The National Residuals Discharge Inventory: An Analysis of the Generation, Discharge, Cost of Control, and Regional Distribution of Liquid Wastes to Be Expected in Achieving the Requirements of Public Law 92-500 (1976)

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An Analysis of the Generation, Discharge, Cost of Control, and Regional Distribution of Liquid Wastes to be Expected in Achieving the Requirements of Public Law 92-500

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Environmental Studies Board
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NOTICE

The project that is the subject of this report was approved by the members of the Study Committee on Water Quality Policy. This report, however, represents the views and opinions of the authors and not necessarily those of either the Study Committee on Water Quality Policy or the National Research Council.

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CONTENTS

FOREWORD

Section 315 of the Federal Water Pollution Control Act of 1972[1] created a National Study Commission (hereinafter referred to as NCWQ or the Commission) to make a full and complete investigation and study of all the technological aspects of achieving certain goals set forth in the Act, and of all aspects of the total economic, social, and environmental effects of achieving or not achieving these goals. Early in the course of its study program the Commission contracted with the National Academy of Sciences, as contemplated in Section 315, for assistance in developing and implementing the Commission's study program. Under this contract, Number WQ 4AC002, dated February 12, 1974, a Study Committee on Water Quality Policy (hereinafter referred to as CWQP, or the Committee) was created to assist, advise, review, analyze, and critique, at the request of the Commission, the formulation, progress, and results of work performed by the Commission staff or under contract to the Commission. To assist in the accomplishment of its assigned tasks, CWQP determined that an independent assessment of residuals generation and discharges and of the costs of reducing residuals discharges was needed. This report, which is submitted to the NCWQ as a supplement to the Committee's report of January 5, 1976, summarizes the work done and reports the findings of the consultants appointed to assist the Committee.

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1 Public Law 92-500, October 18, 1972, 86 STAT. 816, 904, usually referred to herein as the 1972 Act.

CHAPTER 1

INTRODUCTION

The Study Committee on Water Quality Policy requested its consultants and staff to study the regional distribution of activities or sources discharging residuals to the waters of the nation; the magnitude of such residuals; reductions to be expected upon achieving the technological requirements of the 1972 Act; estimates of the distribution of the costs of achieving the requirements; and some illustrative analyses of policy implications of several alternative policies for achieving the water quality objectives of the 1972 Act. These analyses were intended to complement those of the National Commission on Water Quality and to assist the Committee in carrying out its task of reviewing and commenting on the work performed for the Commission and on its Staff Draft Report. Wherever possible, work of the Commission staff and contractors has been used and evaluated in developing the analysis. In addition to serving the Committee's needs, it is hoped that an independent approach will be of value to NCWQ as it moves toward preparation of its own final report.

To carry out this assignment, the CWQP consultants were requested to:

- document the distribution of residuals[1] generation and discharges by region;
- document the distribution of residuals generation and discharges by activity;
- describe the relative importance of residuals discharges from point and areal activities by region;
- document the distribution of residuals discharge reduction costs by region;
- document the distribution of residuals discharge reduction costs by activity;
- indicate the sensitivity of estimates of residuals generation, discharge, and discharge reduction costs to various assumptions;
- evaluate the quality of basic data on residuals generation, discharge, and discharge reduction costs used by the NCWQ contractors and describe other possible data sources; and
- perform special analyses of factors affecting water quality in the Delaware Estuary and Potomac Estuary, in order to show the impact of various management policies on water quality and the

relationship of residuals from point and areal sources to water quality impacts.

To provide a basis for handling the immense amount of data available from the NCWQ contractors' reports, EPA, and other sources, the consultants devised a system for computerized analysis called the National Residuals Discharge Inventory (NRDI). It is important to note that NRDI represents a first effort requiring the use of data of widely varying quality, coupled with many assumptions inherent in such an effort. As set forth in the text, every effort has been made to document the sources, and to make explicit the assumptions. NRDI is viewed as an additional tool which may prove useful in evaluating available information, in structuring inquiry, and in testing possible policy options.

NRDI contains a quantitative assessment of residuals generation and discharge and of the costs of residuals discharge reduction in each of the 3,111 counties in the contiguous U.S. The purposes of making this assessment were: (a) to provide a comprehensive measure of residuals generation and discharge of biochemical oxygen demand (BOD) and total suspended solids (TSS), aggregated for the nation and for each of the Water Resources Council's 18 Water Resource Regions (WRRs) and 99 river basins or Aggregated Sub-Areas (ASAs); (b) to indicate the relative importance of various activities as sources of residuals after BPT/ST and BAT/BPWTT are applied;[2] (c) to provide estimates of the costs of residuals reduction associated with applying BPT/ST and BAT/BPWTT aggregated for the nation, the 18 WRRs, and the 99 ASAs; and (d) to estimate possible cost savings to the nation of pursuing alternative policies. The NRDI analyses include point sources, which are defined as discharges from municipal and industrial activities, and areal sources, which are defined as urban runoff and runoff from non-irrigated agricultural activities.

This report to CWQP describes the compilation techniques of NRDI and the data sources used, and develops findings on the following issues:

- the distribution of the diverse residuals generating activities and types of water-borne residuals in all river basins constituting the continental U.S., and the implications of this diversity;
- the relative effects on a simple measure of water quality of applying BPT/ST and BAT/BPWTT to industrial and municipal activities in each of the river basins;
- the estimated costs to the nation of applying BPT/ST and BAT/BPWTT for industrial and municipal activities; and
- the estimated costs to the nation of pursuing policies other than the imposition of national uniform effluent limitations on industrial and municipal activities.

NOTES

1 "A residual is a quantity of material or energy left over when, in the course of a human production or consumption activity, inputs are converted into outputs. Examples are waste heat from thermal-electric generation and fruit and vegetable trimmings in canning. How do we know what is going to be left over? A widely useful, but not infallible, rule of thumb is simply to identify as products those material or energy outputs that have prices in normally existing markets. Outputs that are not so priced are the residual outputs."
Russell, C. and W. Spofford, Jr. (1972) A quantitative framework for residuals management decisions. In Allen Kreese and Blair Bower (eds.) Environmental Quality Analysis. Baltimore: The Johns Hopkins Press.

2 BPT/ST and BAT/BPWTT refer to the technology definitions for point sources/public owned treatment works to meet 1977 and 1983 effluent limitations, respectively. They are defined as:
point sources,
BPT = best practicable control technology currently available
BAT = best available technology economically achievable
publicly owned treatment works,
ST = secondary treatment
BPWTT = best practicable wastewater treatment technology
NRDI definitions for BPT/ST and BAT/BPWTT are given in Chapters 3 and 4.

CHAPTER 2

NATIONAL RESIDUALS DISCHARGE INVENTORY

The National Residuals Discharge Inventory (NRDI) is a systematic computational system which can be used to investigate a number of issues related to water quality management under P.L. 92-500. The inventory is structured to permit estimates to be made of potential reductions in liquid residuals discharged into the ambient water environment from point and areal sources, and of the associated costs of such reductions under alternative policies. Discharges from designated kinds of point sources can be compared with those from areal or nonpoint sources, primarily urban runoff and non-irrigated agriculture. All computations can be made for geographic units of river basins, defined as either 99 ASAs or 18 WRRS comprising the continental U.S. (Computations can also be made for counties.) Information from NRDI can be used to evaluate policies alternative to the uniform application of residuals reduction technologies to point sources, defined in P.L. 92-500, including investigation of the cost-effectiveness of alternative policies, a criterion explicitly stated in Section 208 of P.L. 92-500.

NRDI is designed to permit an assessment to be made of national water quality management (WQM) policy in a spatial context. To achieve this objective, the computational system must give both comprehensive coverage of the nation and geographically specific information sufficient to depict regional differences. The broad conceptual background for NRDI is the Regional Environmental Quality Management (REQM) model for the Lower Delaware Valley developed by Resources for the Future (RFF) (Russell and Spofford 1972).

A quantitative framework is used for analysis of liquid residuals management (water quality management) problems in river basins covering the contiguous U.S. as a whole, rather than for a particular river basin or region. Some concepts, such as activity modeling of residuals generation and discharge, are the same as in the RFF REQM model. NRDI was not, however, developed to analyze explicitly all types and forms of residuals and the interactions among them. Consistent with P.L. 92-500, its focus is on water and liquid residuals.

NRDI was built upon the following guidelines:

1. NRDI is designed to address a selected set of issues relating to P.L. 92-500, primarily the differential

effects and costs of different effluent limitations as for river basins covering the U.S. as a whole. The issues were clearly defined and then a methodology was developed for addressing them, rather than a methodology developed to find a set of issues. While this decision limits the number of issues which NRDI can be used to address, it does mean that NRDI can more adequately address these particular issues.

2. NRDI is primarily an empirical construction recognizing the complexity of residuals generation and the potential range of impacts. Its use can provide insight into questions of uniformity and diversity. NRDI uses as many data as are available, but it does not attempt to address an issue in a manner more sophisticated than the state of the data and modeling capacity would allow.

3. NRDI is a simple model, as will be evident in the following chapters. It uses only those functional relationships needed to estimate residuals generation and discharge, the costs of residuals discharge reduction, and impacts on water quality. It abstracts from reality to the degree that it does not take into account all possible variations in residuals generation; all possible options for reducing residuals discharges; the increased residuals discharges resulting from specific inter-industry linkages in the economy; the water quality impacts of residuals discharged into a given river segment; and intermedia residuals relationships.

The primary subsystem in NRDI is an activity inventory which identifies the type, quantity, and location of residuals generation per unit of raw material input or per unit of product output (i.e., pounds of organic residuals per barrel of crude oil processed or per ton of pulp) in relation to a given set of material inputs, production technology, product specifications, and factor prices. Similarly, for agricultural activities the quantities and types of residuals generated are associated with such variables as crop type, slope, and soil type. Municipal residuals generation and urban storm runoff residuals generation are based on such factors as population served, per capita water use, life style, population density, frequency of street cleaning, and rainfall. Appropriate residuals discharge reduction technologies are assigned to each generator in relation to the WQM policy being investigated, and the costs are calculated. The specificity of the activity inventory depends upon the importance of each sector within the inventory as a residual generator, and the available data. The NRDI activity inventory assumes that raw material/production process/product output, and the extent of material energy recovery and by-product production as affected by factor input prices, will not change to reduce residuals generation.

The second subsystem is a water dilution index which relates residuals discharged to the available aggregate assimilative capacity in a river basin. The NRDI water quality analysis simply describes the dilution of a specified residual in the ambient water environment without allowing for transformation (i.e., decay) or transportation. The index can then be used to rank order the severity of the impact of residuals discharges on water quality in river basins.

Four points should be made concerning NRDI. First, it is not structured as a direct optimization computational procedure. Rather, it is designed to assess quickly the impacts of alternative specified residuals discharge reduction policies (national WQM policies), as these affect the various residuals generators/dischargers. NRDI does this by computing the quantities and/or the costs of reduction for each discharger or group of dischargers, and the aggregate effect on water quality in each river basin of the resulting discharges. Evaluation of alternatives is based upon the manual integration of a set of modular programs.

Second, except for the costs of dewatering and disposing (landfill) of sludges, NRDI does not account for the modification and discharge of secondary residuals, such as those generated in modifying gaseous residuals to meet air quality management regulations.

Third, although NRDI is not as sophisticated as some models in its evaluation of economic activities which generate residuals, its coverage of residuals, and its water quality model, it was designed specifically for national policy evaluation. NRDI gives a comprehensive description of certain liquid residuals discharges in all areas of the nation. The activities covered include point sources and non-irrigated agriculture and urban runoff. Thus, the magnitude and diversity of the water quality management problem can be characterized for all regions in the nation rather than for just one region.

