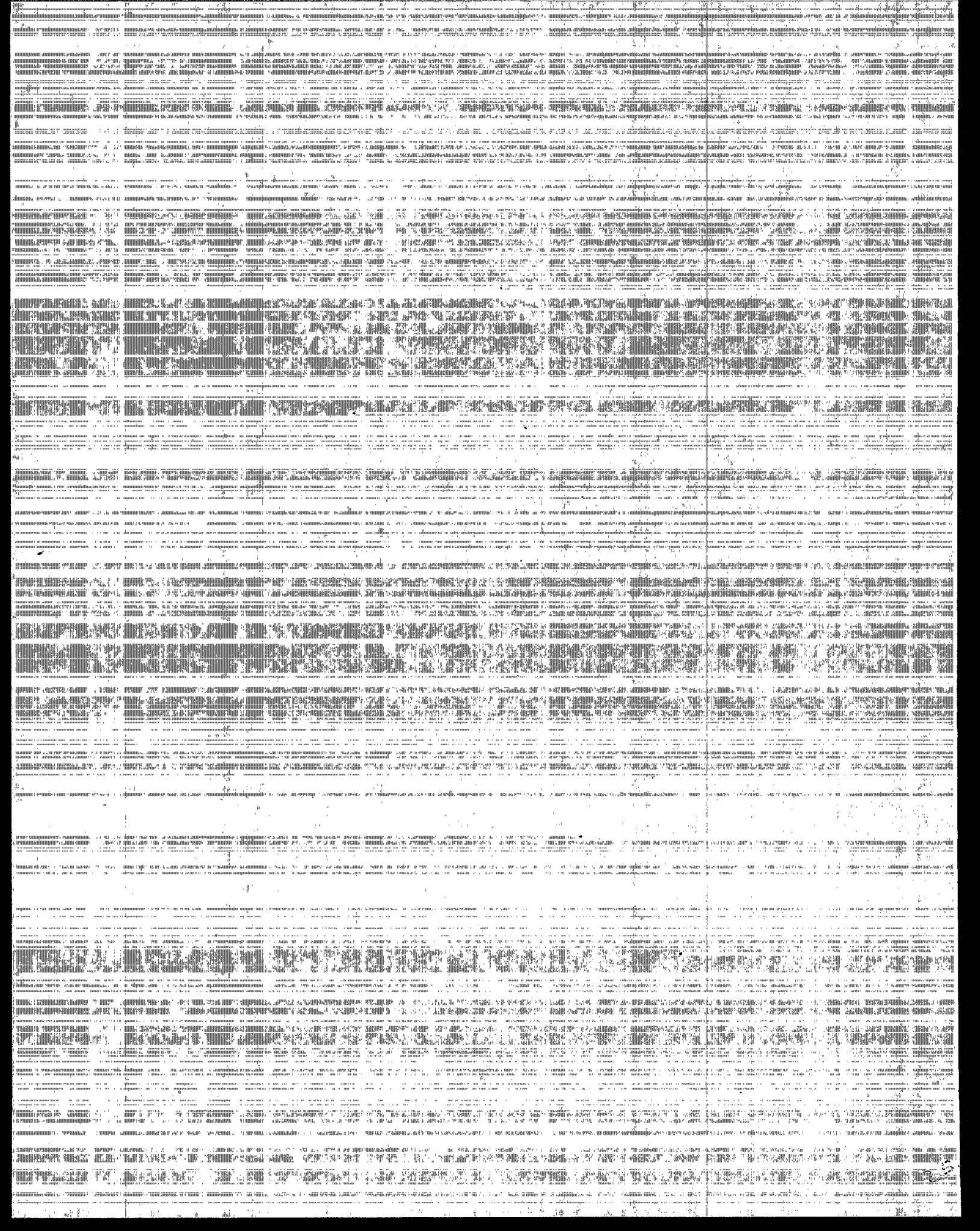
Total per-site costs (Exhibit B–4–8), less the cost savings (Exhibit B–4–9), were multiplied by the number of construction starts summarized in Exhibit B–4–1 to obtain total national costs which are shown in Exhibit B–4–10. Total estimated post-construction runoff control costs are approximately $178 million per year.

[2]EPA assumes that because BMP costs are incurred at all sites, all sites could potentially reduce storm water drain costs. This may overestimate the potential cost savings if some of the construction sites that install BMPs are not able to reduce their subsurface storm water costs. The bias introduced by the linear footage assumption is uncertain. It may tend to overestimate average storm sewer lengths for smaller developments, but underestimate average lengths for larger developments. Nevertheless, it is important to realize that this analysis includes only one type of cost savings. If the rule encourages developers to implement design strategies such as clustering, or if the rule encourages flexibility in building requirements such as street widths or parking lot sizes, the construction cost savings are potentially large.

Exhibit B–4–10. Estimated Post-Construction Runoff Control Costs

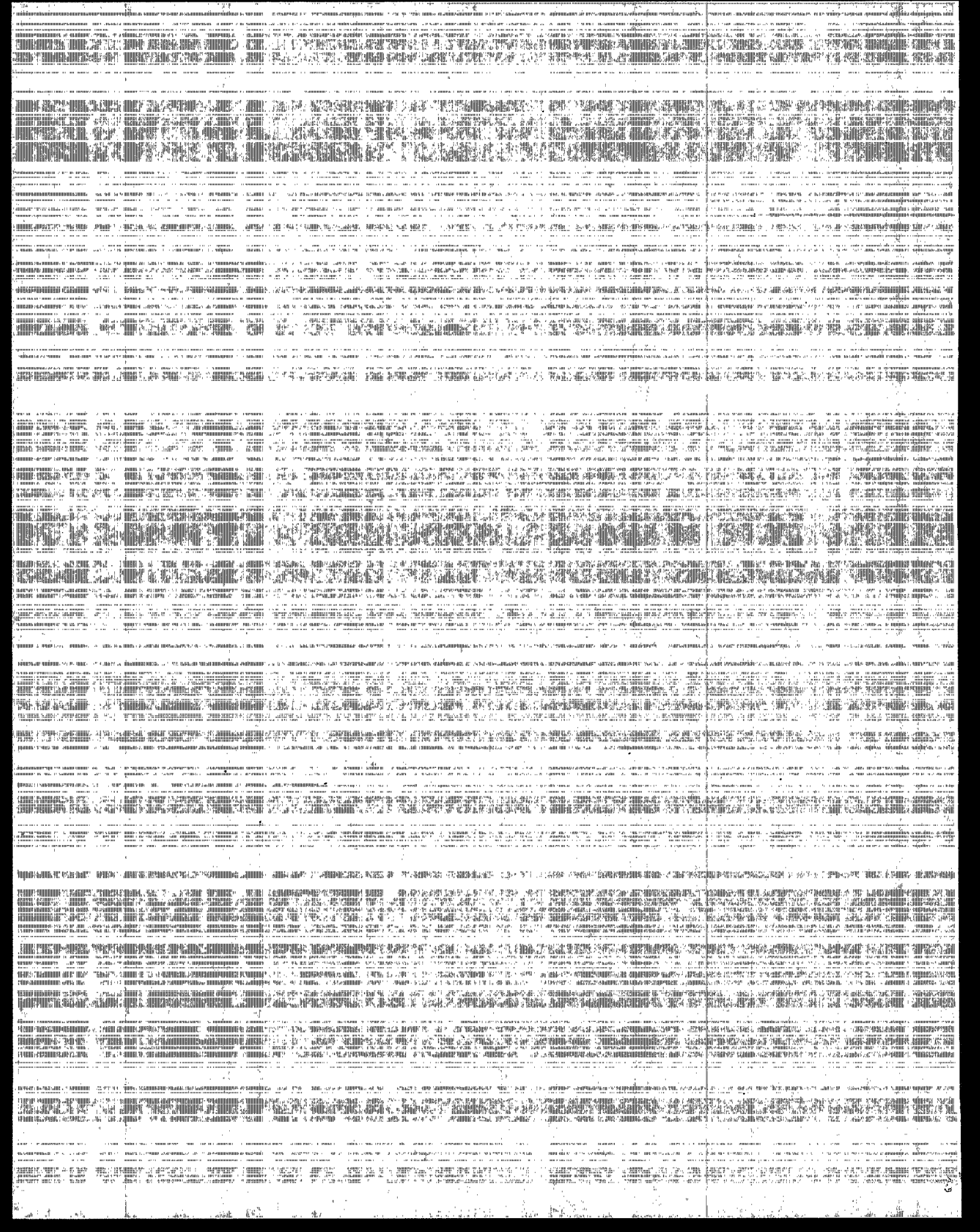
Area	35% Impervious (Multi-Family Residential)	65% Impervious (Multi-Family/ Commercial/ Institutional)	85% Impervious (Commercial)	Total Cost (1998 dollars)
1 Acre	$503,163	$14,318,035	$25,530,478	$40,351,676
3 Acres	$1,486,961	$29,571,535	$29,588,931	$60,647,426
5 Acres	$2,001,641	$11,835,630	$9,151,038	$22,988,309
7 Acres	$3,863,272	$23,910,571	$26,494,414	$54,268,258
Total Cost	$7,855,037	$79,635,771	$90,764,861	$178,255,669

This approach to estimating costs on a per-site basis implicitly assumes that this measure is implemented by installing structural BMPs on a site-by-site basis. It is important to note, however, that the Phase II Storm Water rule allows flexibility in how MS4s design and implement their post construction runoff control programs. Consequently, some programs may adopt alternative approaches such as implementing a watershed management strategy, which may be more cost effective than site-by-site BMPs. Furthermore, developers may also have flexibility in whether they implement structural or nonstructural BMPs. These types of flexibility cannot be readily be incorporated in the cost analysis, and as a result the analysis may represent the higher end of the potential cost range.



Appendix B–5

Federal and State Cost Analysis and Assumptions



Appendix B–5

Federal and State Cost Analysis and Assumptions

Promulgation of the Phase II rule will expand the universe of municipalities and construction activities required to submit an application for a National Pollutant Discharge Elimination System (NPDES) storm water permit. The Phase II rule has the potential to increase the universe of municipalities by a total of 5,106 places/counties and to require permitting authorities to process permit applications from approximately 110,223 construction sites and 19,452 waivers each year. The annual cost to the Federal government is estimated to be approximately $457,000 and the annual cost to State governments is estimated to be approximately $4,861,000.

B.5.1 Federal Costs

Once the Phase II rule is implemented, EPA will be required to operate the NPDES program in non-NPDES authorized states.[3] Environmental Protection Agency (EPA) will be responsible for two types of costs: start-up costs and annual costs. The start-up costs include the incorporation of Clean Water Act 401 certification language into the general permit that EPA anticipates developing for small MS4s, the review and filing of non-NPDES-authorized States/Territories plans, development of storm water goals for these states and territories, and the designation of additional . All the start-up costs associated with the administration of Phase II will occur once as the rule becomes implemented. Some of these start-up costs may also be incurred periodically as needed at the beginning of each new permit cycle. For example, the incorporation of 401 certification language into the general permit language is likely to only need to be done once, while the designation of additional MS4s may occur occasionally at the beginning of each new permit cycle.

When the Federal government is the permitting authority for the Phase II municipalities, EPA will be required to annually process the applications, review plans, issue NPDES storm water permits to the municipal applicants, and review and file any reports. For construction sites disturbing between one and five acres of land in non-NPDES authorized States, EPA will be required to process the notices of intent (NOIs) to be covered by the construction general permit, the notices of termination (NOTs), and the waiver certification. For small MS4s, EPA will be required to process and review the NOI and report. Exhibit B–5–1 provides the estimated start-up costs and Exhibit B–5–2 presents the annual costs to the Federal government.

[3]The non-NPDES authorized States and territories include Alaska, Arizona, District of Columbia, Idaho, Maine, Massachusetts, New Hampshire, New Mexico, Puerto Rico. While Florida and Texas will not administer the storm water portion of the NPDES program until the year 2000, they are counted as part of the NPDES authorized states and territories since the Rule will take effect in 2003.

Exhibit B–5–1. Estimated Federal Start-Up Costs (1998 dollars)

Phase II Program Element	Respondents Per Year[1]	Burden Hours per Respondent[2]	Hourly Labor Costs[3]	Estimated Cost[4]	Annual Cost Over Permit Period[5]
Review and File Modified State Programs	9	12	$28.37	$3,064	$613
Develop Storm Water Goals in Non-Authorized States	9	100	$28.37	$25,533	$5,107
Incorporate 401 Certification Language	9	5	$28.37	$1,277	$255
Designation of Additional MS4s	9	66.6	$28.37	$17,005	$3,401
TOTAL COSTS[6] $46,879					$9,376

[1] The number of respondents, 9, represents the non-NDPES states and territories that EPA will operate the NPDES program for.
[2] Burden hours per respondent were estimated by EPA.
[3] Hourly labor costs are based upon an average annual Federal employee salary of $39,338, divided by 2,080 labor hours per year and then increased 50% to represent overhead costs (US Office of Personnel Management, 1998).
[4] Estimated cost is the product of the respondents per year, hours per respondent, and hourly labor costs.
[5] To determine annual costs over permit period, estimated cost is divided by five years.
[6] Numbers may not total due to rounding.

Exhibit B–5–2. Estimated Federal Annual Costs (1998 dollars)

Phase II Program Activity	Respondents Per Year[1]	Burden Hours per Respondent[2]	Hourly Labor Costs[3]	Estimated Cost[4]
Construction Program				
Waiver Cert. Processing & Review	1,607	1	$28.37	$45,590
NOI Processing & Review	9,104	1	$28.37	$258,280
NOT Processing	9,104	0.5	$28.37	$129,140
Small MS4 Program				
NOI Processing & Review	357	0.8	$28.37	$8,102
Report Processing & Review	357	1.6	$28.37	$16,205
Annual Total[5]				$457,318

[1] The number of respondents per year was based on the 1990 Bureau of Census data for small MS4s and 8.26% of total starts that are in non-NPDES states and territories in Exhibits B–2–3 and B–2–4 for construction.
[2] Burden hours per respondent were estimated by EPA.
[3] Hourly labor costs are based upon an average annual Federal employee salary of $39,338, divided by 2,080 labor hours per year and then increased 50% to represent overhead costs (US Office of Personnel Management, 1998).
[4] Estimated cost is the product of the respondents per year, hours per respondent, and hourly labor costs.
[5] Numbers may not total due to rounding.

B.5.2 State Costs

States and Territories that are authorized to operate the NPDES program will experience both start-up costs and annual costs.[4] The start-up costs include the costs associated with revising each NPDES authorized State's procedures, as described by 40 CFR 123.62(b), the incorporation

[4] There are 44 States and Territories authorized to operate the NPDES program. No Native American Tribes currently have NPDES authorization.

of Clean Water Act 401 certification language into the general permit, and designation of additional MS4s. The annual cost includes the State's responsibility as the permitting authority. For the Phase II municipal program, States will be required to will be required to annually process the applications, review plans, issue NPDES storm water permits to the municipal applicants, and review and file any reports. For construction sites disturbing between one and five acres of land, the States will be required to process the NOIs, NOTs, and waiver certification form. For small MS4s, States will be required to process and review the NOI and report. Exhibit B–5–3 provides the estimated start-up costs and Exhibit B–5–4 presents the annual costs to the State government.

Exhibit B–5–3. Estimated State Start-up Costs (1998 dollars)

Phase II Program Element	Respondents Per Year[1]	Burden Hours per Respondent[2]	Hourly Labor Costs[3]	Estimated Cost[4]	Annual Cost Over Permit Period[5]
401 Certification	44	12	$26.87	$14,187	$2,837
State Revision Procedures[6]	44	100	$26.87	$118,228	$23,645
Designation of Additional MS4s	44	66.6	$26.87	$78,739	$15,748
TOTAL COSTS[7]				$211,154	$42,230

[1] The number of respondents represents the 44 NPDES-Authorized States and Territories.
[2] Burden hours per respondent were estimated by EPA.
[3] The hourly labor rate for NPDES Authorized States and Territories was based on the average hourly rate for state and municipal employees as determined by the US Department of Labor, Bureau of Labor Statistics, Employment Cost Indexes and Levels, 1975–1995, Bulletin 2466.
[4] Estimated cost is the product of the respondents per year, hours per respondent, and hourly labor costs.
[5] To determine annual costs over permit period, estimated cost is divided by five years.
[6] 40 CFR 123.62(b).
[7] Numbers may not total due to rounding.

Exhibit B–5–4. Estimated State Annual Costs (1998 dollars)

Phase II Program Element	Respondents Per Year[1]	Burden Hours per Respondent[2]	Hourly Labor Costs[3]	Estimated Cost[4]
Construction Program				
Waiver Cert. Processing & Review	17,845	1	$26.87	$479,495
NOI Processing & Review	101,119	1	$26.87	$2,717,068
NOT Processing	101,119	0.5	$26.87	$1,358,534
Small MS4 Program				
NOI Processing & Review	4,749	0.8	$26.87	$102,085
Report Processing & Review	4,749	1.6	$26.87	$204,169
Annual Total[5]				$4,861,350

[1] The number of respondents per year was based on the 1990 Bureau of Census data for small MS4s and 91.7% of total starts that are in NPDES states and territories in Exhibits B-2-3 and B-2-4 for construction.

[2] Burden hours per respondent were estimated by EPA.

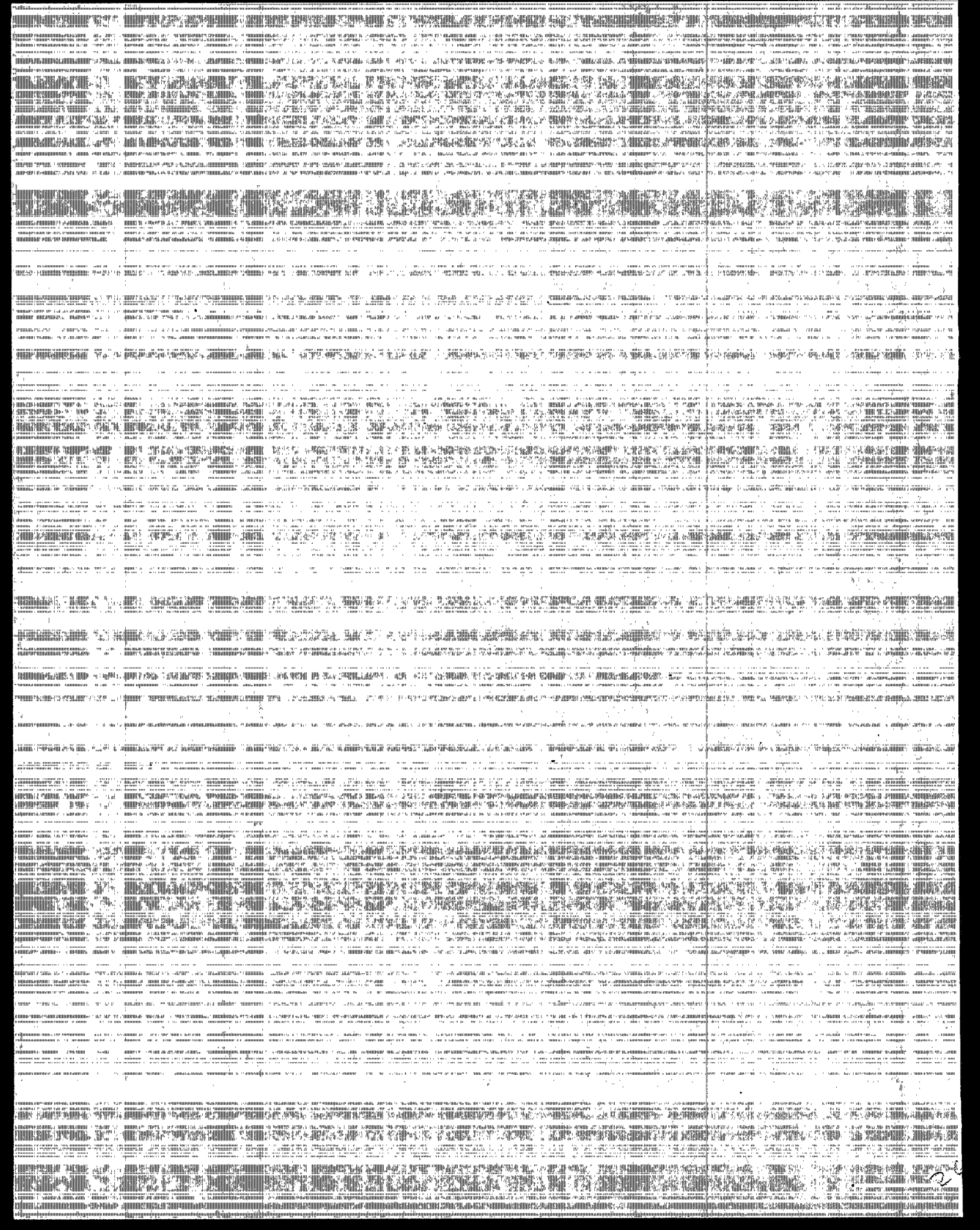
[3] The hourly labor rate for NPDES Authorized States and Territories was based on the average hourly rate for state and municipal employees as determined by the US Department of Labor, Bureau of Labor Statistics, Employment Cost Indexes and Levels, 1975-1995, Bulletin 2466.

[4] Estimated cost is the product of the respondents per year, hours per respondent, and hourly labor costs.

[5] Numbers may not total due to rounding.

Appendix C

Supplemental Benefits Calculations



APPENDIX C

EPA developed a three-step method for extrapolating the results of the Santa Monica Bay epidemiological study (Haile et al., 1996) to estimate the potential health impacts to swimmers in marine waters of the Phase II Storm Water Rule:

- estimate potential range of contamination concentrations at storm sewer drains in Phase II coastal communities
- estimate potential number of swimmers who swim near storm sewer drains in Phase II coastal communities
- estimate incremental illnesses using "attributable numbers" from the Santa Monica Bay study (Haile, et al., 1996).

Assuming that swimmers are not likely to swim near storm sewer drains during "wet weather" flows, the estimated number of incremental illnesses represents illnesses that occur during "dry weather" when low flows in storm sewers are caused by illicit connections and infiltration. By targeting the removal of such flows, the Phase II Storm Water rule should reduce the number of related illnesses among swimmers in marine waters.

Potential Range of Contamination Concentrations

The attributable numbers in the Santa Monica Bay study (Haile et al., 1996) depend on total coliform (TC) concentrations in marine waters near storm sewer drains. The concentration of total coliform (TC) in the vicinity of a storm sewer drain depends on the extent to which the waste water mixes with the receiving water body. The extent of mixing is site specific and depends on several parameters such as the location of the outfall, the type of outfall, and currents in the receiving water. All of these parameters can be grouped into one variable, the dilution ratio. The dilution ratio can be used as a measure of the level of mixing at the discharge point or at the vicinity of an ocean outfall.

Dilution ratios at coastal sewer drains vary greatly and are specific to each system. EPA does not have location information for the drains in coastal Phase II communities, much less location-specific dilution ratios. For a general analysis, EPA assumed that the dilution ratio varies from 100 to 1,000. This range of dilution ratios is representative of mixing conditions encountered at the vicinity of coastal sewer drains. A dilution ratio of 100 represents a low mixing level at the ocean outfall and is used to represent the high-end of expected TC concentrations. Similarly, the dilution ratio of 1,000 indicates a high level of mixing and is used to represent the low-end of TC concentrations. The die-off and transport of TC organisms is not incorporated in the estimation since the intent is to estimate the TC concentrations in the immediate vicinity of the discharge point. Such die-off and transport components are usually incorporated when estimating the TC concentration at various distances from the outfall.

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Combining these dilution ratios with an estimate of mean TC concentration in waste water, EPA obtained a range of TC concentrations at coastal sewer drains. EPA (1976) reports a mean TC concentration of 3.10^5/100 ml for the discharge from storm sewers and unsewered areas. The resulting concentration range at the outfall is 300 cfu/100 ml to 3000 cfu/100 ml. The low and high ends of this range fall on either side of the 1,000 cfu/100 ml cut point for the attributable numbers in the Santa Monica Bay study. This allowed EPA to use the low attributable numbers to characterize low health impacts and the high attributable numbers to characterize high health impacts.

Potential Number of Swimmers at Ocean Sewer Drains

In the second step in the analysis, EPA estimated the annual number of people who might be exposed to these concentrations as a result of swimming near these drains: The Section 6.2.2 on the benefits of enhanced marine recreational swimming estimated that approximately 166 million swimming days take place annually at Phase II beaches. Some fraction of these swimming trips will bring people within one yard of a storm sewer drain, which is the impact range for the attributable numbers this analysis used from the Santa Monica Bay study. EPA used the exposure rates from the Santa Monica Bay study to establish an upper bound of 7% (i.e., of the 11,686 people in the final sample, 827 swam within one yard of one of the three drains in the study areas). The resulting upper bound exposure estimate is 11.6 million swimmers per year. It is interesting to note that children appeared more likely than adults to swim near these drains; children made up 48% of the study sample, but they accounted for 62% of the subsample that swam within one yard of an outfall.