Fourth, NRDI can include estimates of growth in residuals generating activities to the year 1985. NRDI can be used to evaluate both 1973 conditions and future conditions. Thus, it can aid in assessing the critical issue of whether the nation needs more stringent effluent limitations in order to prevent residual discharges from exceeding 1973 conditions or conditions after application of BPT/ST. The following discussion provides more description of the components of NRDI; detailed discussion is in subsequent chapters.

COMPONENTS OF NRDI

NRDI consists of (a) inventories of production and consumption activities, which generate and discharge residuals; (b) a set of unit residuals modification processes relating costs, flow, and removal efficiency; (c) a model for computing a water quality index; and (d) a system for generating increased industrial production and population growth. With these components, various residuals discharge reduction policies can be investigated, including the enunciated policies in P.L. 92-500. Figure 2-1 relates each of these components; each of the blocks in the diagram is briefly described below and documented in more detail in the following chapters.

Activity Inventories

The activity inventories have two purposes. First, the inventories provide the classification system for relating raw material/production process/product output characteristics to residuals generation coefficients, to calculate residuals generation for a particular activity. Second, the inventories assign both the existing degree of RDR and the appropriate additional RDR technology, as specified under a given policy alternative, thereby enabling the computation of RDR costs and of the residuals discharged into the ambient water environment. The specificity of the individual activity inventories for the above computations depends upon the importance of each activity sector as a residuals generator and upon the availability of data.

The activity inventories include the following: the municipal category includes a sewage treatment plant inventory; the industrial category includes a plant-by-plant inventory for most of the significant process water users and a general industry inventory for the vast majority of other residuals generating industries; and the areal category includes an urban runoff inventory comprising 243 SMSAs and a non-irrigated agriculture inventory of all non-irrigated cropland in the contiguous U.S. by county.

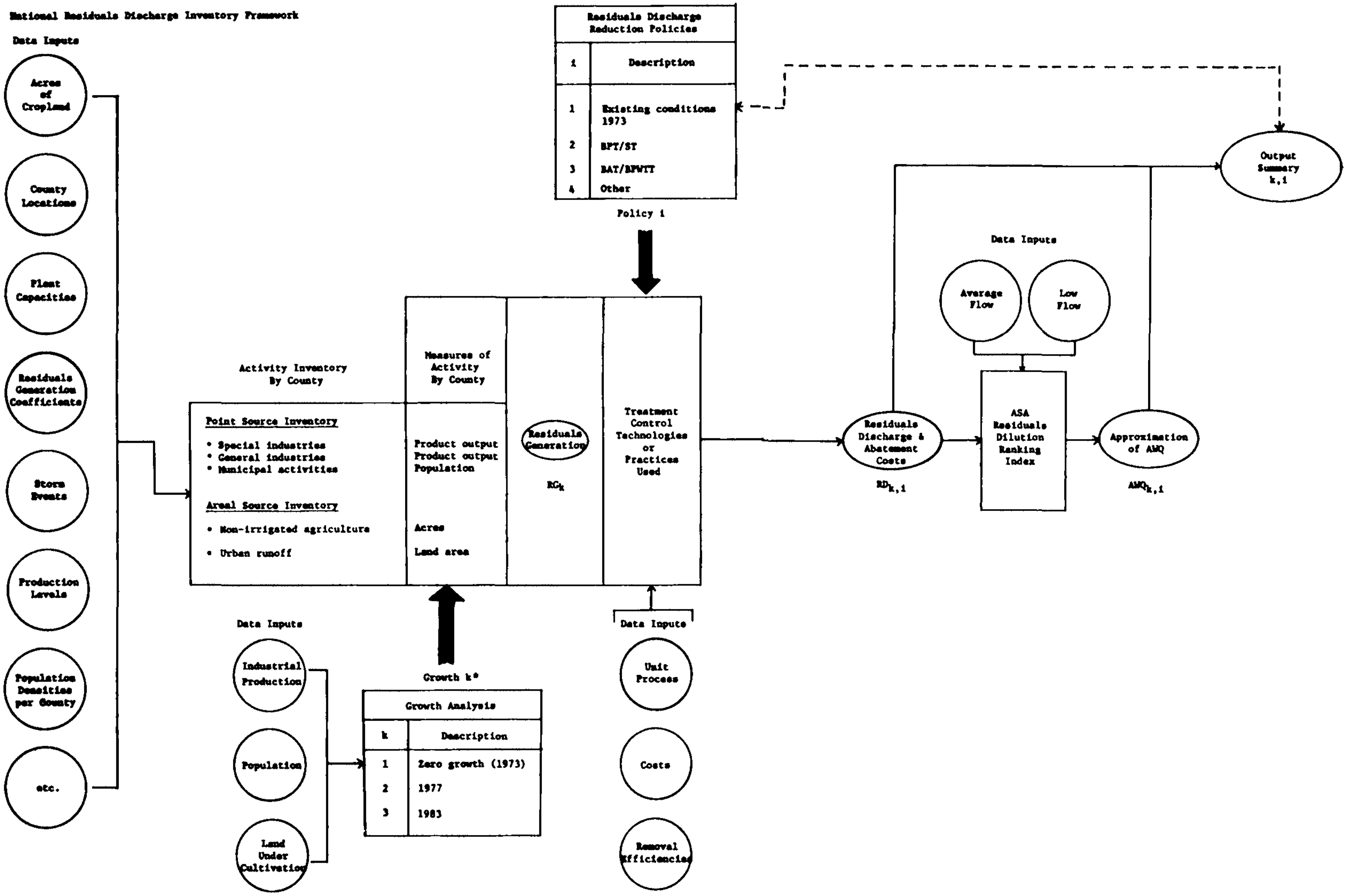
The RDR costs are capital or initial investment costs, i.e., construction costs.

The data input file for activity inventories contains information on identifiable point and areal source residuals generating activities. The point and areal activities combined cover most major waterborne residuals generating activities. Information about these activities, where appropriate and available, includes location of activity, measures of production (physical output, employees, land area, or population), type of production process, product output, and current RDR technologies in place.

For industries this file specifies either residual generation coefficients for each production process within an industry category or, where this information is unavailable, gives an estimate of total residuals generation for the nation for a four-digit SIC category. The coefficients are expressed as weights of residuals per production output unit or per unit of raw material processed (for example, pounds of organic residuals generated per ton

FIGURE 2-1

National Residuals Discharge Inventory Framework



*For most of the analysis performed herein K=1 of pulp or per barrel of crude oil processed). The residuals included are BOD, TSS, and waste water flow.

This input file also specifies the various RDR technologies available for each of the activities. Information specified for each technology or unit process includes capital costs and RDR rates or removal efficiencies. Most of the residuals generation coefficients for the industries studied in depth in NRDI were taken from EPA development documents and, where possible, NCWQ contractor reports. The coefficients were checked against the corresponding SEAS data.[1]

Residuals Discharge Reduction Costs

A set of unit processes for reducing the discharge of residuals from each type of activity was specified, and the costs for different levels of reduction (removal efficiencies) were developed. These cost-reduction relationships were based on wastewater flow[2] and were developed from six different sources. The majority of the functions (27 out of 39) were taken from the Metcalf and Eddy report to NCWQ (see Appendix A). Cost functions relate to BOD and TSS jointly. However, because the sets of unit processes were developed in accord with the processes specified by EPA for BPT/ST and BAT/BPWTT, the costs include, in some cases, those relating to reducing discharges of residuals in addition to BOD and TSS.

Water Quality Index

The purpose of the water quality indexing procedure is to convert the information on residuals discharged into one rough measure of water quality, BOD concentrations. The procedure involves computing the concentration resulting from BOD residuals discharged, using low flow and average flow conditions. The low flow conditions are based upon the average daily flow in the calendar month with the lowest flow in an ASA. Average flow conditions are based upon the average annual daily flow for an ASA. The computational procedure ranks basins according to concentration. Such a ranking may then be used to identify those ASAs in which water quality is relatively better or poorer under current conditions and which may be significantly affected by different water quality management policies. Since the "average" conditions do not reflect a real situation at any given location or time, they cannot be used to attempt to pinpoint specific water quality problems in a sub-basin or stream segment.

Growth Analysis

The purpose of the growth analysis is to project levels of residuals generation and discharge in "1985" or any year to 1985. The projected growth for industry is based on increases in physical output for two-digit manufacturing activities. No regional projections of growth are made; the spatial pattern of industrial growth is assumed to be the same as current production. The projected growth for municipalities is based on population growth rates. Growth is not projected for urban runoff or non-irrigated agriculture activities. Growth projections for industrial and municipal categories are made at the national level only, and are used to evaluate the effect of growth on the conclusions drawn, based upon 1973 conditions, of applying BPT/ST and BAT/BPWTT.

The projected growth for industry is available from either the Wharton Econometric Forecasting Analysis used by NCWQ (Wharton 1975) or the U.S. Department of Commerce, OBERS Series E (U.S. WRC 1974a). The projected growth for municipalities is based on U.S. Department of Commerce, Census Series E population growth rates (U.S. WRC 1974b). Also included could be information on changes in process water use over time, based on such factors as water conservation--through reuse or recycling, technological change, or product output specification change.

Output Summaries

The ASA outputs resulting from analysis of each WQM policy alternative are:

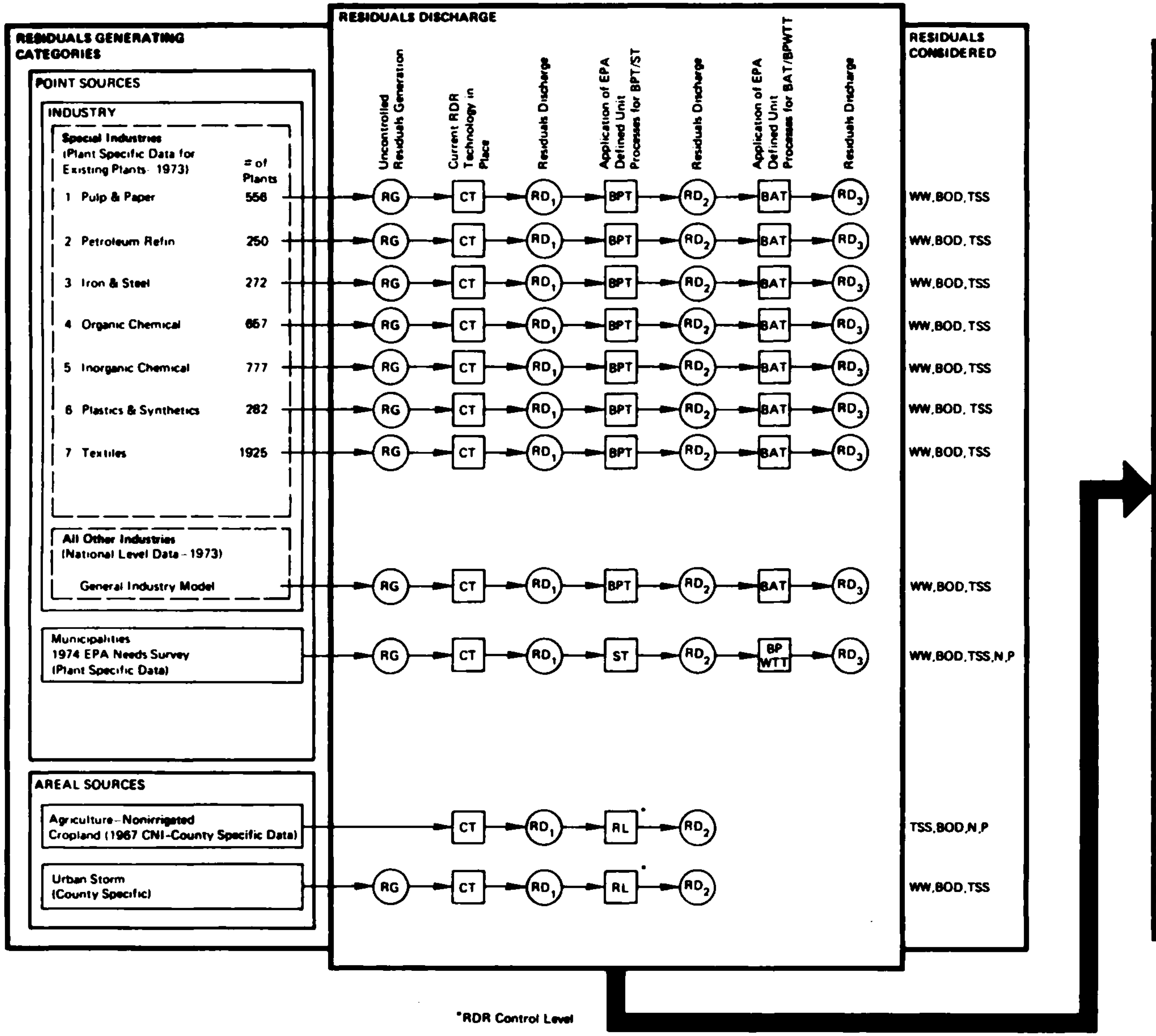
- residuals generation;
- residuals discharge;
- residuals discharge reduction (RDR) costs; and
- water quality index.

These outputs must be taken together to evaluate a given WQM policy, because no one output by itself is an adequate evaluation measure. To provide an idea of the relationship between the input and output data in NRDI, the interaction of the activity inventories and residuals discharge outputs for one ASA are presented in Figure 2-2.

Alternative Policies

The drawing mechanism in evaluating alternative policies with NRDI is a specified WQM policy. The initial policies evaluated are the application of BPT/ST and BAT/BPWTT technological objectives. The BPT and BAT technologies for industrial activities are the EPA defined series of RDR processes for each industrial subcategory. The ST and BPWTT technologies for municipal activities are the series of RDR

FIGURE 2-2
Sample Residual Discharge of NRDI



*RDR Control Level

ASA RESIDUALS DISCHARGE SUMMARIES

Sample: ASA #8

UNITS
WW expressed in MGD
BOD,TSS expressed in 1000= D

Residuals Generating Categories	Residual	RG	RD_1	RD_2	RD_3
Point Sources					
Pulp & Paper	WW	44 3	44.3	44.3	44 3
	BOD	84.1	81 0	8.4	4.2
	TSS	206.0	195.3	16 5	6.2
Organic Chemicals	WW	.8	.8	.8	.8
	BOD	50 7	50 7	4.8	1.0
	TSS	0	0	0	0
Petroleum Refin.	WW	5 4	5.4	5.4	5 4
	BOD	4.3	2.9	.2	1
	TSS	1.1	5	0.0	0.0
Iron & Steel	WW	6.4	6.4	6.4	6.4
	BOD	0.0	0.0	0.0	0.0
	TSS	13 7	13 7	3.8	0.0
All Other Industry	WW	690.2	690.2	690.2	690.2
	BOD	3584 0	3584.0	358.4	179.2
	TSS	3030.8	3030.8	303.1	151.6
Municipalities	WW	1821 9	1821.9	1821.9	1821.9
	BOD	3018.8	1321.7	482 9	241 5
	TSS	3051.8	1329.3	570.0	285.0
Point Source Totals	WW	2569.1	2569.1	2569.1	2569 1
	BOD	6741.8	5040.1	854.7	426 0
	TSS	6303.4	4569.7	893.4	442.7
Areal Sources					
Agricultural (Nonirrigated)	TSS	N/A	233.3	145.7	145 7
	BOD	N/A	31.6	19.4	19.4
ASA Totals					
	WW	2569.1	2569.1	2569.1	2569.1
	BOD	6741.8	507.2	874.1	445.4
	TSS	6303.4	6902.7	2350	1899

technologies specified in the 1974 Needs Survey (U.S. EPA 1975) for secondary treatment and for levels of discharge reduction greater than secondary treatment, respectively. There are no EPA defined RDR options for either urban runoff or non-irrigated agriculture.

Any of a number of other policies can be evaluated using NRDI. For example, one policy assumes technological options for reducing residuals discharges from urban runoff and non-irrigated agriculture. The RDR options for urban runoff are two sets of RDR technologies identified by NCWQ contractors. The RDR option for non-irrigated agriculture is defined as a set of conservation practices identified by the U.S. Department of Agriculture, as reported by an NCWQ contractor. A second policy exempts point source activities from either BPT/ST or BAT/BPWTT requirements if these activities are estimated to be ocean dischargers. A third policy exempts point source activities from BAT requirements if these activities discharge into ASAs with sufficient assimilative capacity to preclude reduction in ambient water quality below specified standards.

DESCRIPTION OF GEOGRAPHIC UNITS OF NRDI

NRDI contains a quantitative assessment of residuals generation and discharge and of RDR costs in each of the 3,111 counties or county approximations in the contiguous U.S. Data in the industrial, municipal, urban runoff, and non-irrigated agriculture inventories are available for each county, if the activity is present in that county. However, the data are not displayed at the county level, but rather are aggregated for purposes of analysis to the Water Resources Council's 99 ASAs (Chapter 8) and 18 WRRs (Appendix B), and for the nation. The ASAs and WRRs are often generically referred to in this report as "river basins," even though the boundaries are primarily along county lines.

The boundaries of the 99 ASAs representing the contiguous U.S. are illustrated in Figure 2-3 and the names of these ASAs are listed in Table 2-1. Along with the names of the ASAs are included data on population and land area. The criteria for delineating ASAs follow.

1. An ASA includes that area drained by: a river system, reach of a river and its tributaries in that reach, a closed basin or basins, or a group of streams forming a coastal drainage area.
2. An ASA is intended to represent a geographic area with common or unique water management problems, such as water supply, water use, or water quality.
3. In addition to drainage area boundaries, each ASA was delineated along those county boundaries which most nearly approximate the drainage boundary.

FIGURE 2-3

WRC Aggregated Subareas with WRR Boundaries

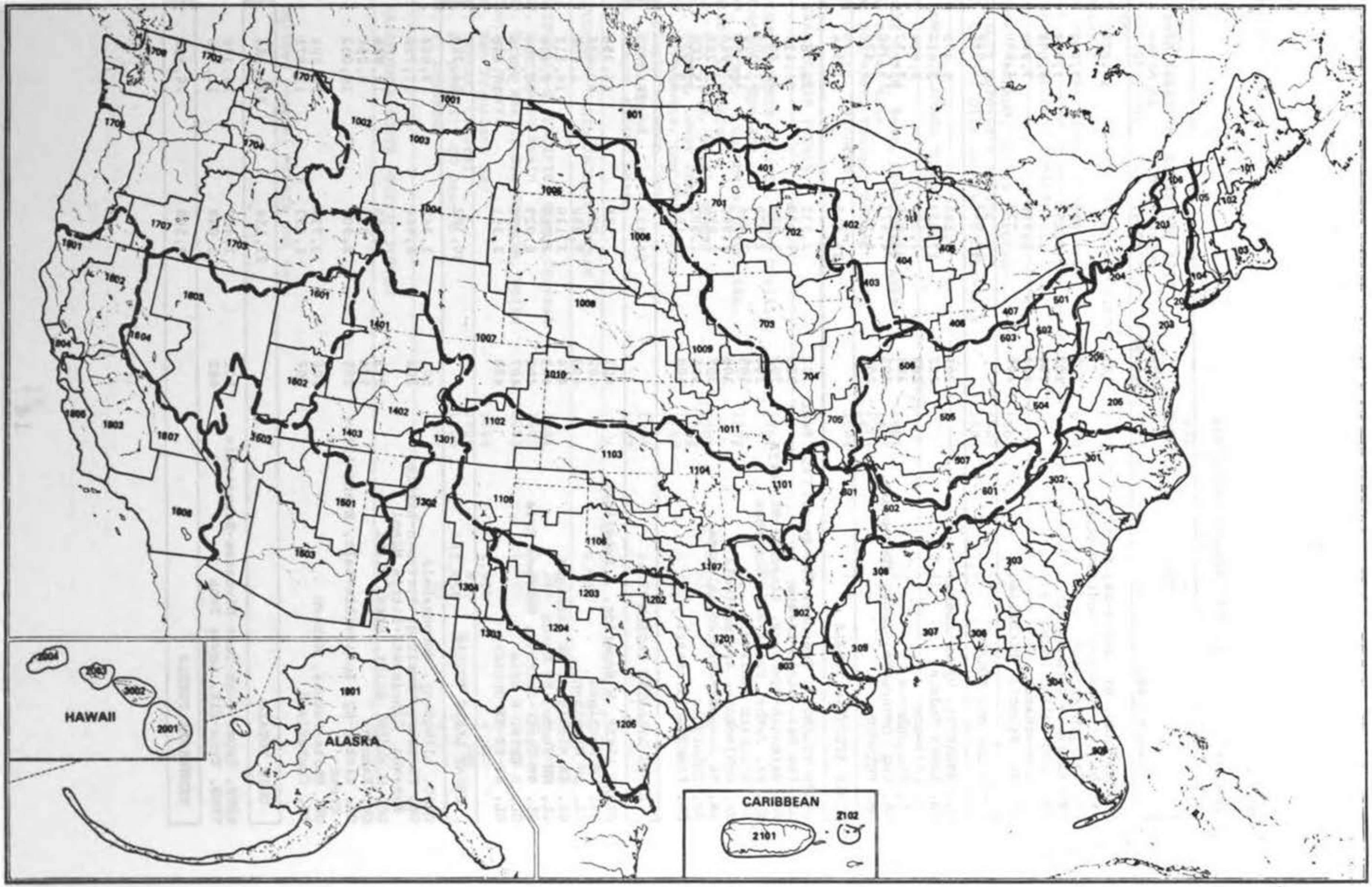


TABLE 2-1

Aggregated Sub-Areas And Water Resource Region Data

Name of ASA	ASA Number	1975 Estimated Population (000)	Total Area in Acres (000)
NEW ENGLAND, St. Johns-St. Croix, Penobscot, Kennebec-Androscoggin	101	667	18,624
NE, Saco, Merrimack	102	921	3,904
NE, Marrmode Is Coastal	103	6,153	3,904
NE, Long Island Sound	104	2,380	3,008
NE, Connecticut	105	1,999	7,808
NE, St. Francis, Richelieu	106	372	4,800
NEW ENGLAND TOTALS		12,492	42,048
MID ATLANTIC, Upper Hudson	201	2,145	9,472
MA, Lower Hudson	202	17,023	2,816
MA, Delaware	203	7,982	9,664
MA, Susquehanna	204	3,676	17,152
MA, Upp Chesapeake, Lower Chesapeake	205	4,673	15,360
MA, Potomac	206	4,113	9,472
MID ATLANTIC TOTALS		39,612	63,936
SOUTH ATLANTIC, Roanoke, Tar-Reuse, Cape Fear	301	3,133	22,784
SA, Pee Dee, Sante-Edisto	302	4,939	26,432
SA, Savannah-Ogeechee, Altamana-St Marys	303	1,973	22,400
SA, St. Johns, Tampa Bay, Suwannee	304	3,979	17,600
SA, Southern Florida	305	3,486	11,264
SA, Ochlockone, Apalachicola	306	2,960	17,984
SA, St Josephs-Perdido, Alabama	307	1,890	20,288
SA, Tombigbee	308	1,901	15,168
SA, Pascagoola, Pearl	309	1,162	12,800
SOUTH ATLANTIC TOTALS		25,423	166,720
GREAT LAKES, W Superior, S Superior	401	535	16,256
GL, NW Michigan	402	1,077	10,496
GL, SW Michigan	403	9,988	6,208
GL, SE Michigan, NE Michigan	404	3,110	16,512
GL, NW Huron, SW Huron	405	1,316	8,448
GL, St Clair-Detroit, Western Erie	406	6,929	10,304
GL, S Erie, E Erie	407	5,056	5,376
GL, SW-SE-NE Ontario	408	2,381	10,688
GREAT LAKES TOTALS		30,392	84,288
OHIO, Allegheny, Monongahela	501	1,342	9,664
OH, Pittsbrg-Wheeling, Portsmth-Little Kanawha, Cincinnati-Little Miami	502	6,664	17,728
OH, Muskngm, Sciot, Great Miami	503	4,165	12,928
OH, Kanawha	504	895	8,256
OH, Lickin-Ky. Louisville-Salt, Evansville-Green	505	2,960	20,032
OH, White-Patoka, Wabash	506	3,739	21,504
OH, Cumberland	507	1,393	11,072
OHIO TOTALS		21,158	101,184
TENN, Upper Tenn-Tenn-Hiwassee-Sequatchie	601	2,467	15,360
TENN, Tenn-Elk, Lower Tenn	602	1,098	11,200
TENNESSEE TOTALS		3,565	26,560