The 7% upper bound most likely overstates the percentage of people who swam within one yard of an outfall because it is based on the swimmers in the three study areas of the bay. EPA has no estimate of total swimming at the beaches, however, to adjust the figure. Furthermore, it is unknown how representative this percentage is of distribution of swimmers at Phase II beaches.

Incremental Number of Illnesses

A study of 13,278 swimmers at three public beaches in Santa Monica Bay found that people who swam within 100 yards of storm drains experienced increased incidences of gastrointestinal and respiratory diseases, and that illness rates were often highest among those who swam in the immediate vicinity of the storm drain (Haile et al., 1996). The increased incidence of illness was associated with swimming in areas where monitoring results showed high densities of bacterial indicators. The study identified illicit connections to storm sewer drains as possible sources of contamination.

The Santa Monica Bay study did not calculate specific dose-response curves for infection and symptomatic illness as a function of concentrations of the indicator microorganisms such as TC

or fecal coliforms (FC) that were detected in recreational waters because of the extensive variability in exposures and observed symptoms in bathers who were interviewed. Instead, the study presented incidence rates for symptoms that could be attributed to exposures to wastewater from three beach storm sewer drains under various conditions.

The study calculated these incidence rates, termed "attributable numbers," as the difference between the number of symptomatic cases resulting from exposure at the drains and the number of cases at the control distance of 400 yards down current from the drains. The study reported attributable numbers, which were normalized to expected numbers of illnesses per 10,000 exposures, for several exposure levels that were separated by observed TC concentration "cut points," including the following:

- total exposures at all TC concentrations;
- exposures when TC concentration was > 1,000 colony-forming units (cfu) /100 ml; and
- exposures when the TC concentration was > 5,000 cfu /100 ml.

The attributable numbers depended on the TC concentration and on the TC to fecal coliform (FC) ratio. Lower TC:FC ratios were assumed to represent higher relative rates of fecal contamination of the wastewater. Exposures at TC concentrations > 1,000 cfu/100 ml and with TC:FC ratios of five or less appeared to be more significant in causing disease symptoms than other exposures. The study presents attributable numbers for each type of health effect by TC:FC ratio. Exhibit C–1 summarizes low and high attributable numbers for five different TC:FC ratios. The low values shown in the exhibit correspond to attributable numbers for exposures when TC concentration is < 1,000 cfu/100 ml and the high values correspond to exposures when TC is > 1,000 cfu/100 ml. EPA used the low and high attributable numbers to reflect uncertainty about whether TC concentration rates from illicit sewer connections are likely to be above or below the 1,000 cfu/100 ml cut point. EPA averaged the attributable numbers across the TC:FC ratios reported in the exhibit to incorporate additional uncertainty about the level of contamination at storm sewer drains.

Exhibit C–1. Summary of Attributable Numbers by Reported Health Symptom, Total Coliform to Fecal Coliform Ratio, and Total Coliform Concentration (additional cases above background levels per 10,000 people exposed)

Symptom	TC/FC = 2		TC/FC = 4		TC/FC = 5		TC/FC = 6		TC/FC = 8		Average[1]	
	Low[2]	High[2]	Low	High	Low	High	Low	High	Low	High	Low	High
Fever	—	194	—	139	—	128	—	86	—	89	—	127
Chills	—	0	—	99	—	87	—	68	—	43	—	74
Nausea	—	65	—	180	—	152	—	151	—	137	—	137
Vomiting	—	140	—	90	—	71	—	68	—	38	—	81
Diarrhea	19	222	105	187	106	180	167	167	116	189	103	189
Cough	70	236	56	132	59	125	58	95	51	132	59	144
Cough+phlegm	—	165	—	40	—	36	—	34	—	24	—	60
Runny nose	—	492	—	141	—	163	—	105	—	170	—	214
Sore throat	63	247	67	121	77	93	73	104	58	128	68	139
HCGI 1[3]	—	167	—	96	—	83	—	55	—	42	—	89
HCGI 2[4]	0	117	28	110	28	104	19	99	48	79	31	102
SRD[5]	—	220	—	84	—	69	—	68	—	71	—	102

Notes:

[1] Simple average across five TC/FC ratios, except the high estimate for chills, which is an average over four ratios excluding a missing ratio for the TC/FC=2

case, and the low estimate for HCGI 2, which is an average over four rations excluding a missing ratio for the TC/FC=2 case.

[2] Low values correspond to TC concentrations of <1000 cfu/100 ml and high values correspond to TC concentrations of >1000 cfu/100 ml.

[3] Highly credible gastroenteritis one (HCGI 1) is defined as a person having either 1) vomiting, 2) diarrhea and fever, or 3) stomach pain and fever.

[4] Highly credible gastroenteritis two (HCGI 2) is defined as a person having vomiting and fever.

[5] Significant respiratory disease (SRD) is defined as a person having 1) fever and nasal congestion or 2) fever and sore throat and 3) cough with sputum.

Source: Haile et al. (1996)

Using the exposure assumption described above, EPA multiplied the number of annual exposures (divided by 10,000 to match the attributable number units, which are cases per 10,000 people) by the average low and high attributable numbers for each health symptom. For example, given the average high attributable number for nausea of 137 and the exposure estimate of 11.6 million, the health impact calculation is:

$$137 \times (11{,}640{,}000 / 10{,}000) \cong 159{,}500 \text{ additional cases of fever.}$$

Exhibit C–2 summarizes the potential increase in the number of illness symptoms for the exposure assumption and the high and low concentration assumptions (i.e., > 1000 cfu/100 ml and < 100 cfu/100 ml). This analytical method produces a wide range of potential cases for each symptom because the attributable numbers are based on a cut point rather than a smooth exposure function.

Exhibit C–2. Estimated Marine Health Impacts Associated with Contaminated Dry Weather Discharges from Storm Sewers in Phase II Coastal Communities by Symptom, Exposure Assumption, and Total Coliform Concentration

Symptom	Low Contamination (TC <1000 cfu/100 ml)	High Contamination (TC >1000 cfu/100 ml)
Fever	0	148,068
Chills	0	86,431
Nausea	0	159,475
Vomiting	0	94,754
Diarrhea	119,432	220,006
Cough	68,446	167,624
Cough+phlegm	0	69,610
Runny nose	0	249,340
Sore throat	78,690	161,338
HCGI 1[1]	0	103,135
HCGI 2[2]	35,795	118,501
SRD[3]	0	119,199

Notes:

[1] Highly credible gastroenteritis one (HCGI 1) is defined as a person having either 1) vomiting, 2) diarrhea and fever, or 3) stomach pain and fever.

[2] Highly credible gastroenteritis two (HCGI 2) is defined as a person having vomiting and fever.

[3] Significant respiratory disease (SRD) is defined as a person having 1) fever and nasal congestion or 2) fever and sore throat and 3) cough with sputum.

Because the health risk estimates were based on contamination cut points rather than a dose-response function, EPA could only estimate changes in health risks in instances where the rule is expected to completely remove a contamination source. Thus, the analysis is restricted to evaluating avoided health impacts caused by illicit connections and infiltration that generate contaminated sewer discharges during dry weather periods because the rule is expected to remove these contamination sources. As the Haile et al. (1996) study shows, contaminated flows during dry weather can lead to additional health risks, e.g., storm sewers discharge an average of 10–25 million gallons per day into Santa Monica Bay during the dry summer months, which is when the study was conducted.

Consequently, the health risk analysis was not able to assess avoided health impacts during wet weather events because some contaminated sewer flow will reach marine environments. The rule is expected to reduce the contamination levels in wet weather discharges from storm sewers in Phase II communities, but EPA is not able to estimate changes in health impacts because the method used can only distinguish between contamination levels above and below the 1000 cfu/100 ml cut point; i.e., changes in contamination levels above or below the cut point will not generate changes in symptoms using this approach. Consequently, if people are exposed to contaminants in wet weather discharges at Phase II beaches (i.e., if beaches are not closed to avoid potential health impacts), then there may be some additional health benefits associated with reducing pathogen contamination levels in wet weather flows that are not captured by the analysis.

The analysis also implicitly assumes that there are no instances when a person is swimming next to a storm sewer drain and there is no contaminated water coming from the drain. In the larger Phase II coastal communities, there may be a persistent flow from these drains even in dry weather. In smaller Phase II communities, however, there may be periods when there is no contaminated flow coming from the drain. Any adjustment to account for this situation would be necessarily arbitrary and should be conducted only for a sensitivity analysis. The one and a half order of magnitude range of the current exposure assumption is wide enough to potentially account for this additional source of uncertainty.

Appendix D

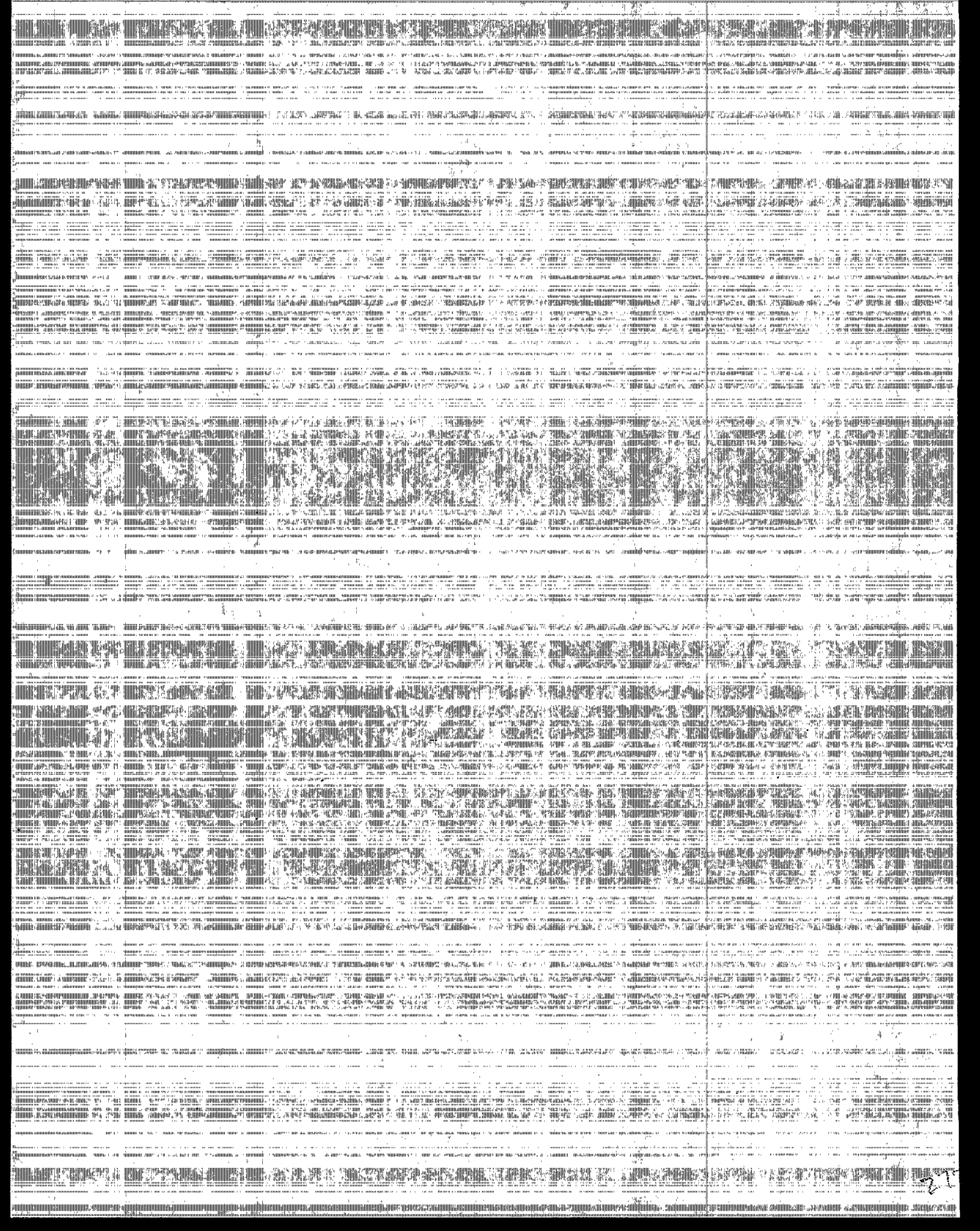
Data Associated with the Phase II No Exposure Provision

Appendix D–1 No-Exposure Certification Form

Appendix D–2–1 Unit Monitoring Costs by Industrial Subsector

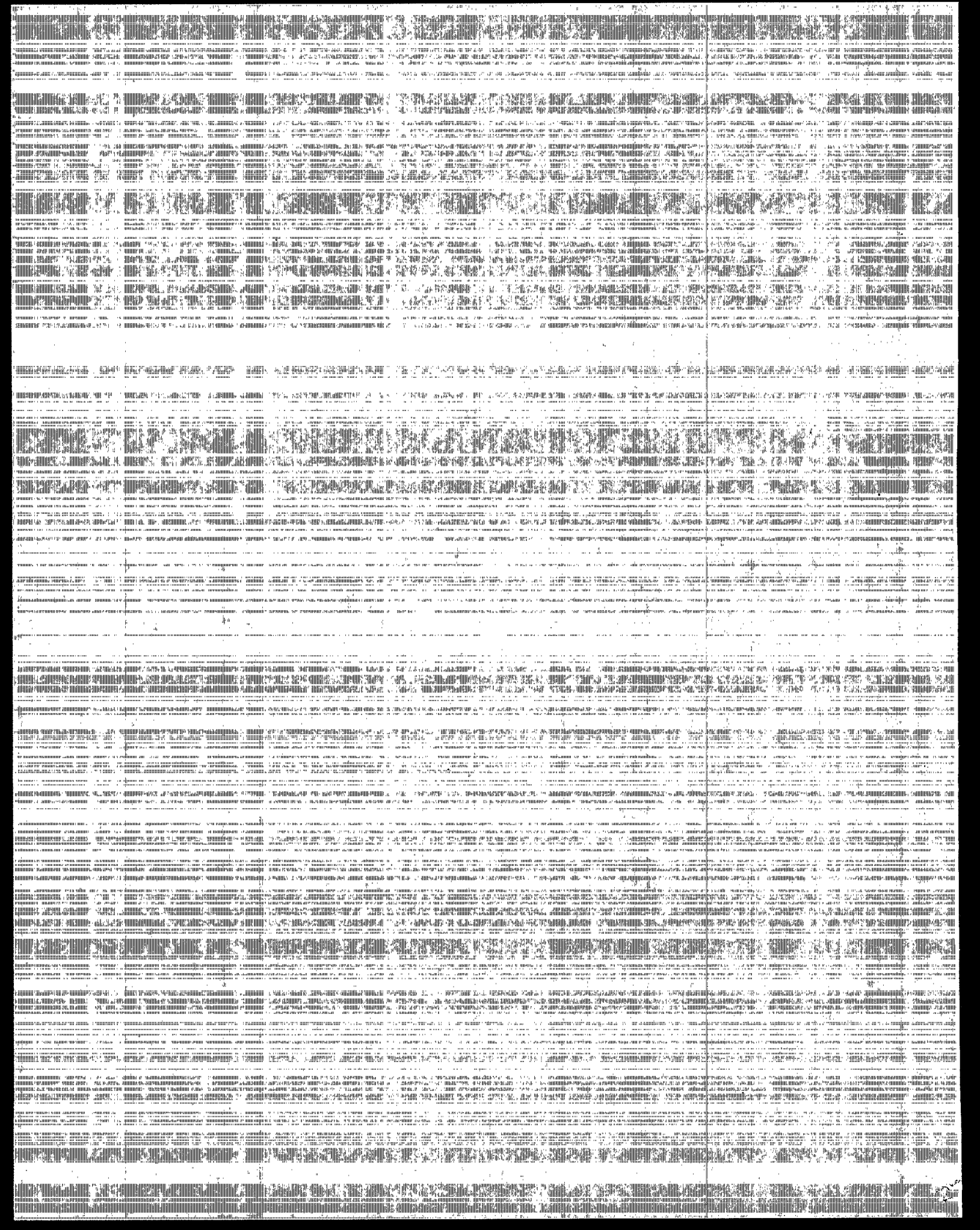
Appendix D–2–2 Analytical Monitoring by Industrial Subsector

Appendix D–2–3 Projected Cost Savings by Industrial Sector



Appendix D–1

No-Exposure Certification Form



NPDES FORM 3510-11 (5-99)

United States Environmental Protection Agency
Washington, DC 20460

OMB No. XXXXXX

NO EXPOSURE CERTIFICATION for Exclusion from NPDES Storm Water Permitting

Submission of this No Exposure Certification constitutes notice that the entity identified in Section A does not require permit authorization for its storm water discharge associated with industrial activity in the State identified in Section B under EPA's NPDES Storm Water Multi-Sector General Permit due to the existence of a condition of no exposure. A No Exposure Certification must be provided for each industrial facility or site qualifying for the no exposure exclusion. Obtaining the no exposure exclusion obligates the discharger to comply with the terms and conditions of 40 CFR 122.26(g). ALL INFORMATION MUST BE PROVIDED ON THIS FORM. PLEASE READ AND MAKE SURE YOU COMPLY WITH ALL REGULATORY REQUIREMENTS.

A. Facility Operator Information

1. Name: 2. Phone:
3. Mailing Address: a. Street:
b. City: c. State: d. Zip Code:

B. Facility/Site Location Information

1. Facility Name:
2. a. Street Address:
b. City: c. County:
d. State: e. Zip Code:
3. Is the facility located on Indian Lands? Yes ☐ No ☐
4. Is this a Federal Facility? Yes ☐ No ☐
5. a. Latitude: ° ' " b. Longitude: ° ' "
6. Total size of site associated with industrial activity: _____ acres
7. a. Was the facility or site previously covered under an NPDES storm water permit? Yes ☐ No ☐
b. If yes, enter NPDES permit number: _____
8. SIC/Activity Codes: Primary: Secondary (if applicable):
9. a. Have you paved or roofed over a large, formerly exposed, pervious area in order to qualify for no exposure? Yes ☐ No ☐
b. If yes, please indicate approximately how much area was paved or roofed over (completing this question does not influence your qualifying for the no exposure exclusion and is for informational purposes):
Less than one acre ☐ One to five acres ☐ More than five acres ☐

C. Exposure Checklist

Are any of the following materials or activities exposed to precipitation, now or in the foreseeable future? (Please check either "Yes" or "No" in the appropriate box.)

	Yes	No
1. Using, storing or cleaning industrial machinery or equipment, and areas where residuals from using, storing or cleaning industrial machinery or equipment remain and are exposed to storm water	☐	☐
2. Materials or residuals on the ground or in storm water inlets from spills/leaks	☐	☐
3. Materials or products from past industrial activity	☐	☐
4. Material handling equipment (except adequately maintained vehicles)	☐	☐
5. Materials or products during loading/unloading or transporting activities	☐	☐
6. Materials or products stored outdoors (except final products intended for outside use [e.g., new cars] where exposure to storm water does not result in the discharge of pollutants)	☐	☐
7. Materials contained in open, deteriorated or leaking storage drums, barrels, tanks, and similar containers	☐	☐

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NPDES FORM 3510-11

EPA

NO EXPOSURE CERTIFICATION for Exclusion from NPDES Storm Water Permitting

OMB No. XXXXXX

C. Exposure Checklist (continued)

	Yes	No
8. Materials or products handled/stored on roads or railways owned or maintained by the discharger	☐	☐
9. Waste material (except waste in covered, non-leaking containers [e.g., dumpsters])	☐	☐
10. Application or disposal of process wastewater (unless otherwise permitted)	☐	☐
11. Particulate matter or visible deposits of residuals from roof stacks and/or vents not otherwise regulated (i.e., under an air quality control permit) and in quantities detectable in the storm water outflow.	☐	☐

D. Certification Statement

I certify under penalty of law that I have read and understand the eligibility requirements for claiming a condition of no exposure and obtaining an exclusion from NPDES storm water permitting.

I certify under penalty of law that there are no discharges of storm water contaminated by exposure to industrial activities or materials from the industrial facility or site identified in this document (except as allowed under 40 CFR 122.26(g)(2)).

I understand that I am obligated to submit a no exposure certification form once every five years to the NPDES permitting authority and, if requested, to the operator of the local municipal separate storm sewer system (MS4) into which the facility discharges (where applicable). I understand that I must allow the NPDES permitting authority, or operator where the discharge is into the local MS4, to perform inspections to confirm the condition of no exposure and to make such inspection reports publicly available upon request. I understand that I must obtain coverage under an NPDES storm water permit prior to any point-source discharge of exposed storm water from the facility.

Additionally, I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is to the best of my knowledge and belief true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Print Name: _____

Print Title: _____

Signature: _____ Date: _____

Instructions for the NO EXPOSURE CERTIFICATION for Exclusion from NPDES Storm Water Permitting

Who May File a No Exposure Certification

Federal law at 40 CFR Part 122 prohibits point source discharges of storm water associated with industrial activity to waters of the U.S. without a National Pollutant Discharge Elimination System (NPDES) permit. However, NPDES permit coverage is not required for discharges of storm water associated with industrial activity if the discharger can certify that a condition of "no exposure" exists at the industrial facility or site.

Storm water discharges from facilities identified in 40 CFR 122.26(b)(14)(x) and (b)(15)(i), as well as sources designated under 40 CFR 122.26(a)(1)(v), (a)(9)(i)(B),(C),(D) and (b)(15)(ii) are not eligible for the no exposure exclusion. Also, the exclusion from NPDES permitting is available on a facility-wide basis only, not for individual outfalls.

This document may be used to certify that at the industrial facility or site described herein, a condition of no exposure exists. This certification is under the auspices of the EPA only and must be made at least once every five years. Should the industrial facility or site change such that a condition of no exposure no longer exists, this certification is no longer valid and coverage under an NPDES storm water permit must be obtained immediately.

Where to File the No Exposure Certification Form

Mail the completed no exposure certification form to:

Storm Water No Exposure Certification (4203)
USEPA
401 M Street, SW
Washington, D.C. 20460

Completing the Form

OBTAIN AND READ THE NO EXPOSURE EXCLUSION PROVISION AT 40 CFR 122.26(g). You must type or print, using uppercase letters, in appropriate areas only. Enter only one character per space (i.e., between the marks). Abbreviate if necessary to stay within the number of characters allowed for each item. Use one space for breaks between words, but not for punctuation marks unless they are needed to clarify your response. One form must be completed for each facility or site for which you are seeking to certify a condition of no exposure. If you have any questions concerning this form, call EPA's Storm Water Hotline at (800) 245-6510. Please make sure you have addressed all applicable questions and have made a photocopy for your records before sending the completed form to the above address.

Definition of No Exposure

A condition of no exposure exists at an industrial facility when all industrial materials and activities are protected by a storm resistant shelter to prevent exposure to rain, snow, snowmelt, and/or runoff. Industrial materials or activities include, but are not limited to, material handling equipment or activities, industrial machinery, raw materials, intermediate products, by-products, final products, or waste products. Material handling activities include the storage, loading and unloading, transportation, or conveyance of any raw material, intermediate product, final product or waste product. The following are allowed to be exposed to precipitation or runoff: drums, barrels, tanks, and similar containers that are sealed and have not been opened (provided those containers are not deteriorated and do not leak); adequately maintained vehicles used in material handling; and final products, other than products that would be mobilized in storm water discharge (e.g., rock salt).

NPDES FORM 3510-11	EPA	NO EXPOSURE CERTIFICATION for Exclusion from NPDES Storm Water Permitting	OMB No. XXXXXX

Section A. Facility Operator Information

1. Provide the legal name of the person, firm, public organization, or any other entity that operates the facility or site described in this certification. Do not use a colloquial name. The name of the operator may or may not be the same as the name of the facility. The operator is the legal entity that controls the facility's operation, rather than the plant or site manager.

2. Provide the telephone number of the operator.

3. Provide the mailing address of the operator (P.O. Box numbers may be used). Include the city, state, and zip code. All correspondence will be sent to this address.

Section B. Facility/Site Location Information

1. Enter the official or legal name of the facility or site.

2. Enter the complete street address (if no street address exists, provide a geographic description [e.g., intersection of Routes 9 and 55]), city, county, state, and zip code. Do not use a P.O. Box number.

3. Indicate whether the facility is located on Indian Lands.

4. Indicate whether the industrial facility is operated by a Department or Agency of the Federal Government (see also Section 313 of the Clean Water Act).

5. Enter the latitude and longitude of the approximate center of the facility or site in degrees/minutes/seconds. Latitude and longitude can be obtained from USGS quadrangle or topographic maps, by calling (800) USA-MAPS, or by accessing the U.S. Bureau of the Census' web page at www.census.gov/cgi-bin/gazetteer.

   Latitude and longitude for a facility in decimal form must be converted to degrees (°), minutes ('), and seconds (") for proper entry on the certification form. To convert decimal latitude or longitude to degrees/minutes/seconds, follow the steps in the following example.

   Example: Convert decimal latitude 45.1234567 to degrees (°), minutes ('), and seconds (").

   a) The numbers to the left of the decimal point are the degrees: 45°.

   b) To obtain minutes, multiply the first four numbers to the right of the decimal point by 0.006: 1234 x 0.006 = 7.404.

   c) The numbers to the left of the decimal point in the result obtained in (b) are the minutes: 7'.

   d) To obtain seconds, multiply the remaining three numbers to the right of the decimal from the result obtained in (b) by 0.06: 404 x 0.06 = 24.24. Since the numbers to the right of the decimal point are not used, the result is 24".

   e) The conversion for 45.1234567 = 45° 7' 24".

6. Enter the total size of the site associated with industrial activity in acres. Acreage may be determined by dividing square footage by 43,560, as demonstrated in the following example.

   Example: Convert 54,450 ft^2 to acres

   Divide 54,450 ft^2 by 43,560 square feet per acre:
   54,450 ft^2 ÷ 43,560 ft^2/acre = 1.25 acres.

7. Indicate whether the facility was previously covered under an NPDES storm water permit. If so, include the permit number.

8. Enter the 4-digit SIC code which identifies the facility's primary activity, and second 4-digit code identifying the facility's secondary activity, if applicable. SIC codes can be obtained from the Standard Industrial Classification Manual, 1987.

9. Check "Yes" or "No" as appropriate to indicate whether you have paved or roofed over a large, formerly exposed pervious area (i.e., lawn, meadow, dirt or gravel road/parking lot) in order to qualify for no exposer. If yes, also indicate approximately how much area was paved or roofed over and is now impervious area.

Section C. Exposure Checklist

Check "Yes" or "No" as appropriate to describe the exposure conditions at your facility. If you answer "Yes" to **ANY** of the questions (1) through (11) in this section, a potential for exposure exists at your site and you cannot certify to a condition of no exposure. You must obtain (or already have) coverage under an NPDES storm water permit. After obtaining permit coverage, you can institute modifications to eliminate the potental for a discharge of storm water exposed to industrial activity, and then certify to a condition of no exposure.

Section D. Certification Statement

Federal statutes provide for severe penalties for submitting false information on this application form. Federal regulations require this application to be signed as follows:

For a corporation: by a responsible corporate officer, which means:

(i) president, secretary, treasurer, or vice-president of the corporation in charge of a principal business function, or any other person who performs similar policy or decision making functions for the corporation, or

(ii) the manager of one or more manufacturing, production, or operating facilities employing more than 250 persons or having gross annual sales or expenditures exceeding $25 million (in second-quarter 1980 dollars), if authority to sign documents has been assigned or delegated to the manager in accordance with corporate procedures **[Note: wording subject to change as a result of NPDES streamlining, rnd. II]**;

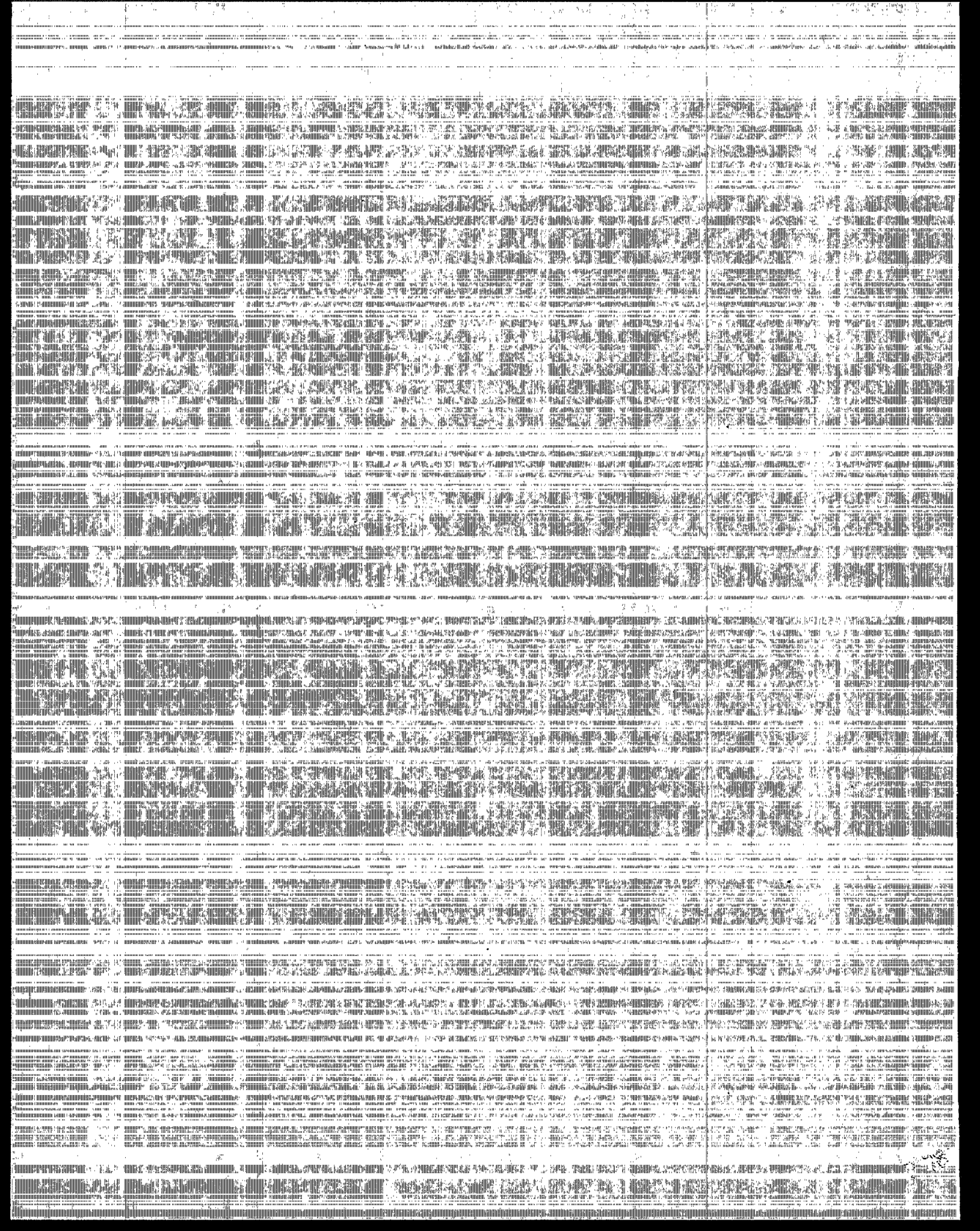
For a partnership or sole proprietorship: by a general partner or the proprietor; or

For a municipal, State, Federal, or other public facility: by either a principal executive or ranking elected official.

Paperwork Reduction Act Notice

Public reporting burden for this certification is estimated to average 0.75 hours per certification, including time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding the burden estimate, any other aspect of the collection of information, or suggestions for improving this form, including any suggestions which may increase or reduce this burden to: Director, OPPE Regulatory Information Division (2137), USEPA, 401 M Street, SW, Washington, D.C. 20460. Include the OMB control number of this form on any correspondence. Do not send the completed No Exposure Certification form to this address.

EPA Form 3510-11 Page 3 of 3



Appendix D–2–1

Estimated Unit Monitoring Costs for Multi-Sector

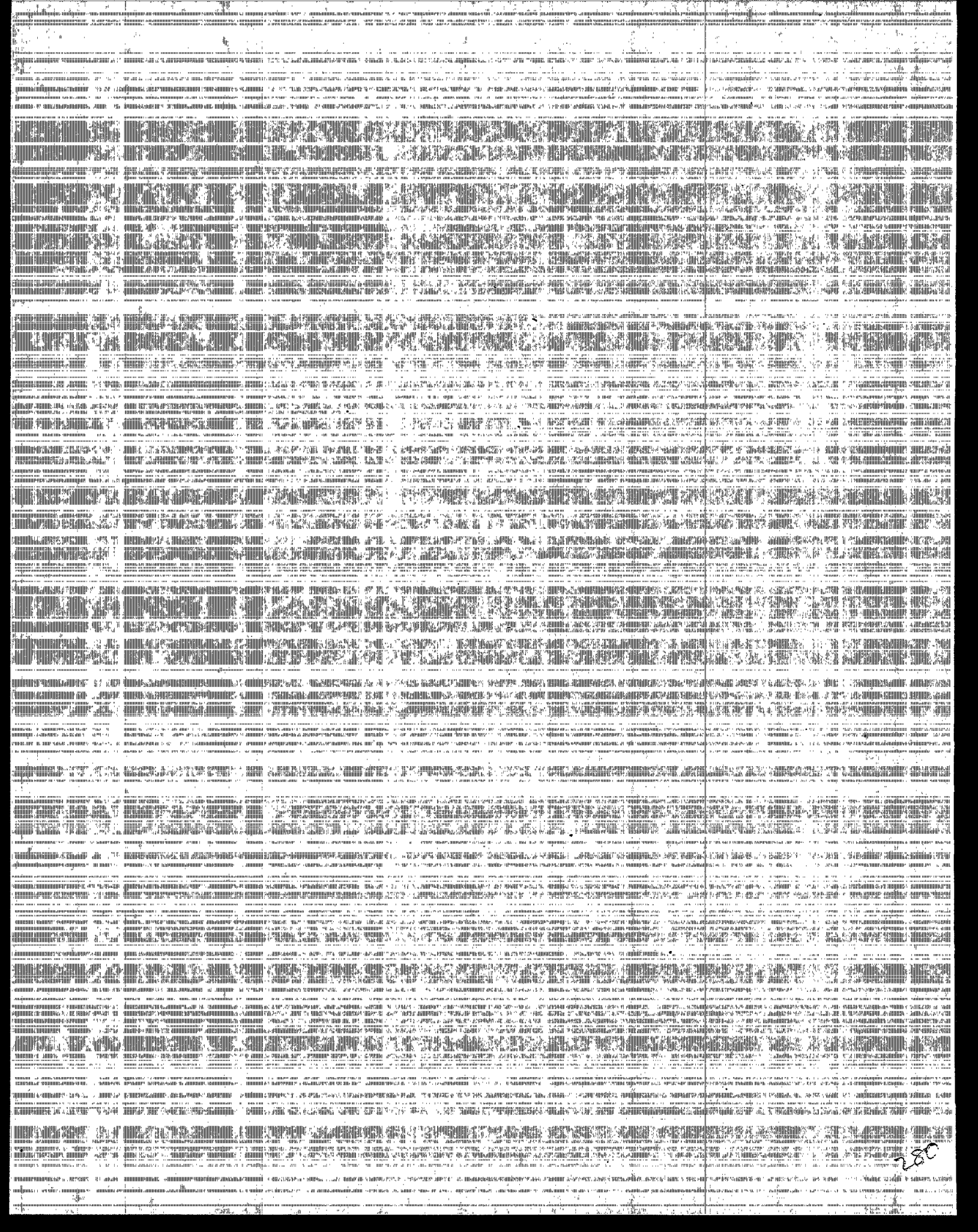


Exhibit D-2-1. Estimated Unit Monitoring Costs for Multi-Sector Permittees, in 1998 dollars

Parameter	Mean	Parameter	Mean
Aluminum	$14.22	Organic Nitrogen	$15.23
Antimony	$13.20	Palladium	$14.22
Arsenic	$13.20	PCBs	$73.63
Barium	$14.22	Pesticides	$109.17
Beryllium	$11.56	pH	$6.09
Biological Oxygen Demand	$25.39	Platinum	$14.22
Bismuth	$14.22	Potassium	$14.22
Boron	$14.22	Selenium	$13.20
Cadmium	$11.56	Semivolatiles	$317.36
Calcium	$14.22	Silicon	$14.22
Chemical Oxygen Demand	$25.39	Silver	$13.20
Chromium	$11.56	Sodium	$14.22
Cobalt	$14.22	Thallium	$11.56
Copper	$11.56	Tin	$14.22
Dissolved Phosphorus	$10.16	Total Ammonia	$22.01
Fecal Coliform	$15.91	Total Dissolved Solids	$8.46
Fecal Streptococcus	$15.23	Total Kjeldahl Nitrogen	$13.54
Iron	$14.22	Total Phosphorus	$9.65
Lead	$11.56	Total Suspended Solids	$8.46
Lithium	$14.22	Vanadium	$14.22
Magnesium	$14.22	Volatiles	$137.10
Manganese	$14.22	Zirconium	$14.22
Mercury	$19.80	Zinc	$11.56
Molybdenum	$14.22	Total Cyanide	$28.10
Nickel	$11.56	Total Phenols	$29.45
Nitrate/Nitrite	$10.16		
Oil & Grease	$32.16		

Note:
These values represent the mean values from four vendors of monitoring supplies and services. Some of the vendors have requested that the data remain confidential and others have their data on the World Wide Web.

Appendix D–2–2

Analytical Monitoring Costs by Multi-Sector Subsector

Exhibit D-2-2. Analytical Monitoring Costs by Multi-Sector Subsector

Subsector	Name	Monitoring Parameters	Average Analytical Costs per Outfall	Sample Collection Costs	Number of Monitoring Events in Permit	Number of Outfalls	Estimated Total Cost (5 yrs)	Estimated Annual Cost
Sector A. Timber Products								
1	General Sawmills and Planning Mills	COD, TSS, Zinc	$45	$22	8	4	$2,129	$426
2	Wood Preserving	Arsenic, Copper	$24	$22	8	4	$1,479	$296
3	Log Storage & Handling	TSS	$8	$22	8	4	$965	$193
4	Hardwood Dimension and Flooring Mills	COD, TSS	$33	$22	8	4	$1,765	$353
4	Special Product Sawmills, NEC	COD, TSS	$33	$22	8	4	$1,765	$353
4	Millwork, Veneer, Plywood	COD, TSS	$33	$22	8	4	$1,765	$353
4	Wood Containers	COD, TSS	$33	$22	8	4	$1,765	$353
4	Wood Buildings and Mobile Homes	COD, TSS	$33	$22	8	4	$1,765	$353
4	Reconstituted Wood Products	COD, TSS	$33	$22	8	4	$1,765	$353
4	Wood Products, NEC	COD, TSS	$33	$22	8	4	$1,765	$353
Sector B. Paper and Allied Products Manufacturing								
1	Pulp Mills	None	NA	NA	NA	NA	NA	NA
2	Paper Mills	None	NA	NA	NA	NA	NA	NA
3	Paperboard Mills	COD	$25	$22	8	4	$1,499	$300
4	Paperboard Containers and Boxes	None	NA	NA	NA	NA	NA	NA
5	Converted Paper and Paperboard Products	None	NA	NA	NA	NA	NA	NA
Sector C. Chemical and Allied Products Manufacturing								
1	Industrial Inorganic Chemicals	Aluminum, Iron, Nitrate + Nitrite	$38	$22	8	4	$1,915	$383
2	Plastics Materials and Synthetic Resins	Zinc	$11	$22	8	4	$1,063	$213
3	Drugs	None	NA	NA	NA	NA	NA	NA
4	Soaps, Detergents, and Cleaning Preparations	Nitrate + Nitrite, Zinc	$21	$22	8	4	$1,383	$277
5	Paints, Varnishes, Lacquers, Enamels, and Allied Products	None	NA	NA	NA	NA	NA	NA
6	Industrial Organic Chemicals	None	NA	NA	NA	NA	NA	NA
7	Agricultural Chemicals	Nitrate + Nitrite, Lead, Iron, Zinc, Phosphorus	$56	$22	8	4	$2,499	$500
8	Miscellaneous Chemical Products	None	NA	NA	NA	NA	NA	NA

Exhibit D-2-2 Analytical Monitoring Costs by Multi-Sector Subsector (Continued)

Subsector	Name	Monitoring Parameters	Average Analytical Costs per Outfall	Sample Collection Costs	Number of Monitoring Events In Permit	Number of Outfalls	Estimated Total Cost (5 yrs)	Estimated Annual Cost
Sector E. Glass, Clay, Cement, Concrete, and Gypsum Product Manufacturing								
1	Flat Glass	None	NA	NA	NA	NA	NA	NA
1	Glass and Glassware, Pressed or Blown	None	NA	NA	NA	NA	NA	NA
1	Glass Products Made of Purchased Glass	None	NA	NA	NA	NA	NA	NA
1	Cut stone and stone products	None	NA	NA	NA	NA	NA	NA
1	Abrasive Products	None	NA	NA	NA	NA	NA	NA
1	Asbestos Products, Tiles, Building Materials	None	NA	NA	NA	NA	NA	NA
1	Mineral Wool, Insulation	None	NA	NA	NA	NA	NA	NA
1	Nonmetallic Mineral Products, NEC	None	NA	NA	NA	NA	NA	NA
2	Hydraulic Cement	None	NA	NA	NA	NA	NA	NA
3	Structural Clay Products	Aluminum	$14	$22	8	4	$1,147	$229
3	Pottery and Related Products	Aluminum	$14	$22	8	4	$1,147	$229
3	Non-Clay Refractories	Aluminum	$14	$22	8	4	$1,147	$229
4	Concrete, Gypsum, and Plaster Products	TSS, Iron	$22	$22	8	4	$1,413	$283
4	Minerals and Earths, Ground or Otherwise Treated	TSS, Iron	$22	$22	8	4	$1,413	$283
Sector F. Primary Metals								
1	Steel Works	Aluminum, Zinc	$25	$22	8	4	$1,511	$302
2	Iron & Steel Foundries	Aluminum, TSS, Copper, Iron, Zinc	$59	$22	8	4	$2,589	$518
3	Primary Smelting and Refining of Nonferrous Metals	None	NA	NA	NA	NA	NA	NA
4	Secondary Smelting and Refining of Nonferrous Metals	None	NA	NA	NA	NA	NA	NA
5	Rolling, Drawing & Extruding - Nonferrous	Copper, Zinc	$23	$22	8	4	$1,427	$285
6	Non-ferrous Foundries	Copper, Zinc	$23	$22	8	4	$1,427	$285
7	Miscellaneous Primary Metal Products	None	NA	NA	NA	NA	NA	NA

Exhibit D-2-2 Analytical Monitoring Costs by Multi-Sector Subsector (Continued)

Subsector	Name	Monitoring Parameters	Average Analytical Costs per Outfall	Sample Collection Costs	Number of Monitoring Events In Permit	Number of Outfalls	Estimated Total Cost (5 yrs)	Estimated Annual Cost
Sector G. Metal Mining (Ore Mining and Dressing) Except Inactive Metal Mining Activities on Federal Lands								
1	Iron Ores	None	NA	NA	NA	NA	NA	NA
2	Copper Ores	COD, TSS, Nitrate + Nitrite	$43	$22	8	4	$2,085	$417
3	Lead and Zinc Ores	None	NA	NA	NA	NA	NA	NA
4	Gold and Silver Ores	None	NA	NA	NA	NA	NA	NA
5	Ferroalloy Ores, Except Vanadium	None	NA	NA	NA	NA	NA	NA
6	Metal Mining Services	None	NA	NA	NA	NA	NA	NA
7	Miscellaneous Metal Ores	None	NA	NA	NA	NA	NA	NA
Sector H. Coal Mines and Coal Mining Related Facilities								
1	Coal Mines and Coal Mining Related Facilities	Aluminum, Iron, TSS	$36	$22	8	4	$1,861	$372
Sector I. Oil and Gas Extraction								
1	Crude Petroleum and Natural Gas	None	NA	NA	NA	NA	NA	NA
2	Natural Gas Liquids	None	NA	NA	NA	NA	NA	NA
3	Oil and Gas Field Services	None	NA	NA	NA	NA	NA	NA
4	Petroleum Refining	None	NA	NA	NA	NA	NA	NA
Sector J. Mineral Mining and Dressing Except Inactive Mineral Mining Activities on Federal Lands								
1	Dimension Stone	TSS	$8	$22	8	4	$965	$193
1	Crushed and Broken Stone, Including Rip Rap	TSS	$8	$22	8	4	$965	$193
1	Nonmetallic Minerals, Except Fuels	TSS	$8	$22	8	4	$965	$193
2	Sand and Gravel	TSS, Nitrate + Nitrite	$18	$22	8	4	$1,285	$257
3	Clay, Ceramic, and Refractory Minerals	None	NA	NA	NA	NA	NA	NA
4	Chemical and Fertilizer Mineral Mining	None	NA	NA	NA	NA	NA	NA
Sector K. Hazardous Waste Treatment Storage or Disposal Facilities								
1	Hazardous Waste Treatment, Storage or Disposal	Ammonia, Magnesium, COD, Arsenic, Cadmium, Cyanide, Lead, Mercury, Selenium, Silver	$170	$22	8	4	$6,125	$1,225

Exhibit D-2-2 Analytical Monitoring Costs by Multi-Sector Subsector (Continued)

Subsector	Name	Monitoring Parameters	Average Analytical Costs per Outfall	Sample Collection Costs	Number of Monitoring Events in Permit	Number of Outfalls	Estimated Total Cost (5 yrs)	Estimated Annual Cost
Sector L. Landfills and Land Application Sites								
1	Landfills and Application Sites	TSS, Iron	$22	$22	8	4	$1,413	$283
1	Open Dumps	TSS, Iron	$22	$22	8	4	$1,413	$283
Sector M. Automobile Salvage Yards								
1	Automobile Salvage Yards	TSS, Aluminum, Iron, Lead	$48	$22	8	4	$2,225	$445
Sector N. Scrap Recycling Facilities								
1	Scrap Recycling and Waste Recycling Facilities	COD, TSS, Aluminum, Copper, Iron, Lead, Zinc	$95	$22	8	4	$3,753	$751
Sector O. Steam Electric Generating Facilities								
1	Steam Electric Generating Facilities	Iron	$14	$22	8	4	$1,147	$229
Sector P. Land Transportation Facilities with Vehicle Maintenance or Cleaning Operations								
1	Railroad Transportation	None	NA	NA	NA	NA	NA	NA
2	Local and Highway Passenger Transportation	None	NA	NA	NA	NA	NA	NA
3	Motor Freight and Warehousing	None	NA	NA	NA	NA	NA	NA
4	US. Postal Service	None	NA	NA	NA	NA	NA	NA
5	Petroleum Bulk Stations	None	NA	NA	NA	NA	NA	NA
Sector Q. Water Transportation Facilities with Vehicle Maintenance or Cleaning Operations								
1	Water Transportation	Aluminum, Iron, Lead, Zinc	$51	$22	8	4	$2,323	$465
Sector R. Ship of Boat Building or Repairing Yards								
1	Ship or Boat Building or Repairing Yards	None	NA	NA	NA	NA	NA	NA
Sector S. Air Transportation Facilities								
1	Air Transportation	BOD, COD, Ammonia, pH	$78	$22	8	4	$3,184	$637
Sector T. Treatment Works								
1	Treatment Works	None	NA	NA	NA	NA	NA	NA

Exhibit D-2-2 Analytical Monitoring Costs by Multi-Sector Subsector (Continued)

Subsector	Name	Monitoring Parameters	Average Analytical Costs per Outfall	Sample Collection Costs	Number of Monitoring Events in Permit	Number of Outfalls	Estimated Total Cost (5 yrs)	Estimated Annual Cost
Sector U. Food and Kindred Products								
1	Meat Products	None	NA	NA	NA	NA	NA	NA
2	Dairy Products	None	NA	NA	NA	NA	NA	NA
3	Canned, Frozen & Preserved Fruits	None	NA	NA	NA	NA	NA	NA
4	Grain Mill Products	TSS	$8	$22	8	4	$965	$193
5	Bakery Products	None	NA	NA	NA	NA	NA	NA
6	Sugar and Confectionery Products	None	NA	NA	NA	NA	NA	NA
7	Fat and Oils Products	BOD, COD, Nitrate + Nitrite, TSS	$68	$22	8	4	$2,885	$577
8	Beverage Facilities	None	NA	NA	NA	NA	NA	NA
9	Miscellaneous	None	NA	NA	NA	NA	NA	NA
10	Tobacco Products	None	NA	NA	NA	NA	NA	NA
Sector V. Textile Mills, Apparel, and Other Fabric Product Manufacturing								
1	Textile Mill Products	None	NA	NA	NA	NA	NA	NA
2	Apparel and Other Finished Products	None	NA	NA	NA	NA	NA	NA
3	Boot and Shoe Cut Stock and Findings	None	NA	NA	NA	NA	NA	NA
3	Footwear except rubber	None	NA	NA	NA	NA	NA	NA
3	Leather Gloves and Mittens	None	NA	NA	NA	NA	NA	NA
3	Luggage and Cases	None	NA	NA	NA	NA	NA	NA
3	Handbags and Other Personal Leather Goods	None	NA	NA	NA	NA	NA	NA
3	Leather Goods NEC	None	NA	NA	NA	NA	NA	NA
Sector W. Furniture and Fixtures								
1	Furniture and Fixtures	None	NA	NA	NA	NA	NA	NA
2	Wood Kitchen Cabinets	None	NA	NA	NA	NA	NA	NA
Sector X. Printing and Publishing								
1	Printing and Publishing	None	NA	NA	NA	NA	NA	NA