TABLE 2-1 (Continued)

Name of ASA	ASA Number	1975 Estimated Population (000)	Total Area in Acres (000)
UPPER COLORADO, Green, Yampa-White, Lower Green	1401	95	29,504
UC, Gunnison, Co headwaters, Colorado-Dolores	1402	141	16,384
UC, Upper St. Juan, Co-San Juan	1403	108	19,520
UPPER COLORADO TOTALS		344	65,408
LOWER COLORADO, Little Colorado	1501	127	16,960
LC, Lake Mead-Lake Mohave	1502	474	40,192
LC, U Gila, Gila-San Pedro-Gila-Salt	1503	1,811	41,600
LOWER COLORADO TOTALS		2,412	98,752
GREAT BASIN, Bear, Great Salt Lake	1601	975	15,936
GB, Sevier Lake	1602	48	12,992
GB, Humboldt, Tonopah Desert	1603	43	46,784
GB, Central Lahontan	1604	196	11,520
GREAT BASIN TOTALS		1,262	87,232
COLUMBIA-NORTH PACIFIC, Pend Oreille, Kootenai, Spokane	1701	610	22,848
CNP, Yakima, U Columbia, Deschutes, Middle Columbia	1702	665	38,016
CNP, Upp Snake, Middle Snake	1703	549	41,600
CNP, Salmon, Lower Snake	1704	171	20,288
CNP, Willamette, Low Columbia, Washington-Oregon Coastal	1705	2,306	24,576
CNP, Puget Sound	1706	2,389	10,048
CNP, Oregon closed basin	1707	14	11,776
COLUMBIA-NORTH PACIFIC TOTALS		6,704	169,152
CALIFORNIA-S. PACIFIC, North Coastal	1801	266	15,040
CSP, Sacramento Basin	1802	1,313	20,224
CSP, Tular Basin, San Joaquin, Delta Central Sierra	1803	1,714	20,864
CSP, San Francisco Bay	1804	4,988	4,416
CSP, Central Coastal	1805	800	7,168
CSP, S. Coastal, CO Desert	1806	12,056	27,200
CSP, S. Lahontan	1807	23	8,832
CALIFORNIA-SOUTH PACIFIC TOTALS		21,160	103,744

* omitted coastal waters and bays

TABLE 2-1 (Continued)

Name of ASA	ASA Number	1975 Estimated Population (000)	Total Area in Acres (000)
UPP MS, MN, MS Headwater, St Croix	701	3,035	27,008
UPP MS, MS-Black-Root, Wisconsin	702	1,244	18,624
UPP MS, MS-Maquoketa-Plum, Rock, Des Moines, Iowa-Quad	703	4,009	35,392
UPP MS. MS-Salt-Quincy, Upp Illinois, Low Illinois	704	1,961	19,392
UPP MS, MS-Kaskaskia-St Louis	705	3,138	11,840
UPPER MISSISSIPPI TOTALS		13,387	112,256
LOW MS, MS-Hatchie, St Francis	801	1,962	17,920
LOW MS, MS-Yazo, Quachta, Tenas, Big Black	802	1,849	31,040
LOW MS, MS-Lake Maureps, La Coast, Delta	803	2,606	15,552
LOWER MISSISSIPPI TOTALS		6,417	64,512
SOURIS-Red-Rainy	901	649	33,920
SOURIS-RED-RAINY TOTALS		649	33,920
MISSOURI, Milk, Mo-Poplar	1001	61	16,896
MO, Mo Headwaters, Mo-Marias	1002	200	23,168
MO, Mo-Musselshell	1003	22	10,752
MO, Upp Yellowstone, Big Horn, Tongue-Powder, Low Yellowstone	1004	281	47,630
MO, Mo-Little Mo, Cheyenne, Oake, Mo-White	1005	420	59,840
MO, James, MO-Big Sioux	1006	590	23,552
MO, N Platte, S Platte	1007	1,968	38,080
MO, Niobrar, Loop, Platte, Elkhorn	1008	622	46,268
MO, Mo-Sioux Cty-Omaha, Mo-Nemaha-Nodaway	1009	1,224	22,032
MO, Republican, Smoky Hill, KS	1010	901	54,768
MO, Grand, Chariin, Osage-Gascnade, Mo-Kansas City	1011	2,543	40,311
MISSOURI TOTALS		8,832	388,297
ARKANSAS-WHITE-RED, White	1101	352	12,544
AWR, Upper Arkansas	1102	457	15,872
AWR, Ar-Ks, Upp Cimarron, Low Cimarron, Keystone	1103	970	29,504
AWR, Verdigrs-Nedshd, Lower Arkansas	1104	2,086	25,024
AWR, Upp Canadian, Tx Canadian, Low Canadian	1105	1,088	46,247
AWR, Red Headwaters, Red-Washita	1106	926	39,579
AWR, Lower Red	1107	967	16,064
ARKANSAS-WHITE-RED TOTALS		6,846	184,834
TEXAS GULF, Sabine, Neches	1201	967	10,880
TG, Upp Trinity, Low Trinity	1202	5,050	16,704
TG, Brazos Headwaters, Middle & Low Brazos	1203	1,282	46,263
TG, Co Headwatr, Lower Co, LLand	1204	1,017	46,394
TG; Guadalue-San Antonio, Nueces-Frio	1205	1,595	24,192
TEXAS GULF TOTALS		9,911	144,433
RIO GRANDE, Headwaters	1301	36	5,120
RG, N Rio Gr.-Mimbres, Closed Basins	1302	1,004	37,440
RG, Big Bend, Low Pecos	1303	71	21,248
RG, Upper Pecos	1304	110	13,056
RG, Amistad, Low Rio Grande	1305	474	10,176
RIO GRANDE TOTALS		1,695	87,040

The boundaries of the 18 WRRs representing the contiguous U.S. are also illustrated in Figure 2-3 and the names of the WRRs are listed in Table 2-1 in the rectangular boxes. Along with the names of the WRRs are included data on population, land area, and the identification numbers of the ASAs which constitute a WRR. For example, the New England Region consists of ASAs 101 through 106. The criteria for delineating the WRR were not available from the Water Resources Council.

GENERAL LIMITATIONS OF NRDI

The implementation of NRDI, like the implementation of any analytical approach to a large problem, is limited by the scope and accuracy of the available data. Data availability determines the scope of a study, when no new primary data collection is possible. Ideally, the effects of such limitations on the results of the analyses can be assessed by sensitivity analysis. Time and resources precluded any rigorous analysis of that type.

A careful attempt was made in developing NRDI to be explicit about all the data assumptions made, so as to enable other analysts to review and evaluate the results in the light of those assumptions. Such a procedure also means that recomputation is made simple when new information is forthcoming on residuals generation and RDR costs.

The availability of data and scope of the study are briefly discussed in this section; accuracy of data and other limitations are also mentioned. Specific limitations of each of the NRDI components are described in the succeeding chapters.

Availability of Data/Scope of Study

Not all of the information which would have been useful in implementing NRDI was available on the desired county-by-county basis, even for conditions for the base year, 1973. With respect to types of residuals, reasonably comprehensive and consistent data exist only for BOD and TSS. Data on other residuals--such as nutrients, heavy metals, and thermal discharges--having significnat impacts on water quality in some or many ASAs, provided either no or only partial coverage of those residuals. Regardless of the importance of these residuals, neither material aggregate analysis nor regional distribution analysis is possible with the available data. Table 2-2 indicates the residuals covered in NRDI.

TABLE 2-2

Residuals Analyzed in NRDI, by Generating Source

Residual	Industry	Municipal	Agricultural	Urban Runoff
BOD	X	X	X	X
TSS	X	X	X	X
N		X	X	
P		X	X	

The residuals generating activities studied in NRDI were limited to those for which residuals generation, residuals discharge, and RDR costs could be meaningfully characterized on a county-by-county basis. The following residuals generating activities were not included in NRDI because of lack of residuals generation, location, and/or RDR cost data: certain manufacturing activities, such as machinery and mechanical products and fruits and vegetables; feedlots; and irrigated agricultural and silvicultural activities. Residuals discharges from these activities can be a serious problem in some areas.

Accuracy of Data

NRDI uses a single residuals generation coefficient for estimating residuals generation by any given type of activity. Two factors affect the accuracy of such data. (1) There is in reality a range in residuals generation reflecting site-specific conditions, even for a given type of activity, such as a subcategory of an industry or a subcategory of agricultural activity. Different data collection agencies may also use different assumptions in developing estimates of coefficients. Table 2-3 compares estimates of BOD generation coefficients from two sources.

TABLE 2-3

Comparison of Selected BOD Generation Coefficients (lbs/1000 lbs production)

	BOD	
Product	EPA	Catalytic
Acetic Acid	0.35	6.4
Acetene	0.26	1.0
Ethylene Glycol	0.34	5.3
Ethylene Oxide	0.70	3.8

Source: U.S. EPA (1975).

(2) The single residuals generation coefficient can be interpreted as being the "steady-state" or median value associated with the activity. There is substantial variation in residals generation in a <u>single</u> industrial plant, municipality, agricultural activity--diurnally, weekly, seasonally. In general, the more complex the operation, the larger the variability in the generation of a given residual over time. Table 2-4 shows the percentage of the time that the raw waste load was equal to or less than the indicated value for various types of petroleum refineries. This normal variability makes it difficult to obtain a representative sample of residuals generation in order to estimate the median.

TABLE 2-4

Variation in BOD Residuals Generation for Petroleum Refining Effluent from API Separator (lbs/100 bbls feedstock)

		Probability	
Category	10%[1]	50% (Median)	90%[2]
Topping	.45	1.2	76.0
Cracking	5.0	25.2	163.0
Petrochemical	14.3	60.0	715.0
Lube	22.0	76.0	265.0
Integrated	22.2	69.0	215.0

1 Probability of occurrence less than or equal to 10 percent.
2 Probability of occurrence less than or equal to 90 percent.

Source: U.S. EPA (1974).

When the future is considered, estimating residuals generation coefficients becomes even more difficult. Estimates of or assumptions about all of the endogenous and exogenous variables affecting generation must be made, such as changing technology, changing factor prices, density of urban population, and housing types.

Similar questions about accuracy arise in relation to the estimation of RDR costs. Not only are costs site specific, but usually only a few of the possible RDR alternatives are analyzed. NRDI, for example, is limited to "end-of-pipe" treatment--changing production processes, changing raw materials, changing production specifications, increasing materials and/or energy recovery, or increasing by-product production are not considered.