Exhibit D-2-2 Analytical Monitoring Costs by Multi-Sector Subsector (Continued)

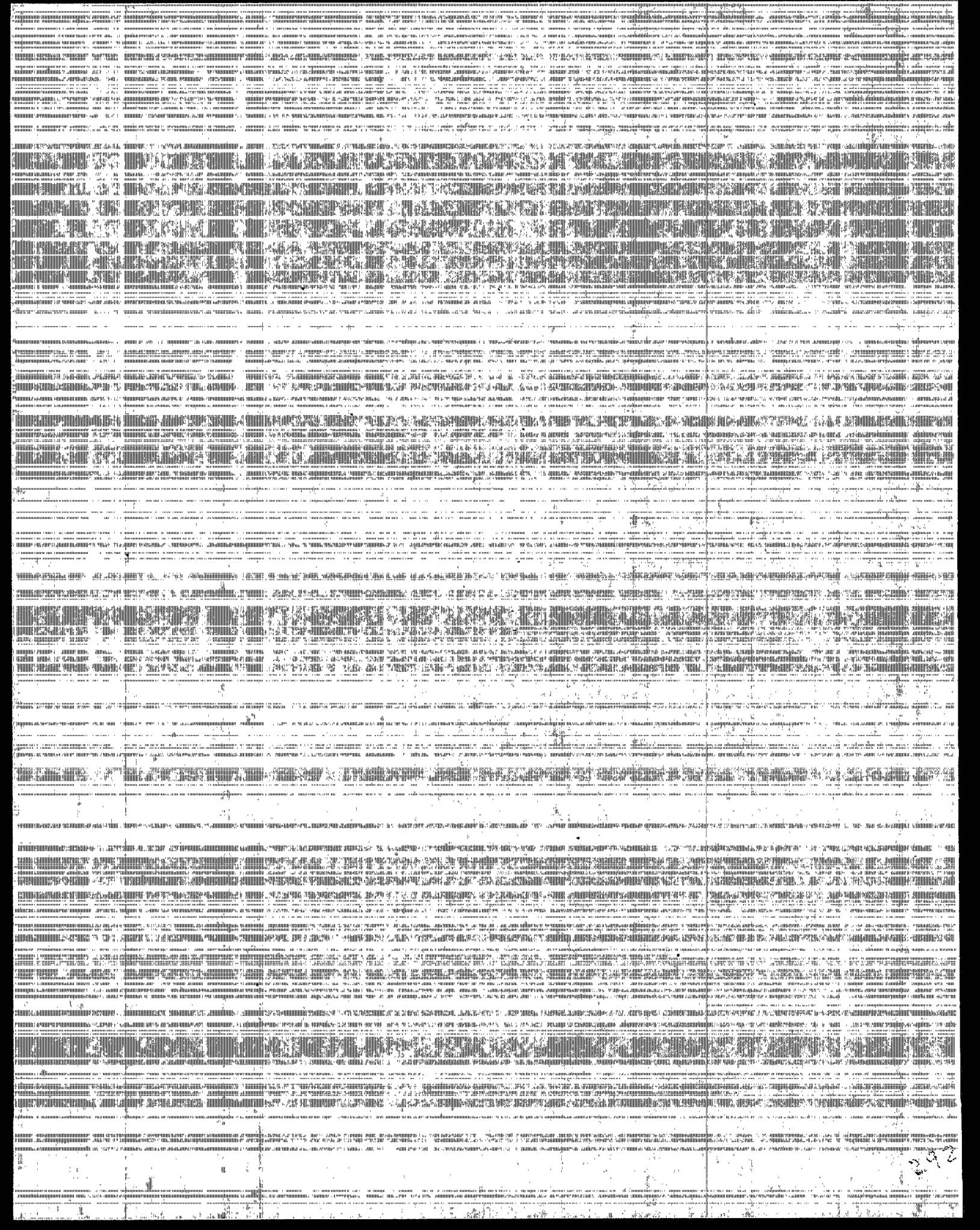
Subsector	Name	Monitoring Parameters	Average Analytical Costs per Outfall	Sample Collection Costs	Number of Monitoring Events in Permit	Number of Outfalls	Estimated Total Cost (5 yrs)	Estimated Annual Cost
Sector Y. Rubber, Miscellaneous Plastic Products, and Miscellaneous Manufacturing Industries								
1	Tires and Inner Tubes	Zinc	$11	$22	8	4	$1,063	$213
1	Rubber and Plastics Footwear	Zinc	$11	$22	8	4	$1,063	$213
1	Gaskets, Packing, and Sealing Devices	Zinc	$11	$22	8	4	$1,063	$213
1	Fabricated Rubber Products, NEC	Zinc	$11	$22	8	4	$1,063	$213
2	Miscellaneous Rubber Products	None	NA	NA	NA	NA	NA	NA
2	Musical Instruments	None	NA	NA	NA	NA	NA	NA
2	Dolls, Toys, Games and Sporting and Athletic Goods	None	NA	NA	NA	NA	NA	NA
2	Pens, Pencils, and Other Artist's Materials	None	NA	NA	NA	NA	NA	NA
2	Costume Jewelry, Costume Novelties, Buttons, etc.	None	NA	NA	NA	NA	NA	NA
2	Miscellaneous Manufacturing Industries	None	NA	NA	NA	NA	NA	NA
Sector Z. Leather Tanning and Finishing								
1	Leather Tanning and Finishing	None	NA	NA	NA	NA	NA	NA
Sector AA. Fabricated Metal Products								
1	Cutlery, Handtools, and General Hardware	Iron, Zinc, Aluminum, Nitrate + Nitrite	$49	$22	8	4	$2,279	$456
1	Fabricated Structural Metal Products	Iron, Zinc, Aluminum, Nitrate + Nitrite	$49	$22	8	4	$2,279	$456
1	Screw Machine Products, and Bolts, Nuts, Screws, etc.	Iron, Zinc, Aluminum, Nitrate + Nitrite	$49	$22	8	4	$2,279	$456
1	Metal Forgings and Stampings	Iron, Zinc, Aluminum, Nitrate + Nitrite	$49	$22	8	4	$2,279	$456
1	Electroplating, Plating, Polishing, Anodizing, and Coloring	Iron, Zinc, Aluminum, Nitrate + Nitrite	$49	$22	8	4	$2,279	$456
1	Miscellaneous Fabricated Metal Products	Iron, Zinc, Aluminum, Nitrate + Nitrite	$49	$22	8	4	$2,279	$456
1	Jewelry, Silverware, and Plated Wire	Iron, Zinc, Aluminum, Nitrate + Nitrite	$49	$22	8	4	$2,279	$456
2	Coating, Engraving, and Allied Services	Zinc, Nitrate + Nitrite	$21	$22	8	4	$1,383	$277

Exhibit D-2-2 Analytical Monitoring Costs by Multi-Sector Subsector (Continued)

Subsector	Name	Monitoring Parameters	Average Analytical Costs per Outfall	Sample Collection Costs	Number of Monitoring Events in Permit	Number of Outfalls	Estimated Total Cost (5 yrs)	Estimated Annual Cost
Sector AB. Transportation Equipment, Industrial, or Commercial Machinery								
1	Industrial and Commercial Machinery	None	NA	NA	NA	NA	NA	NA
1	Transportation Equipment	None	NA	NA	NA	NA	NA	NA
Sector AC. Electronic, Electrical, Photographic and Optical Goods								
1	Electronic and Other Electrical Equipment	None	NA	NA	NA	NA	NA	NA
1	Measuring, Analyzing and Controlling Instruments	None	NA	NA	NA	NA	NA	NA
1	Computer and Office Equipment	None	NA	NA	NA	NA	NA	NA
Sector AD. Any Inadvertent Omissions								
1	Any Inadvertent Omission	None	NA	NA	NA	NA	NA	NA

Notes:

NA = Not Applicable
TSS = Total Suspended Solids
COD = Chemical Oxygen Demand
BOD = Biological Oxygen Demand



Appendix D–2–3

Projected Cost Savings by Industrial Subsector

Appendix D-2-3
Projected Cost Savings by Industrial Subsector

Exhibit D-3 indicates the estimated number of industrial facilities in each subsector (under the multi-sector general permit) that may qualify for the no exposure exemption and the cost savings associated with each subsector. Below are explanatory profiles of each column in the exhibit.

- The column "***number of facilities with no exposure***" represents the estimated number of facilities that by definition require a NPDES permit but may qualify for the no exposure exclusion due to an existence of no exposure on their site. (See Exhibit 9-3.)

- ***Visual monitoring*** annual costs were estimated by multiplying the average wage rate by the number of monitoring events in a year. If the average cost to collect and visual inspect a storm water sample is $22.51 and each facility is required to conduct visual monitoring quarterly and it is assumed that each facility has four separate outfalls, the estimated annual cost to collect and visually inspect storm water samples is estimated to be $355.

- ***Analytical monitoring*** annual costs were calculated by, first, determining the parameters to be monitored for each subsector in the modified multi-sector general permit and, then, adding the mean monitoring costs indicated in Exhibit D-2b for each parameter to the sample collection costs of $22.51 per outfall (see Exhibit D-2b). It was also assumed that each facility would collect samples from 4 outfalls per sampling event. A total five-year cost was calculated and then divided by five to provide an estimated annual cost. (Analytical monitoring is only required to occur during years 2 and 4 of the permit.)

- The low and high ***storm water pollution prevention plan*** costs were previously calculated in Exhibits 9-4 and 9-5. Since facilities have already implemented their storm water pollution prevention plans it was decided to assume that the per facility pollution prevention cost was equivalent to the annual cost, not the total costs.

- ***Per facility annual*** low costs are the sum of visual monitoring costs, analytical monitoring costs, low pollution prevention costs, plus expenditures for submittal of the NOI, notification of the local municipal government, and recordkeeping. The high per facility costs are similar except the high pollution prevention cost was used instead of the low pollution prevention costs.

- The ***annual cost savings*** (low) is the number of facilities with no exposure multiplied by the per facility annual costs (low). The annual cost savings (high) is the number of facilities with no exposure multiplied by the per facility annual costs (high).

Exhibit D-2-3. Potential Cost Savings for Industrial Permittees, in 1998 Dollars

Subsector	Name	Number of Facilities w/ no Exposure	Analytical Monitoring Annual Costs	Per Facility Annual Costs (Low)	Per Facility Annual Costs (High)	Total Annual Costs (Low)	Total Annual Costs (High)
Sector A. Timber Products							
1	General Sawmills and Planning Mills	1278	$427	$4,540	$25,026	$5,800,869	$31,975,218
2	Wood Preserving	105	$296	$4,409	$24,895	$462,064	$2,609,039
3	Log Storage & Handling	3001	$191	$4,304	$24,790	$12,918,183	$74,403,801
4	Hardwood Dimension and Flooring Mills	177	$351	$4,464	$24,950	$789,800	$4,414,216
4	Special Product Sawmills, NEC	42	$351	$4,464	$24,950	$185,778	$1,038,319
4	Millwork, Veneer, Plywood	1027	$351	$4,464	$24,950	$4,583,176	$25,615,498
4	Wood Containers	536	$351	$4,464	$24,950	$2,390,800	$13,362,244
4	Wood Buildings and Mobile Homes	215	$351	$4,464	$24,950	$961,961	$5,376,428
4	Reconstituted Wood Products	65	$351	$4,464	$24,950	$291,798	$1,630,868
4	Wood Products, NEC	604	$351	$4,464	$24,950	$2,696,215	$15,069,219
Sector B. Paper and Allied Products Manufacturing				$3,759	$24,245	$0	$0
1	Pulp Mills	10		$4,113	$24,599	$43,018	$257,269
2	Paper Mills	68		$4,113	$24,599	$277,823	$1,661,528
3	Paperboard Mills	48	$300	$4,413	$24,899	$211,531	$1,193,516
4	Paperboard Containers and Boxes	600		$4,113	$24,599	$2,469,038	$14,766,162
5	Converted Paper and Paperboard Products	676		$4,113	$24,599	$2,781,813	$16,636,721
Sector C. Chemical and Allied Products Manufacturing				$3,759	$24,245	$0	$0
1	Industrial Inorganic Chemicals	322	$383	$4,496	$24,982	$1,445,938	$8,034,161
2	Plastics Materials and Synthetic Resins	155	$210	$4,323	$24,809	$668,808	$3,837,939
3	Drugs	341		$4,113	$24,599	$1,401,661	$8,382,678
4	Soaps, Detergents, and Cleaning Preparations	535	$274	$4,387	$24,873	$2,346,801	$13,304,855
5	Paints, Varnishes, Lacquers, Enamels, and Allied Products	305		$4,113	$24,599	$1,254,684	$7,503,676
6	Industrial Organic Chemicals	214		$4,113	$24,599	$880,967	$5,268,652
7	Agricultural Chemicals	202	$498	$4,611	$25,097	$930,383	$5,063,645
8	Miscellaneous Chemical Products	599		$4,113	$24,599	$2,462,765	$14,728,643

Exhibit D-2-3. Potential Cost Savings for Industrial Permittees, in 1998 Dollars

Subsector	Name	Number of Facilities w/ no Exposure	Analytical Monitoring Annual Costs	Per Facility Annual Costs (Low)	Per Facility Annual Costs (High)	Total Annual Costs (Low)	Total Annual Costs (High)
Sector D. Asphalt Paving and Roofing Materials Manufacturers and Lubricant Manufacturers				$3,759	$24,245	$0	$0
1	Asphalt Paving and Roofing Materials	295	$140	$4,253	$24,739	$1,253,749	$7,292,953
2	Miscellaneous Products of Petroleum and Coal	18		$4,113	$24,599	$72,592	$434,141
Sector E. Glass, Clay, Cement, Concrete, and Gypsum Product Manufacturing				$3,759	$24,245	$0	$0
1	Flat Glass	14		$4,113	$24,599	$57,357	$343,025
1	Glass and Glassware, Pressed or Blown	120		$4,113	$24,599	$492,911	$2,947,873
1	Glass Products Made of Purchased Glass	336		$4,113	$24,599	$1,383,737	$8,275,482
1	Cut stone and stone products	202		$4,113	$24,599	$829,884	$4,963,145
1	Abrasive Products	90		$4,113	$24,599	$370,132	$2,213,584
1	Asbestos Products, Tiles, Building Materials	5		$4,113	$24,599	$19,716	$117,915
1	Mineral Wool, Insulation	50		$4,113	$24,599	$205,230	$1,227,387
1	Nonmetallic Mineral Products, NEC	108		$4,113	$24,599	$442,724	$2,647,726
2	Hydraulic Cement	51		$4,113	$24,599	$211,504	$1,264,905
3	Structural Clay Products	130	$229	$4,343	$24,829	$564,861	$3,229,610
3	Pottery and Related Products	248	$229	$4,343	$24,829	$1,075,791	$6,150,865
3	Non-Clay Refractories	33	$229	$4,343	$24,829	$144,763	$827,689
4	Concrete, Gypsum, and Plaster Products	2058	$281	$4,394	$24,880	$9,040,944	$51,194,859
4	Minerals and Earths, Ground or Otherwise Treated	78	$281	$4,394	$24,880	$341,764	$1,935,257
Sector F. Primary Metals				$3,759	$24,245	$0	$0
1	Steel Works	266	$300	$4,413	$24,899	$1,173,997	$6,624,011
2	Iron & Steel Foundries	256	$517	$4,631	$25,117	$1,183,459	$6,419,222
3	Primary Smelting and Refining of Nonferrous Metals	40		$4,113	$24,599	$165,797	$991,557
4	Secondary Smelting and Refining of	84		$4,113	$24,599	$345,038	$2,063,511

Exhibit D-2-3. Potential Cost Savings for Industrial Permittees, in 1998 Dollars

Subsector	Name	Number of Facilities w/ no Exposure	Analytical Monitoring Annual Costs	Per Facility Annual Costs (Low)	Per Facility Annual Costs (High)	Total Annual Costs (Low)	Total Annual Costs (High)
	Nonferrous Metals						
5	Rolling, Drawing & Extruding - Nonferrous	243	$287	$4,400	$24,886	$1,068,968	$6,045,844
6	Non-ferrous Foundries	354	$287	$4,400	$24,886	$1,559,831	$8,822,052
7	Miscellaneous Primary Metal Products	210		$4,113	$24,599	$864,835	$5,172,176
Sector G. Metal Mining (Ore Mining and Dressing) Except Inactive Metal Mining Activities on Federal Lands				$3,759	$24,245	$0	$0
1	Iron Ores	0		$4,113	$24,599	$0	$0
2	Copper Ores	0	$415	$4,528	$25,014	$0	$0
3	Lead and Zinc Ores	0		$4,113	$24,599	$0	$0
4	Gold and Silver Ores	0		$4,113	$24,599	$0	$0
5	Ferroalloy Ores, Except Vanadium	0		$4,113	$24,599	$0	$0
6	Metal Mining Services	0		$4,113	$24,599	$0	$0
7	Miscellaneous Metal Ores	0		$4,113	$24,599	$0	$0
Sector H. Coal Mines and Coal Mining Related Facilities				$3,759	$24,245	$0	$0
1	Coal Mines and Coal Mining Related Facilities	0	$370	$4,483	$24,969	$0	$0
Sector I. Oil and Gas Extraction				$3,759	$24,245	$0	$0
1	Crude Petroleum and Natural Gas	0		$4,113	$24,599	$0	$0
2	Natural Gas Liquids	0		$4,113	$24,599	$0	$0
3	Oil and Gas Field Services	0		$4,113	$24,599	$0	$0
4	Petroleum Refining	0		$4,113	$24,599	$0	$0
Sector J. Mineral Mining and Dressing Except Inactive Mineral Mining Activities on Federal Lands				$3,759	$24,245	$0	$0
1	Dimension Stone	0	$191	$4,304	$24,790	$0	$0
1	Crushed and Broken Stone, Including Rip Rap	0	$191	$4,304	$24,790	$0	$0
1	Nonmetallic Minerals, Except Fuels	0	$191	$4,304	$24,790	$0	$0
2	Sand and Gravel	0	$255	$4,368	$24,854	$0	$0
3	Clay, Ceramic, and Refractory Minerals	0		$4,113	$24,599	$0	$0

Exhibit D-2-3. Potential Cost Savings for Industrial Permittees, in 1998 Dollars

Subsector	Name	Number of Facilities w/ no Exposure	Analytical Monitoring Annual Costs	Per Facility Annual Costs (Low)	Per Facility Annual Costs (High)	Total Annual Costs (Low)	Total Annual Costs (High)
4	Chemical and Fertilizer Mineral Mining	0		$4,113	$24,599	$0	$0
Sector K. Hazardous Waste Treatment Storage or Disposal Facilities				$3,759	$24,245	$0	$0
1	Hazardous Waste Treatment, Storage or Disposal	545	$1,228	$5,341	$25,827	$2,911,347	$14,078,296
Sector L. Landfills and Land Application Sites				$3,759	$24,245	$0	$0
1	Landfills and Application Sites	0	$281	$4,394	$24,880	$0	$0
1	Open Dumps	0	$281	$4,394	$24,880	$0	$0
Sector M. Automobile Salvage Yards				$3,759	$24,245	$0	$0
1	Automobile Salvage Yards	0	$447	$4,560	$25,046	$0	$0
Sector N. Scrap Recycling Facilities				$3,759	$24,245	$0	$0
1	Scrap Recycling and Waste Recycling Facilities	0	$748	$4,861	$25,347	$0	$0
Sector O. Steam Electric Generating Facilities				$3,759	$24,245	$0	$0
1	Steam Electric Generating Facilities	216	$229	$4,343	$24,829	$939,543	$5,371,863
Sector P. Land Transportation Facilities with Vehicle Maintenance or Cleaning Operations				$3,759	$24,245	$0	$0
1	Railroad Transportation	0		$4,113	$24,599	$0	$0
2	Local and Highway Passenger Transportation	6485		$4,113	$24,599	$26,675,289	$159,532,430
3	Motor Freight and Warehousing	40276		$4,113	$24,599	$165,662,676	$990,751,019
4	US. Postal Service	0		$4,113	$24,599	$0	$0
5	Petroleum Bulk Stations	3904		$4,113	$24,599	$16,059,949	$96,047,047
Sector Q. Water Transportation Facilities with Vehicle Maintenance or Cleaning Operations				$3,759	$24,245	$0	$0
1	Water Transportation	2933	$466	$4,579	$25,065	$13,429,061	$73,505,085
Sector R. Ship of Boat Building or Repairing Yards				$3,759	$24,245	$0	$0
1	Ship or Boat Building or Repairing Yards	672		$4,113	$24,599	$2,762,992	$16,524,166
Sector S. Air Transportation Facilities				$3,759	$24,245	$0	$0
1	Air Transportation	3987	$639	$4,752	$25,238	$18,945,537	$100,618,078
Sector T. Treatment Works				$3,759	$24,245	$0	$0

Exhibit D-2-3. Potential Cost Savings for Industrial Permittees, in 1998 Dollars

Subsector	Name	Number of Facilities w/ no Exposure	Analytical Monitoring Annual Costs	Per Facility Annual Costs (Low)	Per Facility Annual Costs (High)	Total Annual Costs (Low)	Total Annual Costs (High)
1	Treatment Works	0		$4,113	$24,599	$0	$0
Sector U. Food and Kindred Products				$3,759	$24,245	$0	$0
1	Meat Products	0		$4,113	$24,599	$0	$0
2	Dairy Products	0		$4,113	$24,599	$0	$0
3	Canned, Frozen & Preserved Fruits	0		$4,113	$24,599	$0	$0
4	Grain Mill Products	0	$140	$4,253	$24,739	$0	$0
5	Bakery Products	0		$4,113	$24,599	$0	$0
6	Sugar and Confectionery Products	0		$4,113	$24,599	$0	$0
7	Fat and Oils Products	0	$575	$4,688	$25,174	$0	$0
8	Beverage Facilities	0		$4,113	$24,599	$0	$0
9	Miscellaneous	0		$4,113	$24,599	$0	$0
10	Tobacco Products	0		$4,113	$24,599	$0	$0
Sector V. Textile Mills, Apparel, and Other Fabric Product Manufacturing				$3,759	$24,245	$0	$0
1	Textile Mill Products	0		$4,113	$24,599	$0	$0
2	Apparel and Other Finished Products	0		$4,113	$24,599	$0	$0
3	Boot and Shoe Cut Stock and Findings	0		$4,113	$24,599	$0	$0
3	Footwear except rubber	0		$4,113	$24,599	$0	$0
3	Leather Gloves and Mittens	0		$4,113	$24,599	$0	$0
3	Luggage and Cases	0		$4,113	$24,599	$0	$0
3	Handbags and Other Personal Leather Goods	0		$4,113	$24,599	$0	$0
3	Leather Goods NEC	0		$4,113	$24,599	$0	$0
Sector W. Furniture and Fixtures				$3,759	$24,245	$0	$0
1	Furniture and Fixtures	0		$4,113	$24,599	$0	$0
2	Wood Kitchen Cabinets	0		$4,113	$24,599	$0	$0
Sector X. Printing and Publishing				$3,759	$24,245	$0	$0
1	Printing and Publishing	0		$4,113	$24,599	$0	$0
Sector Y. Rubber, Miscellaneous Plastic Products, and Miscellaneous Manufacturing Industries				$3,759	$24,245	$0	$0
1	Tires and Inner Tubes	0	$210	$4,323	$24,809	$0	$0

Exhibit D-2-3. Potential Cost Savings for Industrial Permittees, in 1998 Dollars

Subsector	Name	Number of Facilities w/ no Exposure	Analytical Monitoring Annual Costs	Per Facility Annual Costs (Low)	Per Facility Annual Costs (High)	Total Annual Costs (Low)	Total Annual Costs (High)
1	Rubber and Plastics Footwear	0	$210	$4,323	$24,809	$0	$0
1	Gaskets, Packing, and Sealing Devices	0	$210	$4,323	$24,809	$0	$0
1	Fabricated Rubber Products, NEC	0	$210	$4,323	$24,809	$0	$0
2	Miscellaneous Rubber Products	0		$4,113	$24,599	$0	$0
2	Musical Instruments	0		$4,113	$24,599	$0	$0
2	Dolls, Toys, Games and Sporting and Athletic Goods	0		$4,113	$24,599	$0	$0
2	Pens, Pencils, and Other Artist's Materials	0		$4,113	$24,599	$0	$0
2	Costume Jewelry, Costume Novelties, Buttons, etc.	0		$4,113	$24,599	$0	$0
2	Miscellaneous Manufacturing Industries	0		$4,113	$24,599	$0	$0
Sector Z. Leather Tanning and Finishing				$3,759	$24,245	$0	$0
1	Leather Tanning and Finishing	76		$4,113	$24,599	$313,671	$1,875,919
Sector AA. Fabricated Metal Products				$3,759	$24,245	$0	$0
1	Cutlery, Handtools, and General Hardware	0	$453	$4,567	$25,053	$0	$0
1	Fabricated Structural Metal Products	0	$453	$4,567	$25,053	$0	$0
1	Screw Machine Products, and Bolts, Nuts, Screws, etc.	0	$453	$4,567	$25,053	$0	$0
1	Metal Forgings and Stampings	0	$453	$4,567	$25,053	$0	$0
1	Electroplating, Plating, Polishing, Anodizing, and Coloring	0	$453	$4,567	$25,053	$0	$0
1	Miscellaneous Fabricated Metal Products	0	$453	$4,567	$25,053	$0	$0
1	Jewelry, Silverware, and Plated Wire	0	$453	$4,567	$25,053	$0	$0
2	Coating, Engraving, and Allied Services	0	$274	$4,387	$24,873	$0	$0
Sector AB. Transportation Equipment, Industrial, or Commercial Machinery				$3,759	$24,245	$0	$0
1	Industrial and Commercial Machinery	0		$4,113	$24,599	$0	$0
1	Transportation Equipment	0		$4,113	$24,599	$0	$0

Exhibit D-2-3. Potential Cost Savings for Industrial Permittees, in 1998 Dollars

Subsector	Name	Number of Facilities w/ no Exposure	Analytical Monitoring Annual Costs	Per Facility Annual Costs (Low)	Per Facility Annual Costs (High)	Total Annual Costs (Low)	Total Annual Costs (High)
Sector AC.	Electronic, Electrical, Photographic and Optical Goods			$3,759	$24,245	$0	$0
1	Electronic and Other Electrical Equipment	0		$4,113	$24,599	$0	$0
1	Measuring, Analyzing and Controlling Instruments	0		$4,113	$24,599	$0	$0
1	Computer and Office Equipment	0		$4,113	$24,599	$0	$0
Sector AD.	Any Inadvertent Omissions			$3,759	$24,245	$0	$0
1	Any Inadvertent Omission	0		$4,113	$24,599	$0	$0
	Total					$318,825,521	$1,865,642,987

Notes for Exhibit D-2-3:

1. Includes annual expenditures for visual monitoring costs of $355.00, for submittal of NOI of $3.25, for municipality notification costs of $3.25, and for recordkeeping costs of $91.00.

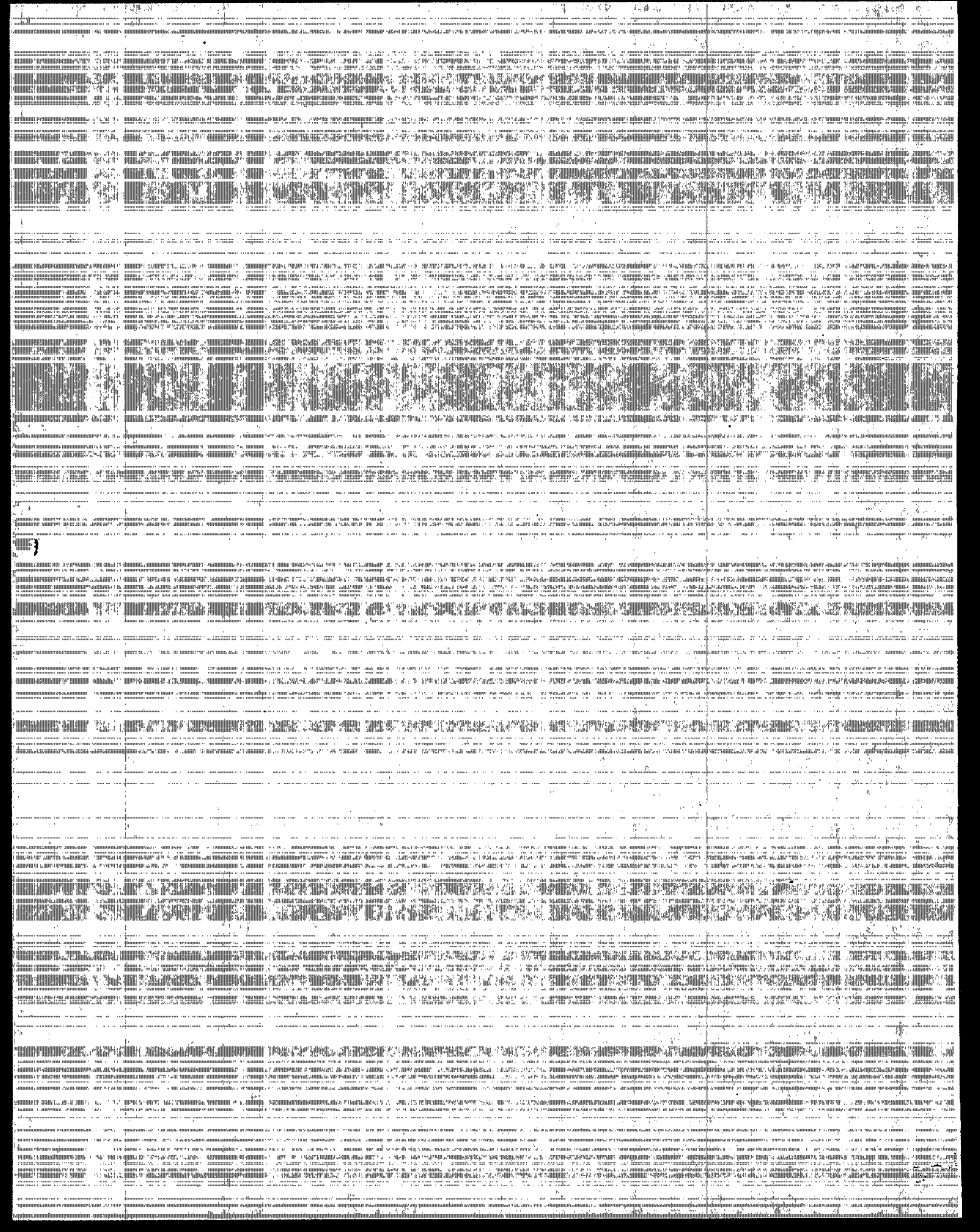
2. The pollution prevention plan costs were $3,661 for the low estimate and $24,147 for the high estimate.

3. The per facility annual costs were calculated as the sum of visual monitoring costs, analytical monitoring costs, submittal of NOI costs, municipality notification costs, recordkeeping costs and the pollution prevention plan costs, for low and high respectively.

4. The total annual cost savings was calculated as the per facility annual cost multiplied by the number of facilities with no exposure for both low and high ranges.

Appendix E

The National Water Pollution Control Assessment Model



RESEARCH TRIANGLE INSTITUTE

The National Water Pollution Control Assessment Model
Benefits Assessment of Stormwater Phase 2 Program

DRAFT - June 1999

Timothy Bondelid, Research Triangle Institute
Ghulam Ali, U.S. Environmental Protection Agency
George Van Houtven, Research Triangle Institute

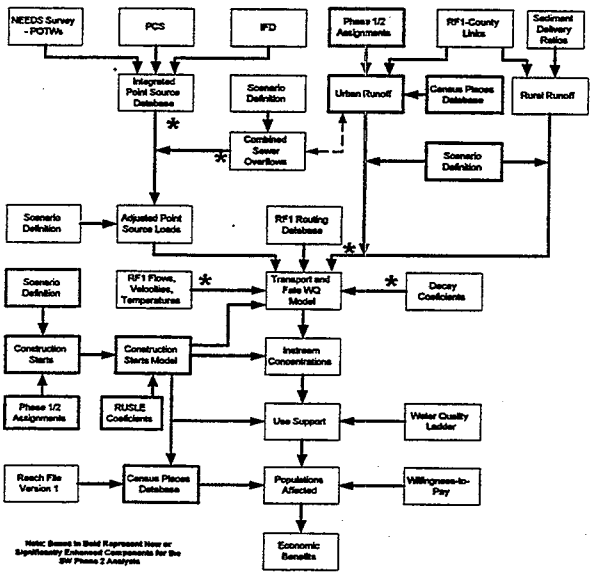


Fig 1. National Water Pollution Control Assessment Model Components

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The National Water Pollution Control Assessment Model
Benefits Assessment of Stormwater Phase II Program

Timothy Bondelid, Research Triangle Institute
Ghulam Ali, U.S. Environmental Protection Agency
George Van Houtven, Research Triangle Institute

Executive Summary

The overall objective of this study is to estimate the water quality and economic benefits that can result from various pollution control policies. For this purpose the National Water Pollution Control Assessment Model (NWPCAM) is developed. This model estimates water quality and the resultant use support for 632,000 miles of rivers and stream in the continental United States plus 34,500 miles of smaller streams associated with construction site runoff. The focus of the analyses in this study is evaluating the economic benefits of implementation of the stormwater Phase II rule. To estimate economic benefits, the model first develops the water quality baseline and then estimates the further changes in water quality as a result of the additional controls of the Phase II rule on construction sites and the automatically designated municipalities in urbanized areas. There are many input databases (point sources, combined sewerage overflows, urban runoff, modeling coefficient, etc.), processes, and post-processing tools that are used for the NWPCAM. To develop the water quality baseline, loadings from municipal and industrial point sources as well as nonpoint sources including rural and agricultural sources are used. Table 1 summarizes the primary assumptions used for the development of the baseline and Phase II analyses. The model uses various studies or data sources for estimation of these loadings into the US waters. In view of these loadings, NWPCAM projects the water quality changes in the network of streams and rivers. To identify the effect of the Phase II controls for 120,047 construction sites and the 5,038 automatically designated municipalities in the urbanized areas, the model takes into account the reduction in loadings and projects the instream changes in water quality in terms of swimmable, fishable, and boatable waters on the basis of standards for the level of fecal coliform, dissolved oxygen, biological oxygen demand, and total suspended solids in waters.

The model then identifies where the water quality change takes place so that the number of households associated with those waters can be identified. Once the numbers of households are estimated, the study uses the willingness to pay (WTP) for the improvement in water quality to swimmable, fishable and boatable to monetize economic benefits. On the basis of Carson-Mitchell WTP estimates of $177, $158 and $210 per household for swimmable, fishable or boatable waters, respectively, the water quality change is monetized. The benefit estimates are based on the improvement in local and non local waters. The local economic benefit analysis

uses a definition of "local" that differs from the original Mitchell-Carson Survey, which considered "local" as "state." In this analysis, "local" waters are defined as reaches that are located near each of the population locations. The definition of "local" depends on whether it is a Census Populated Place or Minor Civil Division. For Populated Places, a circle with an equivalent area to the Place was drawn, centered on the Place Latitude/Longitude coordinates as given by the Census Bureau. Any reaches that fell in whole or in part within that circle were considered "local" to that Place. For Minor Civil Divisions, the closest reach is considered to be the "local" water. The estimation of the "local" benefits is based on use support changes in reaches that are "local" to each population location. The benefits depend on the portion of the local and the national impaired waters improved as a result of the phase II soil and erosion controls for construction sites and the application of pollution prevention measures to control storm water run off from the automatically designated municipalities in the urbanized areas. The benefits estimates fully incorporate the "small streams" benefits as well.

Thus, the model estimates that implementation of Phase II controls, without the consideration of post construction controls, will result in an increase of 4,127 swimmable miles, 4,548 fishable miles, and 2,936 boatable miles. The total benefits of Phase II controls for 120,047 construction sites, without the post construction controls, and 5,038 automatically designated municipalities are estimated to be $1.63 billion per year.

While the numbers of miles that are estimated to change their use support seem small, the benefits estimates are quite significant. This is because urban runoff and, to a large extent, construction activity occurs where the people actually reside and the water quality changes mostly occur close to these population centers. NWPCAM indicates that the changes in pollution loads have the most effect immediately downstream of the pollution changes. This is because rivers "treat" the wastes (using similar processes that occur in a wastewater treatment plant) as they move downstream. As a result, the aggregate willingness to pay (economic benefits) is large because large numbers of households in these population centers are associated with the local waters that reflect improvement in designated use support. If the waters are improved in reaches that are further from the population centers their economic value is comparatively less. NWPCAM benefit estimates "capture" this economic phenomenon. Moreover, the model fully incorporates the construction sites modeling (including the "small streams") and an improved population database for the estimation of benefits. In addition, the benefits estimates are derived using rather conservative assumptions of the pollution control effectiveness of the Phase II program, although EPA believes that the actual implementation of the Phase II minimum measures will result in an overall program effectiveness of approximately 80%. The Phase I and Phase II urban runoff controls used in this analysis employ pollutant removals that are characteristic of detention basins.

To determine the impact of the alternative assumptions, a sensitivity analysis is conducted.

Table 1. NWPCAM Summary For Stormwater Phase II Benefits Analysis

Variable	Baseline For Phase II	With Phase II Implementation
Number of Construction Sites	Current State Programs: 100,316 Phase I: 184,520	Phase II: 120,047 Phase II "R" Waivers: 13,057 0-1 Acres (Unregulated): 91,332
Number of Acres of Construction Sites (Estimated from Input Dataset of Numbers of Starts)	Current Programs: 207,869 Phase I: 1,845204	Phase II: 289,819 Phase II Waivers: 33,517 0-1 Acres (Unregulated): 45,491
Construction Site Parameters	7% Slope, Medium Soils	7% Slope, Medium Soils
Construction Site BMPs	1. Between 0 and 4 Acres: Silt Fence, Seed & Mulch, and Stone Check Dams 2. Greater Than 4 Acres: Seed and Mulch, Stone Check Dams, and Sediment Traps	1. Between 0 and 4 Acres: Silt Fence, Seed & Mulch, and Stone Check Dams 2. Greater Than 4 Acres: Seed and Mulch, Stone Check Dams, and Sediment Traps
Combined Sewer Overflows (CSOs)	742 CSOs on 505 Reaches	
CSO Runoff Control	Detention basin-level of control for CSOs, capturing 85% of the runoff, with 33% removal of biological oxygen demand (BOD5), 60% removal of total suspended solids (TSS), and 70% removal of fecal coliform (FC).	
Urban Runoff Sources Note: Population adjustments made to reflect 1998 values and populations served by CSOs.	Phase I: 1,723 Places, 72.4 million people Not Phase I or Phase II: 35,718 Places with 81.7 million people	Phase II: 5,038 Places, 78.5 million people
Urban Runoff Controls	Capture 85% of the runoff, with 33% removal of BOD5, 60% removal of TSS, and 70% removal of FC.	Capture 85% of the runoff, with 33% removal of BOD5, 60% removal of TSS, and 70% removal of FC.
Swimmable, Fishable, and Boatable Miles	219,547 (32.91%)	223,674 (33.53%) Increased 4,127 miles
Fishable and Boatable Miles	418,190 (62.69%)	422,738 (63.37%) Increased 4,548 miles from Phase I
Boatable Miles	480,515 (72.03%)	483,451 (72.47%) Increased 2,936 miles from Phase I
No Support Miles	186,589 (27.97%)	183,653 (27.53%) Decreased 2,936 miles from Phase I
Economic Benefits		Local: $1,401.4 million Non-Local: $ 227.1 million Total: $1,628.5 million

Alternative analysis assumes different levels of controls, such as 60% or 80% pollutant removals for urban run off. Supplemental sensitivity analysis in conjunction with the controls in the 60% to 80% range indicates that the estimated economic benefits in NWPCAM increase by $200 to $300 million from the $1.63 billion estimate, respectively.

The benefit estimates can be considered quite robust, since model sensitivity analyses have consistently shown that the estimates are stable, even under assumptions of large changes in model input values. As an example, tests were conducted in conjunction with this analysis assuming that the construction sites loads are off by +/- 25%. The resultant local economic benefits estimates show a change of only +/- 5%. Moreover, a statistical groundtruthing of the model to Storage and Retrieval ambient water quality data indicates that the NWPCAM "baseline" scenario can also be considered as a reasonable predictor of the actual use support circa for 1990s.

Introduction

Under PL 92-500 in 1972, now known as the Clean Water Act (CWA), Federal authority to regulate water pollution control facilities was expanded. The CWA established a national water pollution control policy based on technology-driven effluent standards for industrial wastewater and a minimum level of secondary treatment for wastewater discharged to surface waters by municipal facilities. The goal of the CWA was to improve water quality conditions to attain "fishable and swimmable" waters nationwide. The CWA's national policy requirement for a minimum level of secondary treatment for municipal wastewater facilities was seen as a feasible goal that could result in significant improvements in dissolved oxygen levels as well as other related water quality and environmental benefits. Questions concerning the environmental benefits, as well as the cost-effectiveness of this landmark legislation for water pollution control, have been raised by Congress, special interest, environmental, and business advocacy groups.

Unfortunately, information on the status of our Nation's waters and the influence of control measures on water quality is not comprehensive enough for such an analysis (Knopman and Smith, 1993). Although the 1972 CWA included provisions for program evaluation, Congress did not authorize the U.S. Environmental Protection Agency (EPA) to require methodological consistency among the states or to coordinate the states' efforts to gather, store, and retrieve data. The U.S. Geological Survey (USGS) maintains two long-term, nationally consistent, surface-water-quality monitoring networks--the National Stream-Quality Accounting Network (NASQAN) and the USGS Hydrologic Benchmark Network. However, these networks were developed to monitor water quality trends over time, particularly those "resulting from large scale processes, such as changes in land use and atmospheric deposition, rather than localized effects such as changes in the amount or quality of point source discharges" (Lettenmaier et al., 1991).

Others have modeled water quality in attempts to address policy-relevant issues, but did not take into consideration localized changes. Gianessi and Peskin (1981) include many pollutants in their water quality network model; however, their measurements are appropriate for large-scale watershed analyses and do not capture the local effects due to point sources. EPA's Office of Water used time series monitoring data from 22 major waterways to detect trends and changing conditions of several chemical parameters (U.S. EPA, 1992c). These analyses, however, were not intended to establish cause-and-effect relationships. A second EPA effort (U.S. EPA, 1992a) assessed the effectiveness of the Construction Grants Program, but again the case studies were limited to major waterways.

Most of the adverse effects of point source discharges, urban runoff, and construction site runoff occur within a limited number of miles immediately downstream of the discharge. In addition, many point sources (i.e., major and minor dischargers) are linked to the EPA river and stream network, the EPA River Reach File. Therefore, an accurate assessment of the effectiveness of historical water pollution controls should concentrate on these waters. Although no single

monitoring program captures the relevant population of waters downstream of point sources, EPA did support the database development necessary for modeling the ambient water quality effects of controlling point source discharges of some pollutants from most major industrial sources and almost all municipal sources (U.S. EPA, 1993a).

The inconsistencies in data reported by the States, coupled with the diversity of objectives of the national networks, seemed to preclude the aggregation of this data to assess national changes in water quality as a result of changes in point source loadings. However, a recent analysis (Tetra Tech, Inc. and Stoddard, 1998) of Storage and Retrieval water quality database (STORET) has demonstrated that there have been in fact significant, detectable improvements in water quality over the past 30 years, and that this can be shown using statistical analyses of STORET data. This analysis also reviewed several case studies, including those of the New York Harbor, the Potomac River, the Ohio River, and the Upper Mississippi River plus several others that demonstrate significant improvements that have taken place as a result of point source controls. However, this type of analysis cannot be used for estimation of benefits of the stormwater Phase II rule. Nor can it be used to establish a cause and effect relationship required to estimate aggregate economic benefits of a specific storm water program. To quantify benefits one needs to establish not only the cause and effect relationship between the water quality and the storm water pollutants but also to quantify it. Therefore, the National Water Pollution Control Assessment Model (NWPCAM) includes the set of mathematical relationships that approximate the hydrological/ecological processes with reference to fecal coliform, biological oxygen demand, oxygen demand, total suspended solids that affect the instream water quality.

In order to estimate benefits, the model first develops the water quality baseline and then estimates the further changes in water quality as a result of the additional controls of the Phase II rule on construction sites and the automatically designated municipalities in urbanized areas. To develop the water quality baseline, loadings from municipal and industrial point sources as well as nonpoint sources including rural and agricultural sources are used. The model uses various studies or data sources for estimation of these loadings into the US waters. In view of these loadings, NWPCAM projects the water quality changes in the network of streams and rivers. To identify the effect of the Phase II controls for 120,047 construction sites and the 5,038 automatically designated municipalities in the urbanized areas, the model takes into account the reduction in loadings and projects the instream changes in water quality in terms of swimmable, fishable, and boatable waters on the basis of standards for the level of fecal coliform, dissolved oxygen, biological oxygen demand, and total suspended solids in waters.

Purpose and Objectives of the NWPCAM

The objective of this work has been to build a national-level water quality model to estimate the water quality and economic benefits that can result from various pollution control policies. The result of this effort is the National Water Pollution Control Assessment Model. This model

estimates water quality and the resultant use support for 632,000 miles of rivers streams, larger lakes, and some estuaries in the continental United States plus 34,500 miles of smaller streams added from construction sites analyses. The model was used to examine policies that include the Construction Grants Program, overall point source pollution control policies, and wet weather controls such as controls on combined sewer overflows (CSOs). The model can be run for various "baseline" conditions and for alternative scenarios, such as implementation of Phase II stormwater.

The NWPCAM has been used for modeling current conditions with analyses that focus on the effects that various control policies can have on current water quality. The model has not yet been used as a predictive tool for future conditions but can be used for predictive analyses by applying growth factors to various loadings.

The scope and objectives of the NWPCAM make it very different from a typical site-specific model. Objectives include:

- To conduct national-scale, planning-level simulations to determine the effectiveness of alternative regulatory control policy scenarios on point sources.
- To detect significant local-scale changes in water quality.
- To aggregate local-scale changes at larger regional and national levels.
- To link policy-driven changes in water quality to populations and to estimate the resultant economic benefits.
- To design a national-scale model framework that rests upon a foundation capable of performing hydraulic transport, routing and connectivity of surface waters in the entire continental U.S.
- To select water quality state variables based on a relatively simple kinetic framework that can: (a) represent the major processes that control water quality impacts, and, (b) can use parameters linked to available methods to estimate economic benefits.
- To use national-level data sources in order to preclude locally or regionally biased results.

The NWPCAM is implemented on the EPA IBM 3090 mainframe at the National Computer Center in Research Triangle Park, NC. The model is programmed in SAS with a full-screen user interface under TSO/ISPF.

System Enhancements for Phase II Stormwater Rule Analysis

The benefit estimation required significant enhancements to the databases and NWPCAM framework. Primarily, it required an explicit identification of Phase I and Phase II urban runoff locations. Moreover, it required the development of the submodel or sub-system for analysis of construction sites. An improved database of populated areas, including Populated Places and Minor Civil Divisions (MCDs), was needed to provide a clear assignment of Phase I and Phase II regulated communities and other urban runoff locations. A new database of construction starts/sites was also needed to estimate the locations of the construction sites across the country so that they could be integrated into the NWPCAM framework. The development of the submodel was required to estimate and route the loadings from the construction sites into EPA's Reach File Version 1 (RF1) stream network.

These enhancements are discussed in more detail below and additional technical details are provided later in this report.

1. In order to provide an explicit breakdown of Phase I and Phase II communities for estimating benefits for the Phase II controls for automatically regulated municipalities, Census Bureau databases of population sites, based on their files of Populated Places and Minor Civil Divisions, are linked to NWPCAM. This enhanced population database provides a better understanding and estimation of the urban runoff loadings in the modeling and the estimation of the "local" economic benefits. Moreover, there was a need to establish a cross-link between the Populated Places/MCDs and Construction Sites so that sites can be geographically located for assignment of Revised Universal Soil Loss Equation (RUSLE) coefficient to estimate loadings for RF1 NWPCAM framework. Obviously, without the establishment of such links between locations of the construction sites and the populations centers, economic benefits of construction site controls cannot be fully assessed. As a result, there are separate urban runoff loading estimates for the 42,479 separate Census Bureau Populated Places and Minor Civil Divisions in the system, with estimates of annual pollutant loadings for each place and each portion of the reach associated with the place. The source of these loadings is a database of urban loadings by county that is a counterpart to the rural loadings source database. These places are also used for estimating local economic benefits based on changes in water quality on reaches close to each place.

   More specifically, there was a need to identify the specific Phase I and Phase II places in order to model controls on their runoff. To accomplish this, data files containing the lists of communities making up Phase I and Phase II were merged into the enhanced NWPCAM places database so that explicit identification of places associated with each Phase could be made. In addition, the NWPCAM database contains an overlay of Urbanized Areas, in order to identify urban communities. The Phase I or II places were matched to the NWPCAM places database. As a result, each place is identified as either

a Phase I urban area, Phase II urban area, or other. Consequently, 1,723 separate places, comprising 72.4 million people, are incorporated as Phase I urban sites and 5,038 other places, comprising 78.5 million people, for 1998, are included as Phase II urban sites. The rest of the 35,718 places and minor civil divisions comprise 81.7 million people including the CSO population[1]. The population totals for Phase I and Phase II places for 1998 are adjusted for populations already served by CSOs, using data from the CSO NEEDS Survey. However, there was some problem in matches, mainly because of differences in place names between the various files.