Other Limitations

Two other limitations of NRDI merit mention. (1) Only two residuals are used in evaluating impacts on water quality by the water quality dilution index, BOD and TSS. These may or may not be the best measures of water quality in any given area. Further, because of the interactions among residuals and biological components in aquatic environments, the actual concentrations of BOD in a water course may be substantially different from that estimated by using the one parameter alone. (2) The analyses involving growth relate only to the national level, i.e., are not subdivided by ASA. In addition, growth is projected only for industrial and municipal activities, i.e., agricultural activities and urban runoff are held constant.

NOTES

1 The SEAS system, developed by EPA, is a comprehensive collection of interdependent computer models which, when combined with expert opinion, provides information about the consequences of alternative environmental policies. A succinct discussion can be found in:
Plan for the Implementation and Use of Phase III Capabilities in the Strategic Environmental Assessment System (SEAS), prepared for NCWQ by Control Data Corporation, May 31, 1974.

2 Although flow is the principal costing variable, not all unit process cost functions are based upon flow. For example, both the activated sludge and aerated lagoon functions are based upon flow and BOD concentrations and the carbon adsorption function flow and COD concentrations (see Appendix A).

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CHAPTER 3

ANALYZING INDUSTRIAL ACTIVITIES

INTRODUCTION

Industrial activities are analyzed by either an in-depth or a general study of an individual industry. For an in-depth study, an industry's inventory is uniquely defined by predominant production process, product output in the base year, in-place residuals modification facilities,[1] and county location. Residuals generation coefficients are available for production process/product output combinations. For a general study, an industrial inventory uses data only on the number of employees per plant, the number of plants by employment range per county, a uniform estimate of in-place residuals modification facilities, and an estimate of national residuals generation coefficients. For both in-depth and general studies, residuals discharges and RDR costs are estimated for plants which discharge directly to surface waters.[2]

In NRDI, those industries that account for the majority of industrial residuals discharges and associated RDR costs are studied in depth.[3] (These are listed subsequently in Table 3-3). All other industries are studied in the less detailed general manner, on the assumption that a more detailed study would not significantly increase the accuracy of the national and regional data, because of the lack of data, complexity, and relatively less residuals generation for the remainder.

This chapter is arranged in five sections. The first describes a conceptual procedure for industrial activity analysis and illustrates in particular the limitations of end-of-pipe analysis compared to the full range of RDR options available to industry. The next section describes the criteria used for deciding which industries to study in depth. The next two sections respectively describe the analysis and present the residuals discharges and RDR cost results of the in-depth and general studies. The concluding section discusses the limitations of the analysis in light of the assumptions made, compares the NRDI results with those of EPA and NCWQ, discussing likenesses and differences, and then draws some tentative conclusions.

The chapter does not discuss the impact of industrial growth on residuals generation and RDR costs. Chapter 6 discusses the technique used to project growth, and Chapter 8 presents the results of the growth analysis.

CONCEPTUAL PROCEDURE FOR INDUSTRIAL ACTIVITY ANALYSIS

A conceptual procedure for estimating types and quantities of residuals generation and discharge and RDR costs has been documented elsewhere (Bower 1975). The following summary indicates the strengths and limitations of the NRDI in-depth and general industry studies.

Residuals generation by an industrial activity is a function of numerous variables. Some of the more important variables are:

RG(I) = f(RM, PP, POS, MER, PS, OR),

where

RG(I) = residuals generation by an industrial activity;
RM = raw materials;
PP = production process or technology, including age and physical arrangement of the plant;
POS = product specifications or characteristics of the product output(s);
MER = extent of material and energy recovery for direct recycle and/or by-product production;
PS = plant size measured in terms of output capacity per unit time; and
OR = operating rate measured in terms of output produced, or raw product processed, per unit time.

Residuals generation is measured in units either of residuals per unit of product output (such as pounds of organic material per ton of pulp), or of residuals per unit of raw material processed (such as pounds of solids per barrel of crude oil throughput).

An estimate of residuals generation, as opposed to actual measurements for each plant, must either explicitly take into account each of the above variables or must be based on some assumptions about them. The more data on these variables available for each plant, the more accurate will be the estimate of residuals generation. In addition, an estimate of residuals generation must be based on some assumption about time, because residuals generation under normal conditions is likely to show weekly and/or seasonal variations. Residuals generation coefficients are usually assumed, implicitly if not explicitly, to reflect mean conditions.

Residuals discharge from an industrial activity is similarly a function of numerous variables, many of which are the same as for residuals generation. Thus:

RD(I) = f(RM, PP, POS, MER, PS, OR, TRES, EC),

where

RD(I) = residuals discharge by an industrial activity;
TRES = technology of residuals modification; and
EC = effluent constraints, i.e., effluent charges and/or effluent standards, such as the 1977 and 1983 effluent limitations.

Of these variables, EC is the most important because it causes modification in one or many of the other variables in the residuals discharge function. The imposition of an effluent limitation or an effluent charge causes an industrial activity to modify production processes, install residuals modification, change raw materials, and so on. However, other variables in the function may be modified by exogenous changes having nothing to do with water pollution control. Examples are prices of raw materials (including water, energy, fuel), and values of non-product outputs. An increase in the value of non-product outputs might mean the replacement of discharge into the ambient environment by direct recycling back into the production process or into by-product production.

The costs of reducing residuals discharge are a function of which variables are modified in the RD(I) function. Residuals discharge can be modified, for example, by changing production processes, raw materials, and product specifications, as well as by adding residuals modification facilities. The costs of the former are often less than of the latter because the costs of production process modification may increase the efficiency of production as well as reducing residuals discharge. Moreover, further materials/energy recovery and/or by-product production--in addition to that which would be practiced in the <u>absence</u> of effluent constraints--may be cheaper than "waste treatment." Even limiting the means of reducing residuals discharge to waste treatment does not limit the choice to one option or to one unit cost. Several combinations of unit processes constituting waste treatment can be applied, and these combinations generally result in different costs.

The term "modification" of residuals discharge is used rather than "elimination" because residuals cannot be eliminated. Elimination of residuals discharged into the ambient water would only serve to increase the residuals discharged into the ambient air or upon the land, unless they were recycled into production. Reduction, by use of a cooling tower, of heat discharged into the receiving waters, increases the heat being discharged into the air. Similarly, the reduction of organic material in the water effluent increases the volume of sludge to be handled in some other way, such as discharge into the air via incineration or disposal on the land. Consequently, reduction of residuals discharged into receiving waters is essentially a modification of the residuals so that they can be discharged in another form into another receiving medium, or converted into another type of liquid residual less harmful to water environments. Only if the total materials and energy input to the production is reduced, may the total quantity of residuals discharged be reduced.

Since the purpose of this report is to assist NCWQ in evaluating P.L. 92-500, the number of relevant variables to be considered has been deliberately limited in our analysis. Given that the focus of the analysis is not on an individual plant per se, nor even on a single industry, it is not necessary to explain why residuals generation and discharge will vary from plant to plant and/or region to region depending upon the factors enumerated above. Even if explicit consideration of more variables were desired, the lack of data precludes this.

It would be highly desirable to analyze in more detail the range of available options for achieving reduction in residuals discharge and the costs of achieving that reduction. The type of information would obviously be useful in identifying those industrial activities (subcategories of four-digit SIC) which could achieve higher levels of residuals discharge reduction at lower costs than other activities. But many such options are plant and site specific, so that it is impossible to consider them in a national analysis.

CRITERIA FOR CATEGORIZING INDUSTRIES FOR IN-DEPTH OR GENERAL STUDY

The categorization of industries for in-depth or general study in NRDI is approximately the same as that made by NCWQ. This section attempts to provide a substantive explanation for this categorization and to explain how and why the NRDI scheme varies from that of NCWQ.

The major criterion for determining whether an industry should be studied in depth is the magnitude of its residuals generation in relation to residuals generation by all industries. Because there is no systematic data collection of actual residuals generation by existing industrial activities, the next best indicator of residuals generation is assumed to be process water intake. Although this assumption is not always correct, because other factors such as raw material input, type of production process, and product mix/product specifications are also determinants of residuals generation, process water intake is used as a surrogate for residuals generation. For a given water intake cost, in-plant recirculation cost, and effluent constraint level, empirical evidence indicates a reasonably good correlation between raw material/production process/product input, and process water intake. However, there is not a perfect correlation between process water intake and residuals generation.

The Bureau of Census every five years systematically collects data on water use in manufacturing. Until the October 1975 release of the 1972 census data (U.S. Department of Commerce 1975 [referred to after this as COM]), the only Bureau data available on process use of water in manufacturing were the 1967 census data (U.S. COM 1971). The 1972 census, although very informative on changes in water use since 1967, because of disclosure problems does not present as complete a profile of process water use as does the 1967 census. Therefore, the 1967 census has been used as a proxy to identify the major industrial process water users in 1973. Table 3-1 shows the 1972 SIC designations that correspond to 1967 codes used in the 1972 census, the number of plants reported in the 1967 and 1972 censuses, and process water use by SIC category in 1967.

In 1967 the Bureau reported total process water intake by 9,400 manufacturing plants to be about 4,300 billion gallons. The data show that a very limited number of four-digit SIC categories and of plants account for a significant amount of process water intake. The top five four-digit SIC categories, which constitute 9 percent of the plants with water intake of over 20 million gallons per year, account for about 67 percent of the process water intake. The top 15 four-digit SIC categories, which constitute 21.2 percent of the plants, account for about 77 percent of process water intake. In order to include an additional 7 percent of process water intake, the number of SIC categories to be analyzed would have to be doubled. Consequently, the top fifteen four-digit SIC categories, particularly the top six, are important candidates for in-depth industrial studies.

Another criterion, given the data requirements for performing an in-depth analysis, is data availability. NCWQ technology contractor reports, EPA reports and files, and industry directories were used to identify specific plant locations, types of production processes, product outputs, and plant capacities. Although NCWQ technology contractors collected sufficient data on most of the industries they studied and their reports were a principal source of data for development of NRDI, in some cases the data were deemed inadequate (e.g., miscellaneous organic chemicals), while in others, for instance the pulp and paper industry, the data were coded to avoid identifying plant location and were therefore unuseable. Hence, of the 11 major industries NCWQ studied in depth, NRDI includes, because of lack of data, analysis of only 7.

Table 3-2 shows the percentages of total industrial process water use, and which four-digit SIC categories in Table 3-1 are included in in-depth NRDI and NCWQ industry studies. The seven manufacturing industries studied in depth by NRDI account for approximately 74 percent of total

TABLE 3-1

Significant Process Water Intake by Four-Digit SIC

(National Total 4,295.1 Billion Gallons)
(National Total 9,402 Plants)

1972 SIC	1967 Water Use in Manufacturing							Number of Plants in 1972
	Rank	SIC	SIC Name	Process Water Intake Billion Gallons	Percentage of Total	Cumulative Percentage	Number of Plants in 1967	
3312	1	3312	Blast Furnaces	1,034.4	24.1	24.1	199	132
2621	2	2621	Paper Mills	776.0	18.1	42.2	249	221
2631	3	2631	Paperboard Mills	429.4	10.0	52.2	181	174
2869, 2873*	4	2818	Industrial Organic Chemicals NEC	394.0	9.2	61.3	177	183
2611	5	2611	Pulp Mills	229.2	5.3	66.7	31	26
			(8.9% of establishments withdraw 66.7% of process water)					
2911, 2992*	6	2911	Petroleum Refineries	91.7	2.1	68.8	214	201
2819*, 2842* 2873*, 2874*	7	2819	Industrial Inorganic Chemicals NEC	75.2	4.9		223	196
2821, 2891* 3079*	8	2821	Plastics & Resins	50.9			128	143
2061	9	2061	Raw Cane Sugar	48.9			49	11
2011, 2032* 2047*	10	2011	Meatpacking	35.8		73.6	230	162
2823	11	2823	Cellulosic Man-Made Chemicals	30.5			18	10
5339	12	3339	Primary Non-Ferrous Metals	29.0	3.3		13	9
2892	13	2892	Explosives	28.0			21	12
2661	14	2661	Building Paper & Boards	27.4			41	34
2033	15	2033	Canned Fruits and Vegetables	27.0		76.9	220	188
			(21.2% of establishments withdraw 76.9% of process water)					
3331	16	3331	Primary Copper	26.8	7.8		20	14
2037, 2038	17	2037	Frozen Fruits and Vegetables	24.2			109	91
2873*, 2874*	18	2871	Fertilizers	24.2			42	42
2016, 2017	19	2015	Poultry Dressing Plants	23.8			180	105
2261	20	2261	Finishing Plants, Cotton	23.5			50	25
3334	21	3334	Primary Aluminum	23.5			24	23
3351	22	3351	Copper Rolling and Drawing	22.9			50	27
3714	23	3714	Motor Vehicle Parts and Accessories	22.6			139	53
3241	24	3241	Cement, Hydraulic	21.5			142	51
2816	25	2816	Inorganic Pigments	21.2			24	23
3295	26	3295	Minerals, Ground or Treated	21.0			19	7
2063	27	2063	Beet Sugar	20.7			55	23
2211	28	2211	Weaving Mills, Cotton	19.4			124	51
2865	29	2815	Cyclic Intermediates and Crudes	19.3			62	49
2812	30	2812	Alkalies & Chlorine	18.9		84.8	31	24
			(32.6% of establishments withdraw 84.8% of process water)					

*Indicates that part of 1972 SIC is contained in 1967 SIC; arbitrary assumption is that 50% of plants in 1972 SIC "parts" are contained in 1967 SIC.