The NWPCAM places database contains many small communities with less than 2,500 people, so the total number of people assigned to places in NWPCAM is greater than the reported Census Bureau urban population. The Census Bureau defines an urban place on the basis of population of greater 2,500 people. By using this definition, one can compare that portion of populations which is associated with those places, in both databases, for quality control purpose. By imposing the Census Bureau definition of "urban" on the NWPCAM places database (i.e., places in urbanized areas and designated places with more than 2,500 people), an urban total of 192 million people for 1990 is found in NWPCAM. In comparison, the Census Bureau reports the population of 187 million for 1990 (the base year for the NWPCAM places database). This represents a difference of 3%, which can be considered a reasonable difference, given the fact that the NWPCAM is developed from multiple Census Bureau databases.

The point sources of 742 separate CSO loadings, on 505 different reaches, from the NEEDS Survey, are included in the RF1 framework. The urban runoff loadings for Phase I and Phase II communities are cross-linked to the CSO populations, so that double-counting of urban runoff loads does not occur. That is, urban runoff loadings are subtracted if it can be determined that the runoff loadings are already accounted by the CSO component of the system.

The NWPCAM modeling options allow setting pollutant reduction levels for CSOs, Phase I, and/or Phase II places as desired. Currently, the NWPCAM assumes that 85% of the CSO and urban runoff is captured by sewer systems, with the remaining being delivered untreated to the streams. This 85% assumption is selected because it was used in the NEEDS Survey CSO analyses.

2. The Phase II regulation contains controls on construction sites, so a construction starts/sites database is fully incorporated into NWPCAM. The construction site communities totaling 19,378 are incorporated into the NWPCAM framework, with estimates of annual TSS runoff. Each community has estimates of the total number of

[1]The total population for 1998 is projected at 270 million of which about 233 million people are included in the modeling of the water quality impacts.

sites under construction by size range, such as 0 to ½, ½ to 1 acres, etc. The annual estimates of loadings are based on application of the Revised Universal Soil Loss. This equation determines the soil loss on the basis of rainfall, erodability, slope, preconstruction farming conditions, and the application of the best management practices on a construction site. To account for the climatic differences, the coefficient values of RUSLE are separately developed for 15 representative cities. The coefficient values that relate to "Representative Cities" are presented in the U.S. Army Corps of Engineers study for OWM (COE, 1998). To determine the boundaries of the representative cities for determining the number of sites for a representative area, a correspondence between Major Land Resource Areas (MLRAs), which characterize soil and climate for estimation of erosion in various parts of the United States, is used. As RUSLE coefficients also vary by slope and soil type in the model, a 7% slope is assumed with medium soils in this analysis. On the basis of MLRAs and Representative Cities the RUSLE coefficient are set for every one of the 19,378 construction site communities. Table 2 shows the RUSLE coefficient by "representative city" for pre-construction and construction conditions with no best management practices (BMPs), and the coefficient for each of the construction BMPs. The use of these coefficients is discussed in the "Construction Site Loadings" section.

Two issues related to construction site loadings and use support are addressed in the development of a new "small streams" modeling component. The first issue was that many of the construction sites were on small streams that were not already included in the NWPCAM/RF1 framework. The second issue related to the estimation of reduction in loadings from settling as runoff from the construction sites flows to RF1. Therefore, a "small streams" water quality submodel is added to the NWPCAM. The model routes the construction site runoff to the main NWPCAM/RF1 network. This model decays the loadings using the same methodologies as for the rest of the NWPCAM. Data for flow in the "small streams" is based on a hydrologic analysis that relates distance from RF1 to drainage area, and then uses an RF1 flow analysis to estimate mean summer flow as a function of the drainage area. For this initial work on "small streams," a straight-line distance from the construction sites to RF1 is used, that is, sinuosity of the streams is not taken into account. The instream water quality modeling itself does not utilize sinuosity as a parameter, but some future work with sinuosities could improve/change the lengths of the flow paths.

The Phase II rule provides exemptions for areas of low rainfall. This exemption is implemented by exempting construction sites between 1 and 5 acres that have a RUSLE rainfall erosivity factor ("R") less than 5. The average construction period is assumed to last 6 months, so an R factor of 10 is used in this analysis to account for a full year. Because the MLRA's are overlaid on each community with construction, an "R" factor is assigned to each site. Phase II controls are waived for sites with an "R" factor less than 10. In examining Table 1, note that the "Las Vegas" representative city is the only one

that has an "R" factor less than 10, so that those sites that fall within the "Las Vegas" MLRAs will have this particular waiver.

Construction BMPs are incorporated by adjusting the respective RUSLE coefficient that reflect the effects of a given BMP, or multiple BMPs. The BMPs are based on COE report and are selected to be consistent with the Phase II economic analysis carried out by the Office of Wastewater Management: for sites between 1 and 4 acres, a combination of silt fences, seeding and mulching, and stone check dams is used. For sites greater than 4 acres, a combination of seeding and mulching, stone check dams, and sediment traps is used. These BMP effects vary by MLRA, since the RUSLE coefficient vary by MLRA. For estimates, the baseline modeling of the construction sites assumes BMPs at all sites greater than 5 acres (Phase I controls) and the BMP controls for already existing state programs so that benefits of these controls are not attributed to the Phase II rule.

3. The economic benefits analysis (Mitchell-Carson) incorporates the improved population database and the construction sites "small streams" analysis. This means that the benefits are based on better defined set of populations than in previous versions of the NWPCAM and will reflect some of the water quality improvements that can be expected at the smaller streams that are most likely to be affected by many construction sites.

Methodology

Model Development Steps

A model for predicting water quality and beneficial use attainment under different policy scenarios will address several key issues. First, the model must control for loadings from both point and nonpoint sources. Decreasing discharges from a specific point source, even going to zero discharge, may have little or no effect on beneficial use attainment if discharges from other sources are limiting factors. Second, streamflow and stream velocity data are required to simulate dilution and self-purification effects through pollution decay. Third, water quality parameters examined in the model must be related to beneficial use attainment and must reflect all of the essential processes that limit point source controls. Fourth, a methodology is needed to characterize point source loadings under different scenarios (i.e., no treatment of point source discharges or limited treatment in the absence of the CWA). All of these issues must then be integrated into a river network that can characterize a meaningful "universe" of waters. These basic, but essential, components are integrated into the NWPCAM.

In addition to predicting water quality and beneficial use attainment, the NWPCAM can be used to estimate the number of persons living near changed waters. This is an important dimension for evaluating the economic benefits of pollution control policies. It is not enough to know how many miles of rivers and streams have been improved; one also wants to know how the changes affect the nearby population. A first step in this direction is to determine the population

proximate to the improved water resource. The next step involves estimating the population's willingness to pay for the water quality improvements.

A major challenge in developing the NWPCAM was to "wire" all of the components into one system, all of it linked into EPA's Reach File Version 1 river network. As with many models, the bulk of the work is in managing the data so that the numerical modeling can be applied. The effort expended on constructing and integrating the input data at this national scale is much greater than that required for the actual software implementation.

A second challenge was to develop simple yet valid approaches to the water quality kinetics. The principle of "Ockham's Razor" (named after a 14th century monk) is applied, which states that, given no contravening information, the simplest solution to a problem is the best. Fortunately, there are traditional approaches to water quality modeling that employ simple steady-state linear modeling approaches (i.e., first-order decay). These techniques have been employed for many years for wasteload allocations that have formed the basis of pollution control decisions. The large body of work using these approaches also provides a basis for setting model coefficients at reasonable starting points. Therefore, the NWPCAM employs steady-state first order decay processes as the modeling approach.

A third challenge addressed in the model development was to provide for incremental additions and improvements. A model at this large scale must, by necessity, be incremental in its development. For instance, the first version of this model (called the Clean Water Act Effects Model) incorporated only 5-day biochemical oxygen demand (BOD5) and total suspended solids (TSS) and had urban and rural nonpoint sources, municipal point sources, and "major" industrial point sources. Major point sources are defined by each State as those point sources that have a "significant" effect on water quality; there is no clear, universal definition of significant among the States. The next version of the model added fecal coliform (FC) and dissolved oxygen (DO) modeling, with the same point sources as those used in the first version. A third version then added combined sewer overflows and approximately 20,000 "minor" industrial dischargers. In going from the first to the third versions, the scope of water quality parameters and pollution sources were both increased. It is this third version of the model that is presented in this report.

Plans are underway for further incremental development. A preliminary version has been developed that models toxic water pollutants, and this model is undergoing further development at this time. It is also expected that nutrients will be incorporated into the model in the near future. Modeling of nutrients and the resultant algal growth cycles poses particular challenges. Up to this point, the conventional and toxic pollutant modeling techniques in the inland waters have employed linear kinetics, which allow fairly simple closed-form solutions. The nutrient modeling will be nonlinear, so numerical integration techniques will be needed. One significant impact of adding nutrients to the model will be the introduction of ammonia and nitrogen, which would deplete DO further. We recognize that the exclusion of ammonia from the DO modeling has been a significant limitation, and this will be addressed in one of the next incremental

improvements.

Another significant improvement that will take place in a future nutrient modeling increment is enhanced modeling in lakes and some estuaries. Lakes and estuaries are currently modeled as one-dimensional systems; the nutrient modeling effort is expected to employ two-dimensional (and perhaps three-dimensional) modeling techniques in these waters in future versions. The current NWPCAM models everything as one-dimensional, which means the waters are represented as linear features. Two-dimensional modeling will permit modeling "wide" features such as lakes. Three dimensional modeling add the depth variant to the two-dimensional modeling.

Yet another major incremental development that is expected in the near future is a separate effort to model estuarine and coastal waters. This increment will require significant effort because these systems are much more complex than the primarily one-dimensional inland rivers and streams now being modeled in the NWPCAM. The estuarine and coastal modeling will be linked to the current NWPCAM inland modeling by using the NWPCAM streamflows and pollutant loadings as inputs to the coastal and estuarine models[2].

[2]The NWPCAM is being reimplemented on a PC using Microsoft Access and Visual Basic. This step will make the model more accessible to users and will improve linkages to postprocessing analyses such as the use of ArcView Geographic Information System mapping of results.

Modeling Approach

The NWPCAM performs national-level modeling of conventional pollutants in the major inland rivers and streams, larger lakes and reservoirs, and some estuarine waters in the lower 48 states. This is done using the RF1 framework, which covers approximately 632,000 miles of rivers, lakes, reservoirs, and estuaries. The best available nationally consistent data sources were used to predict ambient concentrations of BOD5, TSS, FC, and DO along all river reaches. The model controls for loadings from both point and nonpoint sources, and uses streamflow and stream velocity data to model pollutant fate.

Estimates of total stream miles in the United States range from 1.2 million (U.S. EPA, 1992b), an aggregation of states' estimates, to 3.6 million (U.S. EPA, 1993b), calculated using EPA's expanded surface water network, Reach File Version 3 (RF3). The latter estimate includes intermittent streams. The subset of river and stream miles included in RF1 are the major rivers and streams. Therefore, RF1 waters are not inclusive of **all** of the Nation's streams. Nonetheless, this system does include most waters affected by major industrial, municipal, and CSO point sources and major urban runoff.

The water quality parameters used in this approach (BOD5, TSS, FC, and DO), were selected based on several criteria:

- They can be modeled reliably using simple first-order decay kinetics.
- They are key "conventional" parameters targeted in wastewater treatment.
- Common wastewater treatment characteristics for these parameters are well known and consistent, so that estimating reasonable loadings corresponding to differing levels of point source controls is feasible.
- Detailed data are available both on point source loadings and nonpoint source loadings of the pollutants.
- Existing indices of beneficial use are based, in part, on these water quality parameters.

DO is a widely recognized indicator of beneficial use attainment and is a primary instream benefit of BOD_5 control. Modeled values for percent DO saturation are based on mean summer water temperatures. The classic Streeter-Phelps approach is used to model DO as a function of reaeration, UBOD (i.e., ultimate BOD, estimated by $1.46*BOD_5$), and sediment oxygen demand (SOD). Reaeration is modeled using the methods applied in the WASP model (Ambrose et al., 1987). This method estimates reaeration as a function of stream depth and velocity. The streamflow condition modeled is mean summer flows and velocities developed in conjunction

with RF1 (Grayman, 1982). Stream depths are computed using stable channel analysis (Henderson, 1966). SOD is modeled with a default value of 0.5 g/m^2/d, increased to 1.5 g/m^2/d below point sources and CSOs.

Fecal coliforms are included as a fourth parameter because pathogens are clearly important in determining whether water quality supports swimming. The model employs a simple first-order decay model using data from CSO loadings. The municipal effluent values are set to a low default value as disinfection is assumed to occur (except in no treatment scenarios). There are no industrial point source or nonpoint source estimates for fecal coliforms in the model.

The fate of BOD5, TSS, and FC is modeled using first-order decay equations. The percent DO saturation is modeled based on mean summer water temperatures using the Streeter-Phelps approach. That is, DO is modeled as a function of reaeration, UBOD, and sediment oxygen demand. Reaeration is modeled as a function of average stream depth and velocity, with stream depth computed using stable channel analysis (Henderson, 1966).

These pollutants form the basis for linking water quality to the Resources for the Future (RFF) Water Quality Ladder. This ladder is used as a uniform basis for assigning four categories of beneficial use support (swimming, fishing, boating, no use support) to each computational element in the NWPCAM. Because the model includes the ability to characterize point source loadings under different scenarios (e.g., "without pollution control policies"), the model can be used to estimate the effect of changes in water quality or beneficial use on persons living near those river reaches. This is an important dimension of evaluating the economic benefits of changing water quality.

Model Components and Processes

Figure 1 shows the components, processes, and sequence of actions that are required for a NWPCAM run. Boxes in bold are components that have been either added or significantly enhanced for the Storm Water Phase II analyses. The central path of the NWPCAM starts with the RF1 Routing Module. The primary inputs to this module are the RF1 routing framework, point source loads, combined sewer overflows, NPS loads, reach flows and velocities, and pollutant decay coefficients. The routing module computes pollutant concentrations for each subreach. These concentrations are then compared to the water quality ladder to determine which subreaches (i.e., river and stream miles) are not meeting a particular beneficial use. Next, the number of households corresponding to these reaches is computed using data from the 1990 Census of Populated Places.

The upper left portion of Figure 1 shows the processing of point source loads. The 1988 Survey (NEEDS88), Permit Compliance System (PCS), and Industrial Facilities Discharger (IFD) databases are joined to create a consolidated point source database. This database contains a unique set of pollutant loadings for each discharger that is in NEEDS88, PCS, and IFD, together

with the links to RF1. The point source loadings are then adjusted for the relevant point source control regime being evaluated and are entered into the RF1 routing module.

The upper right portion of Figure 1 shows the processing of the urban runoff and rural NPS loadings databases. The urban and rural county loads are combined and allocated to each reach based on proportional lengths of reaches in each county and the relevant Sediment Delivery Ratios (SDRs) for each watershed. The Urban loads are adjusted by CSO loads to avoid double-counting. The SDR is a coefficient that represents the reduction in pollutant loadings going from the field-level discharge, down drainage channels and smaller streams before reaching the river network (in this case RF1). In essence, the NPS loads are multiplied by the SDR to get the net loading to the RF1 reaches. The NPS loads are then entered into the RF1 routing module.

Pollutant loadings in the system include 24,854 minor and 2, 261 major industrial point sources and 9, 890 municipal point sources (publically owned treatment works, POTWs). The system includes 742 CSO loadings on 505 Reaches. The model also includes urban runoff loadings at 42,479 individual places (Phase I, Phase II and other) and 509,272 construction sites. In addition, NWPCAM includes the rural loadings, primarily from agriculture.

The 37,005 point sources in the model are linked to 12,676 different RF1 reaches. Figure 4 shows a map of the reaches that have point sources. This map shows the distribution of point sources across the U.S. The pattern is as one would expect, with most of the point sources lying in the eastern half of the U.S. with the exception of concentrations located around major cities on the West coast.

The model includes options to change loadings in a way that can simulate various pollution control policies. For instance, urban runoff loadings can be changed that can simulate the pollutant reductions that could be expected from detention basins, construction site loadings can be modeled by applying coefficient that simulate the effects of various BMPs, etc.

There is concern about the accuracy of the inputs to the model and the effect this could have on model results. The effects of errors in the input data elements that have an "*" next to them are addressed in a detailed sensitivity analysis. As can be seen in Figure 1, the sensitivity analysis addresses each of the major inputs to the water quality model.

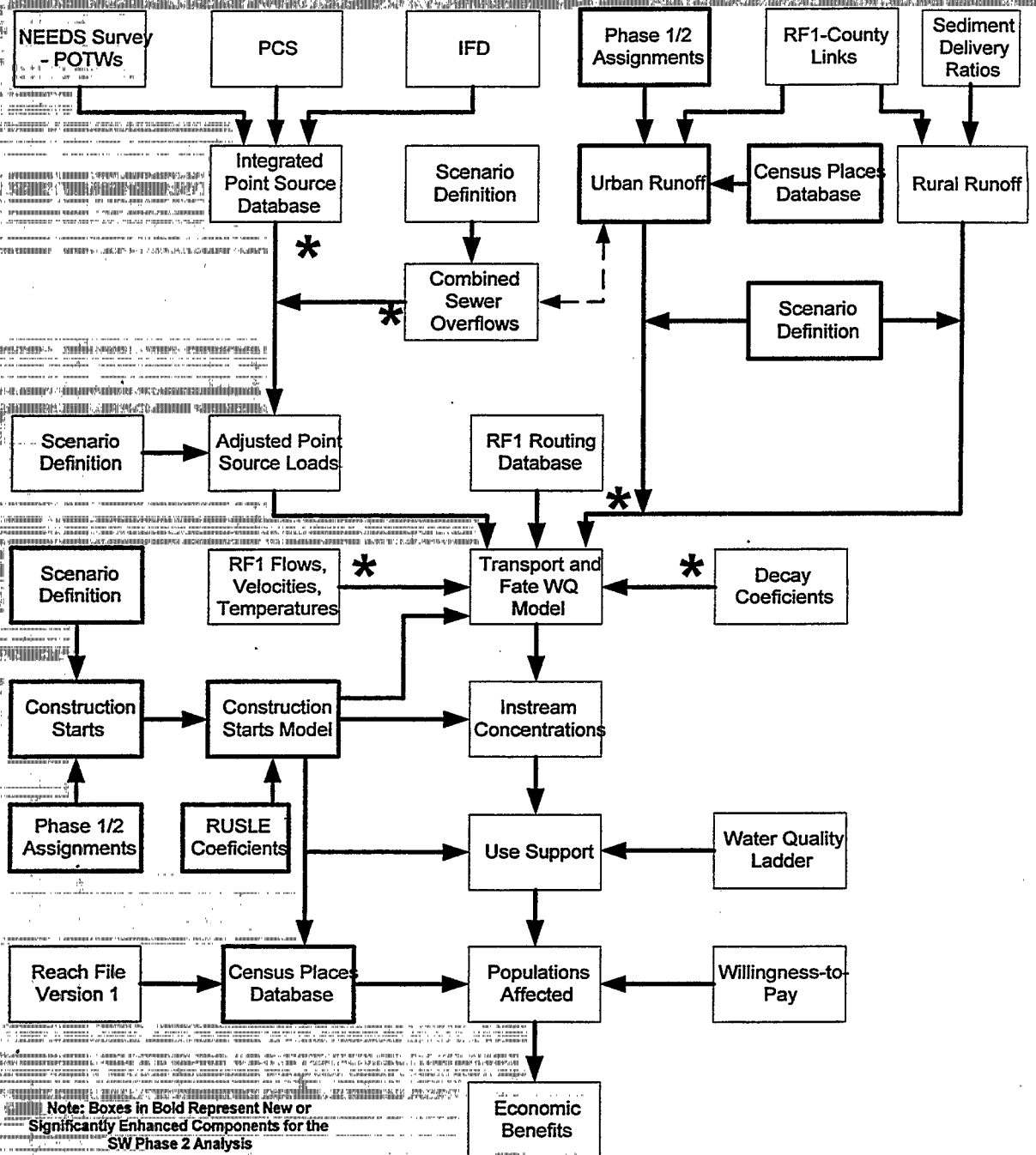


Fig 1. National Water Pollution Control Assessment Model Components

Transport

RF1

The EPA Reach Files are a series of hydrologic databases of the surface waters of the continental United States. The structure and content of the Reach File databases were created expressly to establish hydrologic ordering, to perform hydrologic navigation for modeling applications, and to provide a unique identifier for each surface water feature, i.e., the reach code. Reach codes uniquely identify, by watershed, the individual components of the Nation's rivers and lakes.

RF1 contains approximately 632,000 miles of rivers, streams, and larger lakes. There are approximately 68,000 reaches, of which approximately 61,000 are transport reaches (i.e., water flows down them) with an average length of about 10 miles. The remaining 7,000 reaches are nontransport reaches (e.g., shorelines).

Estimates of mean and low flows and velocities for each transport reach in RF1 have been developed by Grayman (1982). The estimates for mean summer flows and the corresponding velocities were adjusted using mean monthly flow estimates for RF1 reaches (Grayman, 1982). This data provide the basis for the pollutant mixing and routing components of the NWPCAM.

Routing

RF1 has a very powerful routing design ideal for upstream and downstream. This routing design works reach by reach, requiring no more than one Reach database record to be "in memory" at a time and can be set up to run quite rapidly.

There are four fundamental variables involved in the routing design. The basic routing variable is the Hydrologic Sequence Number (SEQNO). This variable gives the order in which reaches are processed. Figure 2 shows a simple river network schematic with the SEQNOs labeled on each Reach. In addition to the SEQNO, three other variables are essential to the routing design, LEV, J, and SFLAG. LEV is the stream level. A mainstem would have a LEV=1, a tributary off of that would have a LEV=2, a tributary off of that a LEV of 3, etc. In RF1, the maximum LEV is 10. In the routing design, the LEV is, in effect, the array subscript for holding accumulated

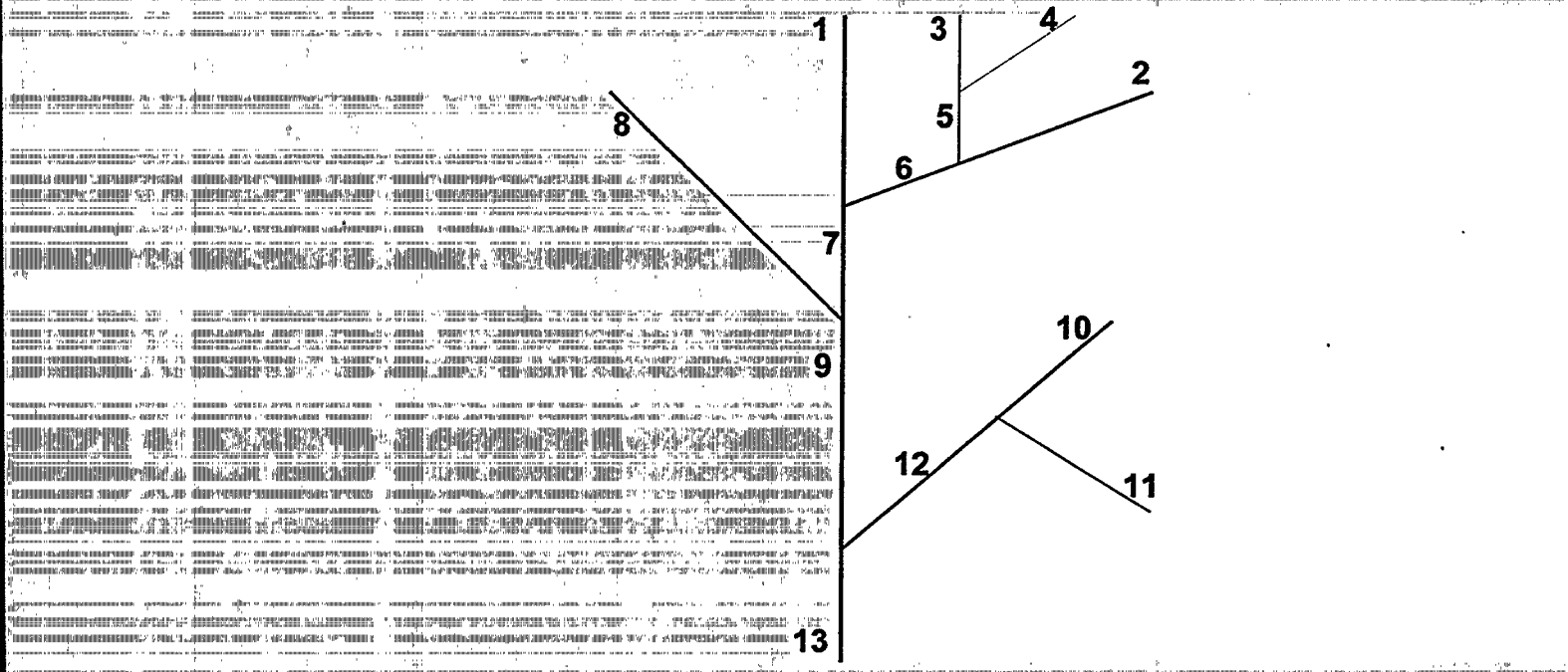


Figure 2. Hydrologic Sequence Numbers.

values as you move down the network. An array of these values is maintained, carrying the values downstream. J is the LEV of the Reach downstream. If J > 0 and J = (LEV-1), then it indicates when the given Reach is the end of a level path and that the accumulated values from the current LEV need to be added to the values of the lower LEV. SFLAG is a flag that indicates if a Reach is a "start" Reach, i.e., no Reaches are upstream of it. If SFLAG = 1, then it is a start Reach. The basic routing algorithm is shown in Figure 3.