TABLE 3-2

Comparison of NCWQ and NRDI Industries Studied In-Depth

Industry Designation	Related 1972 SIC[1]	1967 SIC	Annual[2] Process Water (Billion Gallons)	% of National Total	Studied In-Depth by NAS
Canned Fruits & Vegetables	2032	2032, 2011,[3] 2013[3]	31.0		No
	2033		27.0		
	2034		4.1		
	2035		1.4		
	2037		24.2		
			87.7	2.0	
Electroplating	3471	3471	6.7		No
	3479	3479	0.5		
			7.2	0.1	
Inorganic Chemical	2812	2812	18.9		Yes
	2813	2813	5.3		
	2816	2816	21.2		
	2819	1311,[4] 2819[3]	37.6		
			83.0	1.9	
Iron & Steel	3312	3312	1,034.4		Yes
			1,034.4	24.0	
Organic Chemicals	2865	2815	19.3		Yes
	2869	2818[3]	197.0		
			216.3	5.0	
Miscellaneous Organic Chemicals	2831	2831	0.3		No
	2833	2833	2.6		
	2834	2834	(D)[5]		
	2861	2861	(D)[5]		
	2879	2879	2.0		
	2891	2891	---		
	2892	2892	1.1		
	2895	2895	4.0		
	2899	2899	8.0	1.0	
			29.7		
Petroleum Refining	2911	2911[3]	45.9		Yes
			45.9	1.0	
Plastics & Synthetics	All 281				Yes
	2821	2821[3]	25.5		
	2823	2823	30.5		
	2824	2824	7.7		
	2869	2869	197.0		
			260.7	6.0	
Pulp & Paper	2611	2611	229.2		Yes
	2621	2621	776.0		
	2631	2631	429.4		
			1,434.6	33.4	
Steam Electric	4911	4911[4]	---		No
Textile	All 22	All 22	109.0		Yes
			109.0	2.5	
NCWQ Totals(rounded)			3,300	76	
NAS Totals(rounded)			3,200	74	
Total for all Manufacturing Industries in the Nation(rounded)			4,300	100	

1. Defined by NCWQ.
2. Source: 1967 Census of Manufactures
3. Arbitrarily assumes that 1967 SIC "parts" contain 50 percent of plants in 1972 SIC.
4. Not available in 1967 Census of Manufactures <u>Water Use in Manufacturing</u>.
5. Disclosure problem precludes publication of data

process water intake. The remainder of manufacturing industries, representing the majority of plants but only 26 percent of total process water intake, are studied in less detail as "general" industries. The steam electric industry is not studied either in depth or in general primarily because of lack of data and because this industry's primary residual discharge--heat--is not covered in NRDI. To simplify the grouping of all other industries, the NCWQ format has been adopted. Table 3-3 summarizes the categorization of industries by NRDI for either in-depth or general study, and shows the 41 industrial categories which are identified for general study.

GENERAL ASSUMPTIONS

For most analyses, a series of assumptions must usually be made, because of lack of specific data, to simplify the task, and to make it manageable without inordinately biasing the results. Some assumptions clearly affect analysis results more than others and are therefore more important. The comprehensive analysis described here includes numerous implicit and explicit assumptions. Those assumptions which pertain both to industries studied in depth and to those studied in general are described below, while assumptions applicable only to one type of analysis are described later in the chapter under the appropriate heading. The pervasive assumptions are:

1. industrial residuals discharges are generally compatible with municipal treatment facilities, so that pretreatment costs for industries discharging to municipalities need not be computed;
2. because NRDI does not compute pretreatment costs for industries, a reasonable criterion for adjustment of total industrial RDR costs (excluding those plants discharging to municipalities) is to adjust only those industries which are reported, in the 1972 Census of Manufactures (U.S. COM 1975), to discharge 25 percent or more of their total discharge exclusively to municipalities (see Appendix C);
3. application of only end-of-pipe treatment yields an upper bound estimate of RDR costs of meeting BPT and BAT requirements because lesser cost in-plant changes, such as modifications in production technology, raw material input, product specifications, and so on, would likely be adopted in reality;
4. technologies defined by EPA to be representative of BPT and BAT would meet EPA effluent guidelines (Appendix D evaluates this assumption, given typical residuals removal efficiencies of unit treatment processes);
5. regional differences in residuals generation for a given process-product category and type of unit treatment

TABLE 3-3

Summary of NRDI Industry Study Categorization

Industries Studied In-Depth

1. Pulp and Paper
2. Petroleum Refining
3. Textiles
4. Iron and Steel
5. Plastics and Synthetics
6. Organic Chemicals
7. Inorganic Chemicals

Industries Studied In-General

1. Ore Mining and Dressing+
2. Coal Mining +
3. Petroleum and Gas Extraction+
4. Mineral Mining and Processing+
5. Fish Hatcheries
6. Meat Products and Rendering+
7. Dairy Products+
8. Grain Mills+
9. Cane Sugar Processing+
10. Beet Sugar Processing+
11. Seafood+
12. Timber Products
13. Furniture and Fixtures
14. Builders Paper+
15. Paint and Ink
16. Soap and Detergent
17. Phosphates
18. Fertilizer+
19. Paving and Roofing+
20. Rubber+
21. Leather+
22. Glass+
23. Cement+
24. Structural Clay
25. Pottery+
26. Concrete, Gypsum
27. Asbestos+
28. Fiberglass
29. Ferroalloy+
30. Non-Ferrous Metals+
31. Transportation
32. Water Supply
33. Steam Supply
34. Auto and Other Laundries
35. Foundries
36. Non-Ferrous Mill Products
37. Miscellaneous Food and Beverages
38. Machinery
39. Electroplating*+
40. Fruits and Vegetables*+
41. Miscellaneous Organic Chemicals*+

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*Studied in-depth by NCWQ
+Studied by NRDI

process used, for example, activated sludge being designated instead of aerated stabilization basins in the northeast, are sufficiently negligible to be omitted from the analysis;

6. waste treatment facilities always operate at design efficiencies;

7. the variation in production levels and product mix, and thus in residuals generation and discharge is ignored;

8. all wastewater is treated by each unit process assigned to an industrial category or subcategory; for example, all the wastewater flow in an integrated iron and steel mill is subject to neutralization rather than that from the pickling process alone.[4]

IN-DEPTH INDUSTRY STUDIES

The in-depth industry studies comprise separate analyses of each of the seven significant industries identified in the previous section. This section explains the general methodology used to analyze these industries, the major assumptions that have been made, and some of the specific characteristics of each industry analysis. The technology assumptions (in-place facilities and BPT and BAT RDR process sequences), estimated residuals generation and discharge, the replacement value[5] of existing in-place facilities, and the cost of applying BPT and BAT to each industry are summarized in three tables at the end of this section.

General Method

The assumptions basic to all in-depth industry studies are:

1. all plants are operating at or near full capacity, and product output (units/day) is equal to plant capacity;
2. residuals generation coefficients for an industrial category or subcategory are independent of plant size (although in fact residuals generation does vary significantly with plant size for the same type of plant, i.e., raw material/production process/product combination);
3. residuals generation at a plant is a function of the predominant production process/product output at that plant; that is, no attempt was made in the NRDI study to estimate a weighted residuals generation coefficient reflective of the actual mix of process-output combinations in a plant;
4. the influences of the age of production processes and the physical arrangement of a plant on residuals generation and discharge are negligible; and
5. product specifications of physical output in a subcategory are homogeneous.

The general methodology based on these assumptions is depicted in Figure 3-1, and involves four steps.

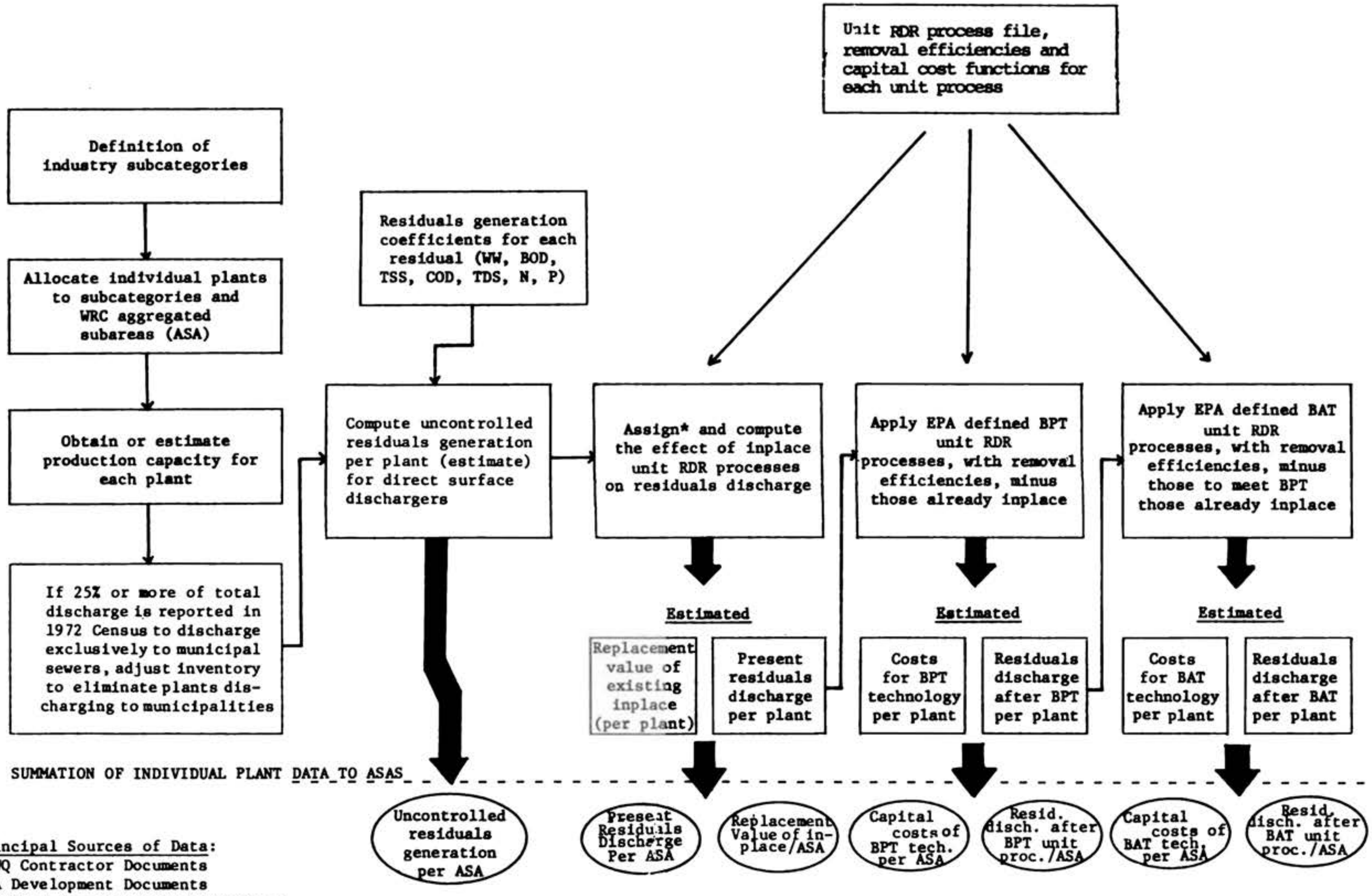
The first step is the development of the most complete inventory possible of the plants existing in that industry in 1973 and the subcategorization of these plants by predominant production process. The inventory also includes data on product output per plant, usually measured in tons or output units per day, and actual or estimated in-place RDR facilities per plant. If 25 percent or more of wastewater discharge in the industry is discharged exclusively to municipalities, the inventory is adjusted to eliminate plants discharging exclusively to municipalities. Otherwise, all plants in the industry are assumed to be direct surface water dischargers. The information on in-place treatment facilities, i.e., combinations of specific unit processes, is taken whenever possible from NCWQ and EPA development documents. Where information about specific plants is unavailable, the average RDR technology estimated to be in place in a subcategory is assumed to be the same for all plants in the subcategory. Table 3-4 lists the principal references used for each industry study.