Computational Elements

The average length of an RF1 Reach is 10 miles. This is too long to be used as a single computational element; in many cases, the entire effect of a discharger could occur within a 10-mile stretch. Therefore, the reach file for the NWPCAM is broken into computational elements of one mile or shorter. Breaks occur beginning from the head of the reach either at 1-mile increments, at major dischargers, or at the end of the reach. For instance, if a reach is 5.25 miles long with a major discharger at 3.75 miles from its head, it is broken into six segments: three 1-mile segments at the upstream end of the reach, a 0.75-mile segment, another 1-mile segment,

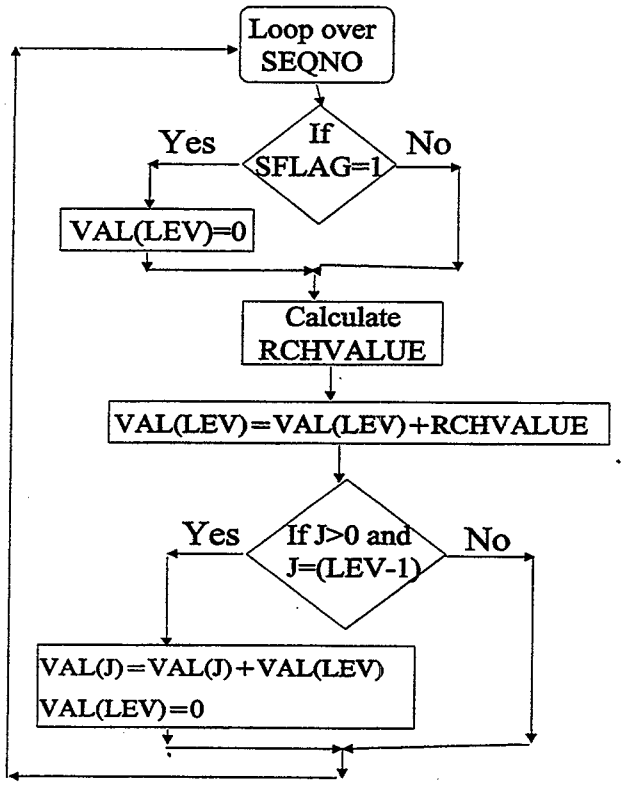


Figure 3. The Basic Routing Algorithm

and one 0.5-mile segment at the downstream end of the reach. This means that the new Reach File contains many more reaches than the original RF1. While the original RF1 contains approximately 61,000 routing Reaches, the expanded RF1 contains approximately 655,000routing elements. The routing variables, i.e., SEQNO, LEV, J, and SFLAG are set for each segment so that the same routing algorithm described above still works for this expanded Reach File.

Pollutant Loadings

Point Source Loadings

The point source data are from EPA databases (U.S. EPA, 1990; Tetra Tech, 1993). Two sources for point source loadings were available: (1) the NEEDS88, which contains BOD_5 and TSS loadings for virtually all municipal wastewater treatment plants in the United States, and (2) the PCS, which contains data from the National Pollutant Discharge Elimination System (NPDES) Discharge Monitoring Reports. If data were available from both NEEDS88 and PCS, the PCS data for 1990 were used.

The lack of minor dischargers (representing many thousands of dischargers) was considered a significant issue in the first versions of the model. Loadings data for minor industrial dischargers is not consistently available in PCS. On advice of PCS staff, only major point source loadings can be considered comprehensive. A third source of point source data, the IFD database, is used in conjunction with PCS to estimate loadings for minor dischargers. For many minor dischargers, IFD contains data on the type of industry, represented by the Standard Industrial Classification (SIC) code, and in many cases the wastewater flow. To develop loadings estimates for minor dischargers based on this data, a methodology is adapted from techniques first pioneered by the National Oceanic and Atmospheric Administration (NOAA) staff for estimating loadings in coastal areas. This methodology uses what data is available to compute Typical Pollutant Loadings (TPLs) and Typical Pollutant Concentrations (TPCs) by pollutant (TSS and BOD5), 2-digit SIC code, and major/minor classification. TPLs and TPCs represent median concentrations and loadings, respectively, that can be expected from a given industrial sector. These are used to estimate the loadings from dischargers for which no loadings are available. TPLs and TPCs are computed as the median loading or concentration, respectively, with a threshold requiring at least eight observations to produce a TPL or TPC.

The TPLs and TPCs are then merged with the IFD inventory of dischargers. If there is a valid TPC, then the loading is estimated by multiplying the TPC by the wastewater flow in IFD. If there is no TPC but there is a TPL, then the TPL is used. In this way, loadings estimates were generated for 24,854 minor dischargers which could be included in the NWPCAM.

NPS and Urban Loadings

NPS loadings are based on county-level loadings for BOD_5 and TSS that were developed for 1990 and 1972 (Lovejoy, 1989; Lovejoy and Dunkelberg, 1990). The annual loadings are allocated to reaches by county and type of Reach. The NPS loadings are provided separately for rural and urban areas by county. In this study, to determine loadings for individual places using the urban runoffs estimated by Lovejoy, the 1990 Census of Populated Places data is overlaid on the Reaches, and Reaches that lie within these Populated Places are assigned the urban portions of the loadings. The remaining Reaches are defined as rural and the rural loadings are assigned to these Reaches. RF1 contains the county Federal Information Processing Standard (FIPS) code(s) for each reach. The loadings are allocated proportionally to the total length of stream miles in each county. For instance, if the total length of RF1 rural streams in a given county is 100 miles, then we allocate 1% of the county rural NPS loads to each mile. For stream segments overlapping more than one county, the NPS loads were allocated from each county by assuming an equal proportion of the segment was in each county; if the segment was in two counties, then half of the reach length was assumed to be in each county. For urban NPS loads the allocation is proportional to stream length as well as the population associated with the Reach.

Only a portion of rural NPS loads actually gets into the stream. The allocation of rural NPS loads to each reach depends on the SDR, which can vary greatly by watershed area (Vanoni,

1975). SDRs are estimated for each of the 2,111 watersheds in the NWPCAM. The methodology for developing the watershed-level SDR estimates is covered later in this report. The 37, 005 point sources in the model are linked to 12,676 different reaches. Figure 4 shows a

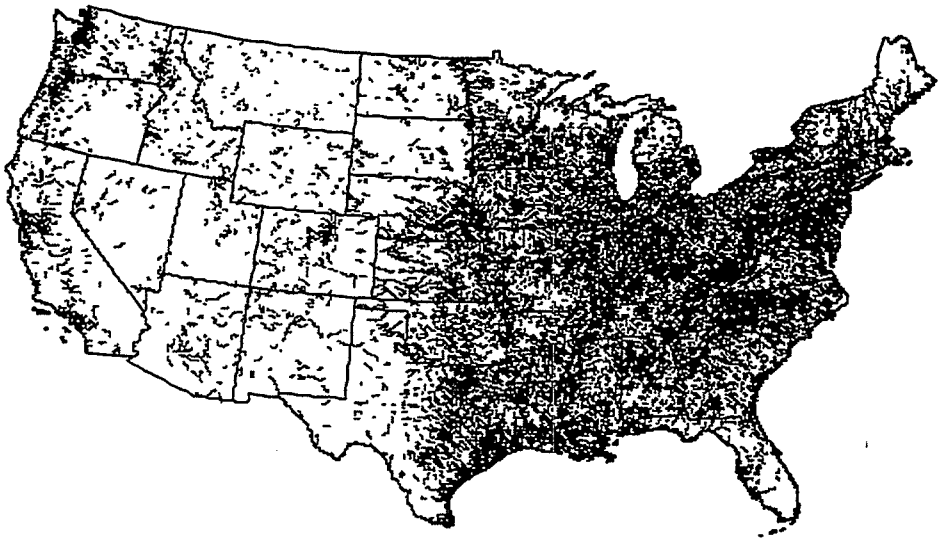


Figure 4. NWPCAM Reaches with Point Sources

map of the reaches that have point sources. This map shows the distribution of point sources across the U.S. The pattern is as one would expect, with most of the point sources lying in the eastern half of the U.S. with the exception of concentrations located around major cities on the West coast.

Construction Site Loadings

The construction site loadings of TSS are based on a methodology developed by the Corps of Engineers for USEPA/OWM. This methodology uses the Revised Universal Soil Loss Equation. The revised soil loss equation determines the magnitude of loadings taking into consideration rainfall, soil Erodability, slope, farming preconstruction conditions and the application of best management practices. The coefficients (Table 2) used in the RUSLE are:

R - Rainfall Erosivity
K - Soil Erodability
LS - Topographic

C - Cover Management; Includes 2 BMPs: #1=Seeding, #2=Seeding and Mulching

P - Support Practice; Includes BMPs Such as Straw, Sediment Traps

Table 1. Soil Erosivity, Erodibility, Topography, Cover Management and Support Factor Variable Values

Representative City	R	Pre-Cons. K	Construct. K	LS	Pre-Cons. C	Construct C	Seeding C	Seed & Mulch C	Pre-Constr. P	Constr. P	STRAW SDR	Silt Trap SDR	STONE SDR	Sedm. Trap SDR
Hartford	130	0.27	0.34	1.06	0.283	0.878	0.44	0.261	1	1	0.65	0.49	0.3	0.4
Duluth	95	0.27	0.34	1.06	0.225	0.873	0.666	0.362	1	1	0.65	0.49	0.3	0.4
Las Vegas	8	0.27	0.34	1.06	0.04	0.809	0.458	0.139	1	1	0.43	0.4	0.3	0.4
Charleston	400	0.27	0.34	1.06	0.359	0.917	0.546	0.295	1	.1	0.8	0.66	0.3	0.4
Bismarck	50	0.27	0.34	1.06	0.206	0.844	0.655	0.345	1	1	0.58	0.45	0.3	0.4
Helena	14	0.27	0.34	1.06	0.16	0.827	0.655	0.379	1	1	0.41	0.4	0.3	0.4
Atlanta	295	0.27	0.34	1.06	0.34	0.898	0.578	0.385	1	1	0.76	0.61	0.3	0.4
Denver	40	0.27	0.34	1.06	0.214	0.841	0.697	0.365	1	1	0.54	0.43	0.3	0.4
Boise	12	0.27	0.34	1.06	0.143	0.818	0.567	0.442	1	1	0.41	0.4	0.3	0.4
Nashville	225	0.27	0.34	1.06	0.34	0.891	0.538	0.408	1	1	0.69	0.53	0.3	0.4
Amarillo	100	0.27	0.34	1.06	0.298	0.859	0.573	0.408	1	1	0.72	0.57	0.3	0.4
Portland	65	0.27	0.34	1.06	0.228	0.864	0.263	0.219	1	1	0.43	0.4	0.3	0.4
Des Moines	160	0.27	0.34	1.06	0.309	0.885	0.643	0.451	1	1	0.69	0.53	0.3	0.4
San Antonio	250	0.27	0.34	1.06	0.361	0.877	0.536	0.434	1	1	0.77	0.62	0.3	0.4
Fresno	12	0.27	0.34	1.06	0.113	0.822	0.251	0.202	1	1	0.4	0.4	0.3	0.4

The coefficient values used for these variables in determining loadings are presented in the Appendix. In the COE methodology, the RUSLE coefficients are defined based on climatic zones indicated by 15 "Representative Cities" to account for the impact of climatic differences, and the BMPs to be considered. To determine the boundaries of the climatic zones represented by these "Cities" Major Land Resources Areas/Regions are used in this study. As a result, the "Representative Cities" are linked to Major Land Resource Areas so that all of the construction sites can be assigned the appropriate coefficients to incorporate the impact of the climatic differences in estimating loadings. Figure 5 shows a map of the MLRAs and the corresponding "Representative Cities" assigned to each city; this is used as a GIS overlay on the construction sites locations to determine each site's RUSLE coefficient. The construction sites loadings are based on a list of 19,427 communities for 1998 in the continental U.S. with estimates of numbers of construction starts/sites of 509,272 (Table 3), by the following size ranges:

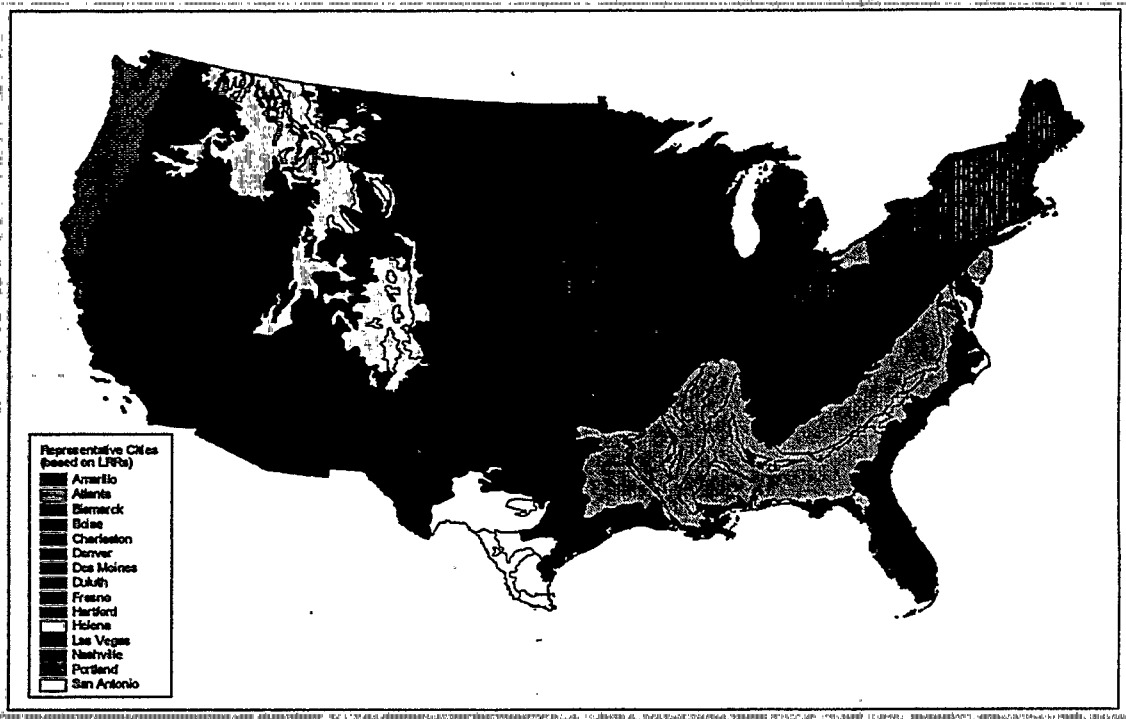
0 - ½ Acre
½ - 1 Acre
1 - 2 Acres
2 - 3 Acres
3 - 4 Acres
4 - 5 Acres
5 + Acres

Table 3. Number of Construction Sites by Size Range

Size Range (acres)	Phase I and Existing State Programs	Phase II and Unregulated 0-1 Acre and Waived Sites	Phase II Sites
0 - ½	11,092	46,015	N/A
½ - 1	11,889	45,317	N/A
1 - 2	33,255	5,685	58,702
2 - 3	19,228	3,241	29,305
3 - 4	11,665	1,701	15,676
4 - 5	13,187	2,428	16,364
Greater Than 5	184,520	N/A	N/A
Total (509,272)	284,836	104,389	120,047

Figure 5.

Major Land Resource Areas of the Lower 48 States



The number of construction sites and the communities is based on the construction site[3] database which was developed by EPA for economic analysis. This database provides a list of 19,427 communities with estimates of the number of construction starts/sites in each community. A database containing the exact location of each construction site in a community does not exist at the national level. Moreover, it is impossible to develop such a database. Therefore, these communities are treated as point sources of construction loadings in the model. The loadings are estimated on the basis of the RUSLE equation for each community. Construction site TSS loadings are determined as follows:

1. Calculate Site Unit Load (SUL) in Tons/Acre/Year for each size range:

$$SUL_{Size} = ® * K * LS * C * P)_{PreC} / 2 + ® * K * LS * C_{BMP} * P_{BMP})_{Con} / 2$$

The COE methodology assumes 6 Months of pre-construction activity followed by 6 Months of construction activity. Therefore, this equation has two separate components associated with preconstruction and construction conditions. The unit load for each site varies depending on the site location according to the climatic zones and the BMPs applied. If no BMPs are applied on a site then the corresponding variable value remains constant indicating no reduction in loadings.

2. Calculate Total Sediment Loadings (TSSL) for each community in Tons/Yr:

$$TSSL_{com} = \sum(SUL_{Size} * nsites * Size^{4})$$

Table 4 presents the estimates of the construction site TSS loadings by size range for the "baseline" and the Phase II scenario conditions The table also shows the percent reduction in TSS loadings by size range. The reductions only occur for sites in the 1-5 acre range (the scope of Phase II rule), and reflect application to only those sites that are not covered by existing equivalent state program to control sediments or have an "R" factor less than 10.

[3]The distribution of Phase II construction sites by size is presented in the Economic Analysis of the Final Phase II Storm Water Rule, 1999. The distribution and total number of sites presented in the Economic Analysis (110,223) is slightly different from the distribution and total of sites used in this study because the waiver was based on a slightly different data set.

[4]For estimating TSS loadings, mid values of the ranges, and 10 acres (assumption) for greater than 5 acres sites are used.

Table 4. Construction Starts TSS Loadings in Thousand Tons/Year

Size Range (ac.)	Baseline Loadings	Phase II Loadings	Phase II Effectiveness[a] (% Net Reduction)
0 - ½	404	404	0%
½ - 1	1,185	1,185	0%
1 - 2	3,506	1,566	55%
2 - 3	2,893	1,377	52%
3 - 4	2,230	1,065	52%
4 - 5	2,951	1,453	51%
5 Plus	18,418	18,418	0%
Total	31,587	25,468	19%

a. Construction sites greater than 5 acres (Phase I sites) and less than 1 acres are not regulated by the Phase II rule, therefore zero is shown for the aggregate effectiveness/impact of the program in reducing over all loadings at the national level.

In estimating reduction in TSS loadings due to Phase II soil and erosion control, construction starts/sites presented in the following states because of equivalent programs are excluded.

- Connecticut (all sites)
- Delaware (all sites)
- District of Columbia (all sites)
- Georgia (two-to five-acre sites)
- Maryland (all sites)
- Michigan (all sites)
- New Hampshire (two- to five-acre sites)
- New Jersey (all sites)
- North Carolina (all sites)
- Pennsylvania (all sites)
- Puerto Rico
- South Carolina (all sits)
- West Virginia (three- to five-acre sites)
- Wisconsin (three- to five-acre sites)

In addition, due to the Coastal Nonpoint Pollution Control Program all construction sites in states of Florida and Rhode Island and sites in CZARA countries in Alaska, Massachusetts, the Virgin Islands and Virginia are excluded. However, these sites are included in estimating the baseline loadings presented in this table.

"Small Streams" Modeling

Construction sites loadings are routed to the overall NWPCAM/RF1 framework by assuming a "small stream" into which the loadings are placed. For each community of construction sites, one small stream is assumed to transport loadings. Thus, 34,500 miles of small streams are added to the water stream network. The rationale for this "small stream" development is that many, if not most, construction sites are on smaller streams that are not in the RF1 network. As a starting point, the length of each small stream is assumed to be the distance of the given construction site community Latitude/Longitude coordinate to RF1. The flow in this stream is estimated in a two-step process. The first step is to estimate the drainage area as a function of the length of the stream. Data from "The Water Encyclopedia" (van der Leeden et. Al., 1990) contains analysis of stream lengths, stream orders, and drainage areas.
Using this data, a log-log regression fits the table quite well ($R^2 = 0.9998$). The resulting formula for estimating drainage area as a function of length is:

$$D.A. = 1.086 * L^{1.868}$$

where

D.A = Drainage Area in sq. Mi.,
L = Length in Miles.

The next step is to estimate an average summer flow in cfs/sq. mi. This was done by analyzing the mean summer flows at the headwater reaches in RF1. Separate unit flows were developed for each of the 329 USGS Accounting Units (the 6-digit watersheds). The headwater drainage areas of the RF1 reaches was estimated by dividing the total lengths of headwater reaches by the total reach lengths. The unit flows were then derived by dividing the total headwater reach flows by the estimated headwater drainage areas. This produces estimates of unit mean summer flows in cfs per sq. mi.

Thus, given a length, a mean summer flow is estimated for each construction site. A minimum length for the small streams is set at 1 mile. This minimum is selected for 2 reasons: (1) 1 mile is the standard computational element length in the NWPCAM system; and, (2) the analyses of stream sizes and orders in "The Water Encyclopedia" finds that the average order 1 (headwater) stream length is 1 mile. Stream velocities and depths are estimated using the same techniques as for the rest of the NWPCAM/RF1 reaches. Background concentrations for TSS are assumed for each "small stream" based on an analysis of STORET ambient water quality data. The mean annual loadings from the construction sites are placed into the "small stream", then decayed and routed to the RF1 reach. These routed loads are then used in the NWPCAM/RF1 framework.

For each "small stream", a use support under the given conditions is computed by comparing the modeled concentration of TSS at the midpoint to the RFF Water Quality Ladder criteria

presented in the Use Support section. Each "small stream" therefore has an associated length and use support, which is then included with the rest of the NWPCAM/RF1 tables that summarize miles by use support. Finally, the majority of these "small streams" are directly linked to the same Populated Places/MCDs used in the economic analyses, so that the "small streams" are fully integrated into the modeling of water quality impacts of the Phase II controls.

4. Using a database combining Census Populated Places and Minor Civil Divisions, 19,378 (99.7%) of these named communities were linked to Populated Places/MCDs with Latitude/Longitude Coordinates.3. Similarly, loadings for each community are linked to the NWPCAM/RF1 framework.

Development of Baseline

To measure the impact of the Phase II rule, it is essential to develop the baseline. The baseline is not exogenously given for measuring additional improvement in water quality, therefore the model needs to develop it. From the baseline, further controls of the Phase II are applied. Additional improvement is measured by the difference of the projected baseline water quality and the resultant water quality due to Phase II rule. The model incorporates the minor and major industrial point sources, municipal point sources POTW loadings, and rural loadings primarily from agriculture. For individual places the model first derives the loadings based on the Lovejoy county level estimates and then employs the applicable controls to determine the magnitude of ultimate loadings. The NWPCAM estimates baseline loadings on the basis of following conditions:

1. All CSOs are controlled by detention basins and assume 85% capture of the runoff (the 85% capture is based on NEEDS Survey assumptions),
2. Detention basin controls are at each of the 1,723 individual NWPCAM Phase I urban sites and assume 85% capture of the runoff,
3. Construction sites BMPs are in place based on existing state and Coastal Zone Authorization Act Amendment programs, and
4. Construction sites BMPs are in place at sites greater than 5 acres.

The Phase II scenario conditions take the baseline conditions and further impose:

1. Detention basin controls at each of the 5,038 individual NWPCAM Phase II urban sites and assume 85% capture of the runoff, and
2. Construction sites BMPs are in place at sites between 1 and 5 acres with an "R" factor > 10 or not already controlled by existing state programs.

The model normally requires an engineering surrogate for treatment of specific pollutants

contained in discharges, whereas the Phase II program includes structural and nonstructural controls. Therefore, model uses detention basins as a proxy to represent the impact of the municipal program. Based on surveys of existing literature and textbooks (e.g., "Wastewater Engineering", Metcalf and Eddy, 1972) on removal of pollutants from detention basins, the changes in urban runoff loadings due to controls assume 33% removal of BOD5, 60% removal of TSS, and 70% removal of FC. These removal rates can be considered as reasonably conservative median values. The model uses these loadings in determining the impact on water quality. The cumputations are presented in the next section.

Model Computations

Temperature and Saturation Concentration of Dissolved Oxygen

Instream temperature data consists of the mean summer temperatures, by Hydrologic Region, derived the STORET database. This data is used to calculate the saturation concentration of DO. The model then estimates the DO by subtracting the computed DO deficit from this saturation concentration. Table 5 shows the mean summer temperatures and DO saturation concentrations for each Hydrologic Region. As described later, the instream temperatures are used for adjusting several model coefficients. The DO saturation concentration is computed using a multiple regression analysis from EPA's QUAL2e water quality model.

Stream Flows and Velocities

For the NWPCAM, streamflows and velocities for each RF1 reach come from estimates developed by Walter Grayman for EPA (Grayman, 1982). The flows are based on an analysis of USGS gaging station data. For reaches that did not have USGS gaging stations, or did not have stations with an adequate period of record, the flows were interpolated or extrapolated using the relative values for known streamflows versus "arbolate sums." The arbolate sum of a Reach is the sum of all reaches upstream of that Reach. Flow estimates were developed for mean flow, low flow (approximately the 7-day, 10-year [7Q10] condition), and mean monthly flow. For the NWPCAM, a mean summer flow was developed for each Hydrologic Region by averaging the flows from June through October. Table 6 shows the results of the regression of mean annual flow on mean summer flow by Region. The QMULT is the resulting multiplier used to adjust the mean annual flow to a mean summer flow. This mean summer flow is the primary reach flow used for modeling in the NWPCAM.