The second step is to assign residuals generation coefficients, developed by production process/product output combination, to each subcategory, and to compute residuals generation. The residuals estimated are BOD, TSS, and wastewater flow. The coefficients are measured in pounds per ton of output or per ton of raw material processed, except for process water which is measured in gallons per ton of output or unit of raw material processed. The residuals generation coefficients are based for the most part on either NCWQ technology reports or EPA development documents for a particular industry.

The third step is to compute: (a) residuals generation and residuals discharges in 1973 and after BPT and BAT technologies are applied, for each plant; and (b) the replacement value of RDR technologies in place in 1973 and the costs of applying BPT and BAT technologies. (The BPT and BAT costs relate only to facilities in addition to those currently in place.) The set of unit processes used in BPT and BAT and their associated removal efficiencies are shown in Table 3-5. The RDR costs include the costs of processing and disposing of the sludge generated in modifying the primary liquid residuals. Sludge processing costs for each RDR facility are computed by sizing sludge processing facilities, i.e., gravity thickening and vacuum filtration, based on the amount of about 4 percent solids sludge estimated to be generated in residuals modification processes at the RDR facility. Sludge disposal costs for each RDR facility are computed by multiplying the amount of sludge, dried to about 16 percent solids sludge, in sludge processing facilites times a per unit landfill cost. The specifications of the cost functions for each unit process

FIGURE 3-1

General Methodology For Analyzing An Industry In-Depth



Principal Sources of Data:
NCWQ Contractor Documents
EPA Development Documents
Industry Association Publications

*Inplace residuals reduction technologies are either assigned by plant, when data exist, or as an industry base level by assumption.

TABLE 3-4

Principal References for In-Depth Industry Studies

Industry Category	Residuals Generation Coefficients	Plant Inventory	Technology Assumptions	
			In Place Estimates	RDR Trains
1. Pulp and Paper	NCWQ Report on Pulp and Paper Industry (Hazen & Sawyer), Table 8, p. 19	Post Directory for the Pulp & Paper Industry	Post Directory for the Pulp & Paper Industry (Plant by Plant); NCWQ Report on Pulp & Paper Industry - Hazen & Sawyer Table 9, pp. 41-52; EPA provided worksheets	EPA Development Document for Pulp, paper and paperboard, Sections IX, X, pp. 215-232, 237-244
2. Petroleum Refining	EPA Development Document for Petroleum Refining, Section V, pp. 63-70	NCWQ Report on the Petroleum Refining Industry (Engineering-Science Inc.), Appendix A	NCWQ Report on the Petroleum Refining Industry (Engineering Science Inc.), Chapter II, pp. II-1 - II-63	EPA Development Document for Petroleum Refining, Section IX, X pp. 143-169, 169-175
3. Textiles Industry	NCWQ Report on Textiles Industry (Lockwood Greene), Table II-1, pp. II-79	Provided by NCWQ Contractor Lockwood-Greene	NCWQ Report on Textiles Industry (Lockwood-Greene), Chapter II pp. II-1 - II-103	EPA Development Document for Textile Mills, Section IX, X pp. 151-179, 181-188
4. Iron and Steel	EPA Development Document for Steel Making, Section V, pp. 133-146	NCWQ Report for the Iron & Steel Industry (McKee), Chapter V pp. V-1 - V-53	EPA Development Document for Steel Making, Section IV pp. 31-108	EPA Development Document for Steel Making, Section IX, X; pp. 319-364, 365-429
5. Plastics and Synthetics	EPA Development Documents, for Synthetic Resins, Section V, pp. 83-88; Addendum for Synthetic Resins Section V, pp. 45-48; Synthetic Polymers, Section V, pp. 161-167	International Research and Technology work based on Procon inventory (NCWQ) (unpublished)	1972 Census of Water Use in Manufacturing, Table 9	EPA Development Documents for: Synthetic Polymers Section X, pp. 251-261, pp. 261-271; Synthetic Resins Section X, pp. 209-212; Section XI, pp. 215-225
6. Organic Chemicals	EPA Development Document for Organic Products, Phase I, Section V, pp. 244-265; Catalytic Report on Organics for NCWQ, Chapter 6, pp. 6-1-6-79; Chapter 10, pp. 10-1-10-29-1	International Research and Technology work based on Catalytic inventory (NCWQ) (unpublished)	1972 Census of Water Use in Manufacturing, Table 9	EPA Development Document For Organic Chemicals, Section X, XI
7. Inorganic Chemicals	EPA Development Documents for Inorganic Products, Phase I - Section V, pp. 65-183; Phase II - Section V, pp. 41-181	International Research and Technology work based on Catalytic inventory (NCWQ) (unpublished)	1972 Census of Water Use in Manufacturing, Table 9	NRDI Approach Based on Catalytic Chapter 10, EPA Development Document, Ph. I and II, Section X, XI

TABLE 3-5

RDR Unit Processes And Their Assumed Removal Efficiencies, Used In Industry Analysis

Type of Treatment	Unit Process	Abbreviation	Assumed Removal[1] Efficiencies (%)	
			BOD	TSS
Pretreatment	Screening	SC	0	0
	Equalization	EQ	0	0
	Oil Separation	OI	0	0
	Ammonia Stripping	AS	0	0
Primary Chemical	Neutralization	NE	0	0
	Incremental Single-Stage Chemical Addition	CH	52	71
	Single-Stage Chemical Addition	SI	52	71
	Chrome Reduction	CR	0	0
	Cyanide Destruction	CY	0	0
Primary Physical	Flotation	FL	40	80
	Primary Clarification	PR	33	52
	Evaporation	EV	100	100
	Petroleum Flotation	PE	40	80
	Earthen Basin[2]	EA	0	80
	Holding Pond	HO	79	68
Secondary Organic	Activated Sludge[3]	AC	85	68
	Aerated Stabilization Basin	AE	75	65
	Trickling Filter	TR	79	68
	Extended Aeration Basin[4]	XA	75	65
Tertiary	Two-Stage Chemical Addition	TW	60	68
	Multi-Media Filtration	MU	50	72
	Carbon Adsorption	CA	60	60
	Ion Exchange	IO	0	0
	Breakpoint Chlorination	BR	0	0
	Nitrification	NI	70	57
	Nitrification-Denitrification	ND	0	0
Disinfection	Chlorination	CL	0	0
Thermal	Cooling Towers	CO	0	0
	Heat Treatment	HE	0	0
Other	Recirculation	RE	0	0
	Surface Outfall	SU	0	0
	Ocean Outfall	OC	0	0
Sludge Treatment	Sludge Digestion	SL	--	--
	Gravity Thickening	GR	--	--
	Vacuum Filtration	VA	--	--
	Drying Beds	DR	--	--
Sludge Disposal	Landfill	LA	--	--
	Incineration	IN	--	--

1. Based upon EPA "A Guide to the Selection of Cost Effective Wastewater Treatment Systems," July, 1973, EPA/430/9-75-002, except where indicated.

2. Based upon EPA "Mineral Mining and Processing Industry," Development Document, October, 1975, EPA/440/1-75/059, Group II.

3. Includes secondary clarification.

4. Based upon EPA, "Fruits, Vegetables, and Specialities Segment of Canned and Preserved Fruits and Vegetables," Development Document, EPA/440/1-75/046, Group I, Phase II.

are in Appendix A and are taken from the several sources cited in that appendix.

The fourth step is to sum the individual plant data to the desired level of geographic detail, (e.g., county, ASA, SMSA, major river basin), and/or level of industry detail, (e.g., subcategory, category, group of categories).

Characteristics of Individual In-Depth Industry Studies

Although each of the industries is analyzed following the same general methodology shown in Figure 3-1, they all exhibit slightly different characteristics. Not all the necessary data existed in the same form for all industries; different sets of assumptions had to be made and manipulations performed to permit all industries to be studied in depth.

The seven industries studied can be roughly classified into three groups which exhibit similar analysis characteristics. They are: (1) pulp and paper and petroleum refining; (2) textiles and iron and steel; and (3) organic chemicals, inorganic chemicals, and plastics and synthetics. Complete inventories of each industry including subcategory breakdowns, the number of plants and production capacity in each subcategory, residuals generation coefficients, residuals generation, residuals discharges after in-place, BPT, and BAT technology, and RDR costs are in Appendix E. Tables 3-6, 3-7, and 3-8 at the end of this section summarize the RDR technology assumptions, RDR costs, and the corresponding residuals discharges for each industry. The following sections describe the characteristics of each of the analysis groups delineated above.

Pulp and Paper and Petroleum Refining Industries

Of the industries studied in depth, these two follow the general method most closely. Complete plant inventories exist for both,[6] and each inventory is subcategorized by predominant production process per plant. Their most outstanding feature is that plant-specific, in-place technology data are available for <u>all</u> plants and appear in the inventory. In all other industries studied in depth, a base level condition (set of unit processes) for 1973 in-place technology is assumed for the industry as a whole or by subcategory, because plant specific, in-place technology data are not available.

The petroleum refining industry is the only industry studied, either in depth or in general, which is an exception to the eighth general assumption described above--that all wastewater discharged is treated by each unit process assigned to the industry. For petroleum refining in the application of BPT unit processes, 5 percent of the total wastewater flow is run through a "special" flotation cost function designed for the petroleum refining industry (Datagraphics Inc. 1975). In the application of BAT technology, 50 percent of the total wastewater flow is run through a cooling tower cost function and an evaporation cost function, as suggested by the NCWQ contractor, Engineering Science Inc. (1975).

The entire petroleum refining inventory was provided by the NCWQ contractor, while for the pulp and paper industry several sources were used. BPT and BAT technologies as specified by EPA for each industry, are the same for all subcategories, because they involve essentially only end-of-pipe options. When computing BPT and BAT costs and related residuals discharges, an RDR technology train is costed out on a unit process basis, taking into consideration the unit processes already in place at each plant. For example, if at a given petroleum refinery oil separation and flotation facilities exist on site, then only the remaining unit processes in the RDR technology train are applied to that refinery as BPT and BAT sequences. (This assumes that the existing processes are performing to some specified removal efficiencies.)