Table 5. Temperature and DO Saturation

Hydrologic Region	Mean Summer Temperature ©	Saturation Concentration of DO(mg/l)
1	18.50	9.3709
2	22.50	8.6603
3	26.00	8.1137
4	18.90	9.2952
5	21.90	8.7607
6	24.20	8.3870
7	21.00	8.9151
8	27.00	7.9686
9	19.00	9.2764
10	19.00	9.2764
11	22.50	8.6603
12	27.44	7.9061
13	19.60	9.1653
14	13.00	10.5368
15	23.10	8.5621
16	15.00	10.0840
17	13.50	10.4202
18	20.70	8.9677

Table 6. Ratio of Mean Summer Flows to Mean Annual Flows with r^2, by Hydrologic Region

REG	QMULT	r^2
1	0.61570	0.97610
2	0.51487	0.98305
3	0.49160	0.92584
4	1.03010	0.99924
5	0.46148	0.99215
6	0.63766	0.97408
7	0.91831	0.99835
8	0.70271	0.99903
9	1.03865	0.98480
10	1.14324	0.99513
11	0.80123	0.97457
12	0.65310	0.92625
13	1.15050	0.96363
14	1.15698	0.99348
15	1.12585	0.99650
16	0.90159	0.92208
17	1.17489	0.98593
18	0.58765	0.87646

Velocities are based on estimates also developed by Grayman. These estimates are based on a compendium of time-of-travel studies. Velocities for the mean summer condition come from a log-log regression analysis of mean flows versus mean flow velocity by Hydrologic Region. Table 7 shows the results of this analysis.

Table 7. Coefficients for $V = VA(Q^{VB})$, with r^2, by Hydrologic Region

REG	VA	VB	r^2
1	0.22185	0.28841	0.93793
2	0.23365	0.28288	0.94476
3	0.21836	0.29048	0.93925
4	0.22574	0.29507	0.91129
5	0.24173	0.26899	0.90456
6	0.23020	0.28499	0.95693
7	0.22324	0.27796	0.93871
8	0.28393	0.25710	0.94205
9	0.18801	0.30005	0.88882
10	0.22650	0.23037	0.86182
11	0.21718	0.27234	0.87888
12	0.21198	0.27369	0.88289
13	0.20999	0.27549	0.90543
14	0.24428	0.24088	0.88334
15	0.26391	0.17197	0.76953
16	0.21151	0.26507	0.82518
17	0.20565	0.28129	0.91492
18	0.19500	0.30904	0.89871

Stream Channel Geometry

Stream channel geometry (depth and wetted perimeter), which is used for modeling of TSS and DO, is estimated using a "stable channel analysis" developed by the U.S. Bureau of Reclamation (Henderson, 1966). The analysis considers the bed shear in relation to the local depth at each point. The result of the analysis is that, given an assumption for the channel side slope angle, the depth and wetted perimeter can be estimated as functions of channel cross-section area. Cross-section area can be computed by dividing the streamflow by the velocity:

$$AREA = \frac{FLOW}{VEL}, \quad (1)$$

where

FLOW	=	streamflow (ft^3/s)
VEL	=	stream velocity (ft/s)
AREA	=	channel cross-section area (ft^2).

For the NWPCAM, a 35 degree slope side angle is assumed, which is the angle considered "typical" in the exposition by Henderson. Under this assumption, the RF1 reach channel geometry is computed as

Y_0	=	(AREA / 2.86)	=	depth at channel center (ft)
YBAR	=	Y_0 * 0.445	=	mean depth (ft)
P	=	4.99 * Y_0	=	wetted perimeter (ft).

Sediment Delivery Ratios for Rural NPSs

Rural NPSs are modeled as an average annual loading with a SDR applied to each loading. As described earlier, the SDR is a coefficient which takes into account the losses in pollutant loadings as the water and pollutants move from across the land, down smaller streams, and then to the RF1 reach. In the NWPCAM, the relationship described in Vanoni is used for developing SDRs in each of the 2,111 cataloging units (CUs). This relationship provides an estimated SDR as a function of drainage area. The drainage area per mile of Reach is calculated as

$$A_{CU} = \frac{AREA_{CU}}{\sum RCHLENGTHS_{CU}} \qquad (2)$$

where

A_{CU}	=	drainage area (mi^2) per mile of Reach
AREA	=	CU area (mi^2)
$\sum RCHLENGTHS_{CU}$	=	sum of the lengths of reaches in the CU.

The SDR for each CU is then estimated from the log-log plot from Vanoni as:

$$SDR_{CU} = 0.422 * A_{CU}^{(-0.31)} \quad . \qquad (3)$$

Modeling Water Quality Parameter Fate

The fate of the water quality parameter is assumed to be driven by a first-order decay process, based on the following differential equation:

$$\frac{dc}{dt} = K * c, \qquad (4)$$

where

dc/dt = the instantaneous change in concentration
K = decay rate (/d)
c = pollutant concentration (mg/L).

The closed-form solution of this simple differential equation is

$$C_t = C_0 * e^{(Kt)}, \qquad (5)$$

where

C_0 = concentration at time zero
C_t = concentration at time t.

Extensive experience from a large number of studies has shown that this differential equation can be adequate for modeling many of the complex physical and biological processes that take place with many constituents in water. The "trick" to this approach is in selecting the decay rate, K. K is generally based on field measurements, other modeling studies, and/or calibration of the model for a particular river system. For biological processes, K has been found to be temperature-dependent. For the NWPCAM, the temperature adjustments to K have been adopted from EPA's QUAL2e model.

BOD5

BOD5 is modeled using the first-order decay process described above. The decay value, $K_{BODinput}$, is an input variable and can be changed for any given model run. The default decay rate is -0.2/d, with the following temperature correction:

$$K_{BOD} = K_{BODinput} * 1.047^{(T-20)}, \qquad (6)$$

where T = stream temperature (°C).

Total Suspended Solids

TSS is modeled based on a presumed net settling velocity, V_{TSS}, of the particles. Research and literature searches have found a "typical" range for particle settling to be 0.1 to 1.0 m/d. The default net settling velocity, V_{TSS}, used in the NWPCAM is 0.3 m/d, which represents a "fine grain" particle. Using a given settling velocity, and the estimated mean depth of the channel, YBAR, a first-order decay process is developed by estimating K_{TSS} as

$$K_{TSS} = \frac{V_{TSS}}{(YBAR * 0.3048)} \quad (7)$$

Fecal Coliforms

FC is modeled as a first-order decay process with the default decay rate, $K_{FCinput}$, of -0.8/d, with the following temperature correction:

$$K_{FC} = K_{FCinput} * 1.07^{(T-20)}, \quad (8)$$

where

T = stream temperature (° C).

Dissolved Oxygen

DO modeling is dependent upon several interacting parameters: the oxygen demand from organic materials (BOD in this model); the Sediment Oxygen Demand, the reaeration from the atmosphere, and the saturation concentration of DO. The actual modeling is of the DO deficit from its saturation level, which is useful since the RFF Water Quality Ladder used for the calculation of economic benefits uses values for the DO deficit. This modeling approach can be found in various places in the water quality modeling literature. A particularly concise source is *The Temporal and Spatial Distribution of Dissolved Oxygen in Streams* by Dr. Donald O'Connor of Manhattan College.

The Ultimate BOD load is the deoxygenation caused by biochemical oxygen demand. UBOD is estimated from BOD5 by the following relationship:

$$UBOD = 1.46 * BOD5 \quad (9)$$

The Sediment Oxygen Demand, SOD, is a deoxygenation effect caused by the benthic demand of bottom sediments, and is expressed as grams of oxygen per square meter of bottom area per day.

In the NWPCAM, this value varies depending upon whether or not there are point sources on either that reach or on the reach immediately upstream. Reaches affected by point sources are presumed to have a higher SOD because of materials deposited by those point source(s). If there are no point sources involved, the SOD_{input} is set to 0.5 g/m^2/d. If there are point sources involved, then the SOD_{input} is set to 1.5 g/m^2/d. This term is then divided by the ratio of the channel's cross-section area to its wetted perimeter, AREA/P, to get the correct units for concentration of mg/L of O_2 demand. In the NWPCAM, the actual modeling is of loads, so the SOD_{input}/(AREA/P) is multiplied by the streamflow (in m^3/s) to get the correct units for computing SOD in g/s. SOD_{input} is also adjusted for stream temperature. The final formula is

$$S = \frac{SOD_{input}}{(\frac{AREA}{P})} * FLOW * 1.06^{(T-20)} . \quad (10)$$

The reaeration rate per day, K_2, is the reoxygenation rate and represents the atmospheric contribution to replenishing the water with O_2. A slow moving, still body of water will have less reoxygenation than a fast-moving, "bubbly" stream. K_2 has been extensively studied over many years, and various researchers have developed methods for estimating it based on depth and velocity. The NWPCAM uses the method used in EPA's WASP model, which combines the results from three researchers: O'Connor-Dobbins, Owens, and Churchill (Ambrose, 1987). Each researcher's studies tended to be in different ranges of depth-velocity combinations. The general form of the equation for estimating K_2 is

$$K_2 = REAK * \frac{VEL_m^{VTERM}}{YBAR_m^{DTERM}}, \quad (11)$$

where

K_2 = reaeration rate (/d)
VEL_m = velocity (m/s)
$YBAR_m$ = depth (m).

Values for REAK, VTERM, and DTERM values are shown in Table 8. The selection of the specific estimation method for K2 depends on the stream depth-velocity combination in the given reach.

Table 8. Reaeration Calculation Values

	Owens	Churchill	O'Connor-Dobbins
REAK	5.349	5.049	3.93
VTERM	0.67	0.969	0.5
DTERM	1.85	1.85	1.5

The K_2 estimate is then adjusted for temperature as follows:

$$K_2 = K_2 * 1.024^{(T-20)}. \quad (12)$$

The Dissolved Oxygen Deficit, DO_{Def}, is the deficit of DO from the saturation concentration. It is a function of the deoxygenation from UBOD, SOD, and the reaeration as represented by K_2. The formula for computing DO_{def} is

$$DO_{deft} = DO_{def0} * e^{-(k2t)} + \frac{K_{BOD} * UBOD}{K_2 - K_{BOD}} * (e^{-(K_2 * t)} - e^{-(K_{BOD} * t)}) + \frac{S}{K_{SOD}} * (1 - e^{-(K_{SOD} * t)}) \quad (13)$$

where

DO_{def0} = initial DO deficit
DO_{deft} = DO deficit at time t (d)

The actual instream DO is computed as

$$DO = DO_{Sat} - DO_{Def} \quad (14)$$

Use Support

Use support is calculated using a modified version of a water quality ladder developed by W.J. Vaughan for Resources For the Future, by choosing appropriate reference conditions for BOD_5, TSS, DO, and FC that correspond to swimmable, fishable, and boatable quality waters (see Table 9). The RFF water quality ladder parameters are DO, BOD_5, turbidity, pH, and FC. For use in the NWPCAM, two modifications are made to the ladder. First, the original ladder contains pH as a criterion; pH is not modeled in the NWPCAM, so it is not included. The second modification is the substitution of TSS for turbidity (JTU). This is a reasonable substitution, since the original development of the JTU measurements were in terms of controlled TSS

concentrations and the two are directly related. The omission of pH, nutrients, and the other water quality parameters that could influence beneficial uses suggests that the model may overestimate the number of river and stream miles in attainment when any of these other factors are limiting.

The model computes the beneficial use for river and stream segments of one mile or less by: (1) determining the values for each water quality parameter, (2) comparing these values to the reference conditions for meeting each of the beneficial uses, and (3) assigning the beneficial use to the entire segment. Use support for any given computational element is based on meeting of any of the four criteria. For instance, if the FC, BOD5, and TSS limits are met for Swimming, but the limit for DO is met only for Game Fishing, then the computational element is classified as Game Fishing. Every computational element is assigned a use support classification. If any of the criteria is not met for Boating, then the element is classified as "None", indicating no recreational use support.

Table 9. NWPCAM Water Quality Ladder

Beneficial Use	Fecal Coliforms (MPN/100 mL)	Dissolved Oxygen (mg/L) / (% sat.)	5-day BOD (mg/L)	Total Suspended Solids (mg/L)
Drinking	0	7.0 / 90	0	5
Swimming	200	6.5 / 83	1.5	10
Game Fishing	1000	5.0 / 64	3.0	50
Rough Fishing	1000	4.0 / 51	3.0	50
Boating	2000	3.5 / 45	4.0	100

Table 10 is a summary the number of miles meeting the designated uses as defined in the RFF water quality ladder under baseline and Scenario Phase II conditions. Miles are reported for swimming, game fishing, boating, and no support, plus changes in miles in each use category.

Table 10. Summary of Miles Meeting Designated Uses Under Baseline and Scenario Phase II Conditions

Use Support	Baseline Miles (mid-1990s)	Phase II Miles	Change in Miles (Phase II - Baseline)
Swimming, Fishing, and Boating	219,547	223,674	4,127
Fishing and Boating	418,190	422,738	4,548
Boating	480,515	483,451	2,936
No Support	186,589	183,653	-2,936
Total Miles	667,104	667,104	n/a

Economic Benefits

Literature review indicates that the Carson-Mitchell study (1993) represents the best available source of nationally derived values on in-situ and existence services and, thus, is used here to develop the benefits of the Phase II controls for construction sites and automatically designated municipalities. For determining economic benefits, the willingness to pay (WTP) values estimated by Carson and Mitchell are updated to1998 values. The WTP values are $210/household/year for Boatable, $158/household/year for Fishable, and $177/household/year for Swimmable waters. Also, since the populations in the NWPCAM databases are for 1990, the populations are uniformly increased by 8% to reflect the U.S. population growth from 1990 to 1998.

To apply WTP estimates to valuing *local* changes in water quality where only a subset of the waters are affected, Mitchell and Carson (1986) describe three "multipliers." First, a *percent-local* multiplier, which defines the percentage of the stated WTP amount that is applied specifically to water quality improvements in the local area in question. Second, an impairment removal multiplier to describe how WTP changes in relation to the fraction of local water that improves (the stated WTP applies to improvements in virtually all impaired waters). And third, a *population* multiplier, which is simply the size of the population benefitting from the local improvement in water quality.

Percent-local Multiplier: In their survey, Mitchell and Carson asked respondents to apportion each of their stated WTP values between achieving the water quality goals in their own state and achieving those goals in the nation as a whole. On average, respondents allocated 67 percent of their values to achieving in-state water quality goals and the remainder to the nation as a whole. Mitchell and Carson argue that for valuing *local* (substate) water quality changes, 67 percent is a reasonable upper bound for the local multiplier. For the purposes of this analysis the locality is defined as urban sites and associated populations linked into the NWPCAM framework.

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Impairment Removal Multiplier: Mitchell and Carson define a simple multiplier that is essentially the fraction of total local water that is initially below a beneficial use target (boatable, fishable, swimmable) but that would attain the target as a result of a policy change. As a lower-bound approximation, it is assumed that the WTP for partial attainment of the specific targets varies in direct proportion to this multiplier. Therefore, for each beneficial use category, the multiplier is calculated at every urban site that is projected to attain the level of use support as a result of the policy.

Population Multiplier: The affected population is defined as the number of households living in the locality of a water quality improvement. The populations are based on the Census populations associated with each urban site in the NWPCAM. For each beneficial use category, if a segment of RF1 or "small stream" attains the level of use as a result of the policy and falls within the defined boundaries of a populated place, then each household within the populated place is included in the multiplier.

The local economic benefits analyses use a definition of "local" that differs from the original Mitchell-Carson Survey, which considered "local" as "state". In this analysis, "local" waters are defined as reaches that are located near each of the enhanced population locations. The definition of "local" depends on whether it is a Census Populated Place or an MCD. For Populated Places, a circle with an equivalent area to the Place was drawn, centered on the Place Lat/Long coordinate as given by the Census Bureau. Any RF1 reaches that fell in whole or in part within that circle is considered "local" to that Place. For MCDs, the closest RF1 reach is considered the "local" water. "Local" benefits are computed based on use support changes on the RF1 reaches that are "local" to each population location. The totals for miles and economic benefits also fully incorporate the construction sites "small streams" results.

Table 11 shows the total number of households that are associated with the "local waters" that reflect increases in use support. The number of households is computed by dividing the population by 2.62, which is the average household size. Note that even though the miles that change use support is a small percentage of the total miles in the NWPCAM, the numbers of households "associated with these changes is quite significant. Resultantly, the magnitude of the economic benefits is also significant because the greater is the number of households associated with local waters the greater is the magnitude of economic benefits according to the economic theory for environmental goods.

Table 11. Households Associated with "Local" Waters that reflect Increase in Use Support Under Phase II Rule

Use Support	Households (millions)
Swimming, Fishing and Boating	24.2
Fishing and Boating	25.7
Boating	23.4

To apply Mitchell-Carson results to value *nonlocal* water quality changes, a similar approach is used. For each category of beneficial use, the fraction of WTP that is assumed to be for local water quality changes only (67 percent) is deducted, which leaves 33 percent (of total WP to attain each use target) for nonlocal water quality changes. This value is multiplied by the fraction of previously impaired national waters (in each use category) that attain the beneficial use as a result of the policy. To measure aggregate national WTP for nonlocal water quality improvements, we then multiply this value by the total number of households in the U.S. Using the methodologies described above, Table 12 summaries the local and nonlocal benefit estimates due to Phase II controls.

Table 12. Local and Nonlocal Benefits Estimates Due to Stormwater Phase II Controls

Use Support	Local Benefits ($million/yr)	Nonlocal Benefits ($million/yr)	Total Benefits ($million/yr)
Swimming, Fishing, and Boating	306.2	60.6	366.8
Fishing and Boating	395.1	51.9	447.0
Boating	700.1	114.6	814.7
Total	1,401.4	227.1	1,628.5

The total estimated benefits of Phase II controls for 120, 047 construction sites and 5,038 automatically designated municipalities in urbanized areas are $1,628.5 million per year. It is worthwhile to note that while the numbers of miles that are estimated to change their use support seem small, the benefits estimates are quite significant. This is because the vast majority of the water quality changes occur where the people live, and the NWPCAM modeling "captures" this phenomenon.

Conclusions

The model estimates that implementation of Phase II controls, without the consideration of post construction controls, will result in an increase of 4,127 swimmable miles, 4,548 fishable miles, and 2,936 boatable miles. The total benefits of Phase II controls for 120,047 construction sites, without the post construction controls, and 5,038 automatically designated municipalities are estimated to be $1.63 billion per year. It is worthwhile to note that while the number of miles that are estimated to change their use support seems small, the benefits estimates are quite significant.

Water quality policy can be broad-based, but the effects are primarily local. A strength of the NWPCAM is that it applies the broad-based policies while also being able to model at the local level. Urban runoff and, to a large extent construction activity, occurs where the people reside. NWPCAM indicates that the changes in pollution loads have the most affect immediately at and a limited distance downstream of the pollution changes. This is because rivers "treat" the wastes (using similar processes that occur in a wastewater treatment plant) as it moves downstream. This means that, for a given stream or river, the "memory" of the pollution in the river can be quite small even 10 or 20 miles downstream. Therefore, controls on the pollution sources mostly improve the water quality near where the controls are in place, which is also where the people live.

The benefits estimates in this analysis are derived using conservative assumptions of the pollution control effectiveness of the Phase II program. The Phase I and Phase II urban runoff controls used in this analysis employ pollutant removals that are characteristic of detention basins. Alternative sensitivity analyses assume different levels of control, such as 60% or 80% pollutant removals for urban run off. Supplemental analyses in conjunction with these assumptions indicate that controls in the 60% to 80% range will increase the economic benefits estimates in NWPCAM by $200 million to $300 million, respectively.

The results can be considered quite robust, since model sensitivity analyses have consistently shown that the benefits estimates are quite stable, even under assumptions of large changes in model input values. As an example, tests were done in conjunction with this analysis assuming that the construction site loads are off by +/- 25%. The resultant local economic benefits estimates show a change of only +/- 5%. It is worthwhile to note that sensitivity analyses performed on the NWPCAM indicate that the system estimates of changes in use support are fairly steady under changes in flow regimes. For instance, a global change of +/- 25% in flow yields a change of approximately +/- 14% or less in miles of change of use support when comparing a scenario to a baseline run. Other tests indicate that the resultant change in economic benefits will be even less that the 14%.

Further work on the NWPCAM could address improved modeling of wet weather runoff events. Some methodologies that could be applied include use of a stochastic process that would

randomize events at various urban sites, using a pattern that reflects the statistical distributions of storm events. Other areas include using the NWPCAM for forecasting by applying growth factors to the loadings; this could be implemented fairly easily once these factors are determined. Another area is evaluation of Total Maximum Daily Load (TMDL) policies. The NWPCAM is unique in being able to integrate most of the individual discharger and watershed-wide processes on a national scale, which can facilitate use for TMDL policy analysis.

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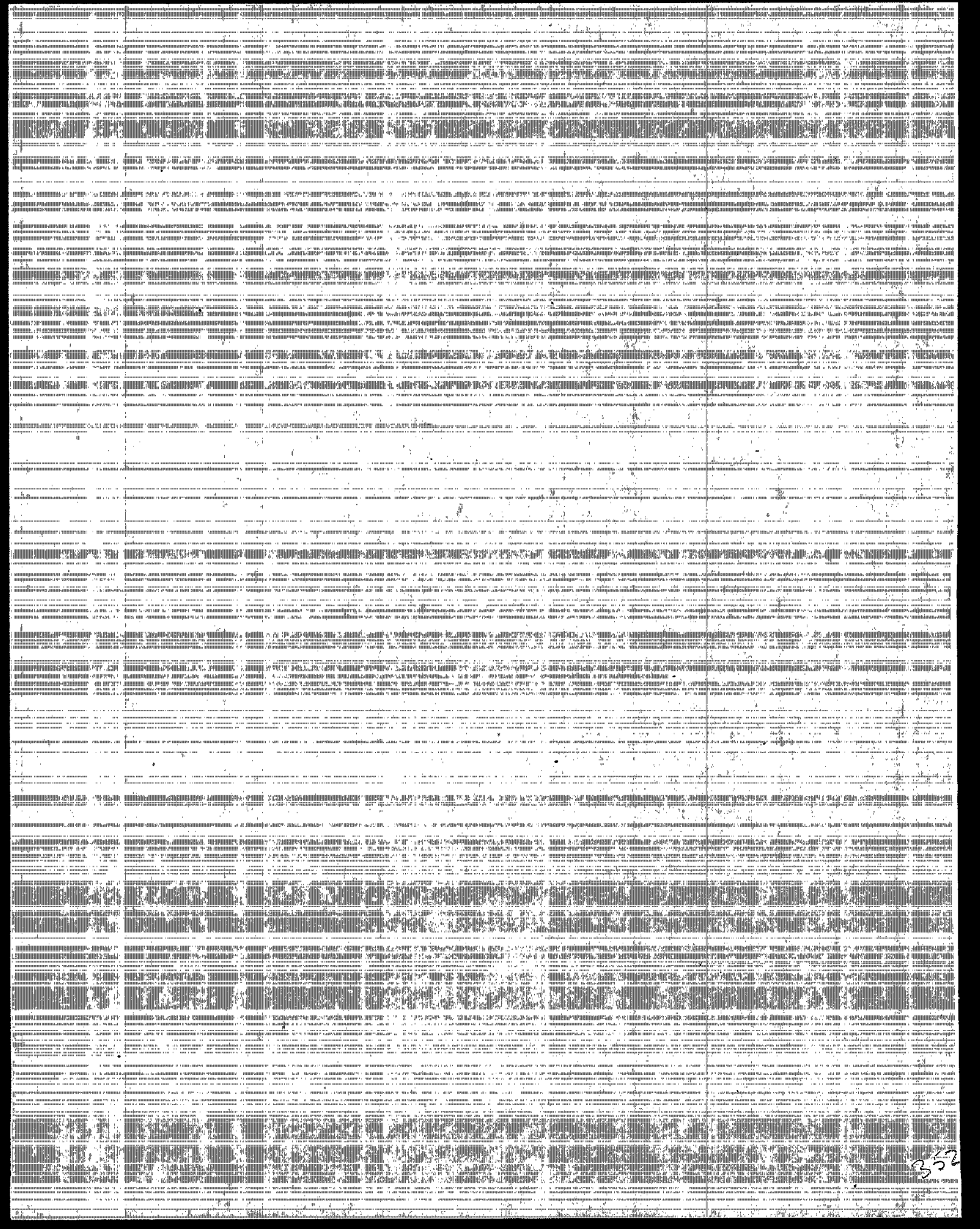
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