Textiles and Iron and Steel Industries

The major similarity in the analysis of these two industries and the principal difference from the preceding group is that the same in-place unit process RDR sequences are assumed to be in place throughout a subcategory, and that BPT and BAT technologies are defined for each subcategory rather than for the industry as a whole. Otherwise, the basic assumptions outlined earlier and the method of analysis are the same as for the general methodology, except in the case of estimating product output per plant in the textile industry.

Unlike the iron and steel[7] industry, where product output data were readily available, in the textile industry such data were available for only 382 plants out of 1,926 wet plants in the industry which responded to a Lockwood Greene questionnaire (Lockwood Greene Engineers Inc. 1975). ("Dry" textile plants do not generate significant quantities of liquid residuals.) Employee data by plant, however, were available for all plants. Product output per plant for the 1,544 plants without product output data was estimated by use of the results of a regression analysis. Regressions were run, using the 382 survey plants, with product output as the dependent variable and the number of employees per plant as the independent variable for each of the 11 production process categories in the industry. Product output for the plants for which no data were available was estimated by using the number of employees in each plant and the relevant regression equation. Because of multiple processes in each plant, only 1,483 mills were categorized by NCWQ. Categorization of the remaining 443 mills for NRDI was based upon the finishing process at each mill. This analysis of the textile industry assumed that the relationship between product output and employees per plant is uniform within a subcategory and that finishing processes account for most of the liquid residuals generation in textile operations.

The textiles industry is also the only industry studied in depth which discharged in 1972 more than 25 percent (actually 55 percent) of its total wastewater exclusively to municipalities and whose inventory, therefore, was adjusted to exclude plants discharging exclusively to municipalities. Since neither NCWQ nor any other source had specific data about which of the 1,920 mills discharged to municipal systems, a random selection process was used based upon the 1972 Census of Manufactures (U.S. COM 1975).

Table 5B in the Census indicates the amount of wastewater from textile mills (SIC 22) discharged exclusively to public utility systems by state. Using this amount of wastewater as a constraint, a random number generator was used to designate mills, by state, discharging to municipalities. Mills are designated until the amount of wastewater for each state indicated by the census to go to municipalities is reached. The mills so designated (1,294) were then eliminated from the inventory of direct surface water dischargers.

Organic Chemicals, Inorganic Chemicals, and Plastics and Synthetics Industries

The distinguishing characteristic of the industries in this group is that their inventories are categorized by type of product rather than by production process. A plant appears in as many subcategories as products it produces, because of the multi-product per plant nature of these industries--80 products in organic chemicals, 30 in plastics and synthetics, and 60 in inorganic chemicals covered by NRDI. In fact, investigation has shown that a plant may also be in more than one industry category. For example, a plant producing organic chemical and plastic products appears in the inventories of both industries.

In order to estimate RDR costs, the product category inventories were converted to plant inventories by computing residuals generation per product per plant and then summing all generation relating to all products in the given industry for each individual plant. Thus the NRDI analysis could take advantage of some of the economies of scale by treating collectively all residuals of interest generated in the production of several products in a single plant, where RDR technology trains are compatible, which is what is typically done in reality. Although similar reasoning is applicable to plants producing products categorized in more than one industry, the possibilities of treating compatible residuals from several industries were not considered. (That is, some plants produce products in all three of these industry categories.) Consequently, cost estimates for these three industries are likely to be high.

The NRDI inventories, shown in Appendix E, were taken from three NCWQ contractors: International Research and Technology Corporation, Catalytic Inc., and Procon Inc. The development of the organic chemicals industry inventory differed from other in-depth studies in that neither NCWQ nor NRDI had a complete inventory of plants or production. The NCWQ inventory contains 345 unique multi-product plants with an estimated process water intake of 125 billion gallons per year (BGY). NRDI contains 550 unique multi-product plants with an estimated process water intake of 97 BGY. The 1967 Census of Manufactures (U.S. COM 1971) estimated 413 BGY of process water intake by 600 plants.

The NRDI inventory is adjusted by scaling up aggregate production at each plant in proportion to process water intake. Since the total process water intake in 1967 was 413 BGY, and process water associated with identified production was 97 BGY, production at each plant was scaled by a factor of 413 divided by 97, or 4.25. This approach assumes that all production in the industry takes place at the 550 plants identified in the inventory.

NCWQ, on the other hand, chose not to adjust its inventory but to scale their final results (RDR costs) in proportion to process water intake, i.e., by a simple ratio of 413 divided by 125, or 3.3. This approach assumes that the remainder of production, the vast majority, takes place at approximately 794 other plants with a mix of waste characteristics, effluent limitations, and production levels similar to those found in the 345 studied in depth.

For the organic chemical and plastic and synthetic industries, in-place unit process RDR technologies are assumed to be uniformly in place throughout each industry, and BPT and BAT technologies are the same for each plant. For inorganic chemicals, although it is also assumed that in-place RDR technology is uniform throughout the industry, eight different BAT and BPT technology trains are defined, seven for the seven major residuals-generating product categories and one for all other product categories. A simple procedure is used to combine those unit treatment processes that are the same and are compatible for discharges from product categories with different BAT and BPT technology definitions. Therefore single, but usually different, treatment trains for BPT and BAT are applied to each plant, reflecting the product mix.

Rather than making in-place RDR technology assumptions based on NCWQ or EPA documents, as was possible for other industries studied in-depth, for the inorganic and organic chemicals and plastic and synthetics industries the 1972 Census of Manufactures (U.S. COM 1975) was used. Table 9 in the Census reports the number of establishments in a four-digit SIC category which use specific unit RDR processes. From this table, the percent of the total number of establishments in each SIC category using each unit RDR process was calculated. A weighted percent of establishments using each specified RDR process was then computed for each industry based upon the SIC categories in the industry. If an RDR unit process was computed to be used in 51 percent of the establishments in an industry, it was then assumed to be in place in all establishments (plants) in the industry; if in less than 50 percent of the establishments, it was then assumed <u>not</u> to be in place in any establishment.

Summaries of In-depth Industry Studies

The following Tables, 3-6, 3-7, and 3-8, summarize, respectively, RDR technology assumptions, residuals generation and discharge, and RDR capital costs.

TABLE 3-6

Summary of Technology Assumptions for Industries Studied In-Depth

Industry	Technology Assumptions		
	RDR Unit Processes In-Place 1973	BPT RDR Unit Processes	BAT RDR Unit Processes Incremental to BPT
PULP AND PAPER Applies to 13 product subcategories, see Appendix E for listing.	Specific plant data actual in place	PR, AC, GR, VA, LA	MU
PETROLEUM REFINING Applies to 5 product subcategories, see Appendix E for listing.	Specific plant data actual in place	RE, EQ, OI, PE, AC, MU, GR, VA, LA	CA, EV, CO
TEXTILES			
Wool scouring	Nothing in place	SC, PR, AC, GR, VA, LA	CL
Wool raw stock	Nothing in place	SC, PR, AC, CL, GR, VA, LA	MU
Wool finishing	EQ, NE, PR, GR, VA, LA	SC, PR, AC, CL, GR, VA, LA	MU
Woven mill	SC, PR, GR, VA, LA	SC, PR, AC, CL, GR, VA, LA	MU
Adhesive mill	Nothing in place	SC, PR, AC, CL, GR, VA, LA	MU
Woven finishing--cotton	SC, PR, GR, VA, LA	SC, PR, AC, GR, VA, LA	TW, MU, CL
Woven finishing--other	SC, EQ, PR, GR, VA, LA	SC, PR, AC, GR, VA, LA	TW, MU, CL
Knit finishing--cotton	PR, GR, VA, LA	SC, PR, AC, GR, VA, LA	TW, MU, CL
Knit finishing--other	SC, EQ, AC, GR, VA, LA	SC, PR, AC, GR, VA, LA	TW, MU, CL
Piece dyeing and printing	EQ, PR, AC, GR, VA, LA	SC, PR, AC, GR, VA, LA	TW, MU, CL
Raw stock and yarn dyeing	SC, NE, PR, BR, GR, VA, LA	SC, PR, AC, GR, VA, LA	TW, MU, CL
IRON AND STEEL			
By-product coking	EQ, AS, PR	EQ, AS, NE, PR, AC, GR, VA, LA	MU, CA, BR
Iron making	EQ, PR	EQ, TW, GR, VA, LA	NE, MU, CA, BR
Steel production--electric arc	EQ, PR	EQ, TW, GR, VA, LA	SI, MU
Steel production--BOF	EQ, PR	EQ, NE, TW, GR, VA, LA	SI, MU
Steel production--open hearth	EQ, PR	EQ, NE, TW, GR, VA, LA	SI, MU
PLASTICS AND SYNTHETICS 17 product subcategories, see Appendix E for listing.	NE, PR, AE, EQ, LA	EQ, NE, PR, AC, GR, VA, LA	TW
ORGANIC CHEMICALS Applies to 64 product subcategories, see Appendix E for listing.	NE, EQ, PR	EQ, NE, PR, AC, GR, VA, LA	MU, CA

TABLE 3-6 (Continued)

Industry	Technology Assumptions		
	RDR Unit Processes In-Place 1973	BPT RDR Unit Processes	BAT RDR Unit Processes Incremental to BPT
INORGANIC CHEMICALS 35 product subcategories; 7 product subcategories have unique technology assumptions.			
Sulfuric acid	NE, PR	EV	
Chlorine (mercury)	NE, PR	NE, PR, EQ, VA, LA	
Nitric acid	NE, PR	NE, PR, EQ, VA, LA	
Carbon dioxide	NE, PR	EQ, OI, SI, FL, MU, VA, LA	EV
Sodium carbonate	NE, PR	PR, EQ, VA, LA	
Hydrogen	NE, PR	OI, NE, PR, EQ, VA, LA	
Nitrogen and oxygen	NE, PR	OI, PR, EQ, LA	
Applies to all other subcategories; see Appendix E for listing.	NE, PR	EQ, NE, PR, VA, LA	MU, TW

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[1] See Table 3-5 for explanation of abbreviations

TABLE 3-7

Summary of Estimated 1973 Residuals Generation And Discharge for Industries Studied In-Depth

Industry	Residuals Generation in 1973 (Million Pounds)		Residuals Discharge in 1973 after In-Place Technologies (Million Pounds)		Residuals Discharge in 1973 after Applying BPT (Million Pounds)		Residuals Discharge in 1973 after Applying BAT (Million Pounds)	
	BOD	TSS	BOD	TSS	BOD	TSS	BOD	TSS
1. Pulp and Paper Mills								
Sulfite Segment	549.62	247.33	373.80	139.63	54.96	19.79	27.48	7.42
Groundwood Segment	344.23	826.16	235.94	515.47	34.42	66.09	17.21	24.78
Soda Segment	37.62	59.40	28.38	43.08	3.76	4.75	1.88	1.78
Bleached Kraft Segment	1,859.72	2,324.64	767.89	751.17	185.97	185.97	92.99	69.74
Unbleached Kraft Segment	359.66	404.61	168.77	156.23	35.97	32.37	17.98	12.14
NSSC Sodium Segment	96.46	43.84	53.97	22.44	9.65	3.51	4.82	1.31
NSSC Ammonia Segment	17.12	9.78	7.92	4.41	1.71	0.78	0.85	0.29
NSSC Kraft Segment	196.35	160.65	59.32	36.35	19.64	12.85	9.82	4.82
Deinked Segment	65.43	201.33	43.72	127.38	6.54	16.12	3.27	6.04
Paperboard from Waste Segment	137.40	274.81	111.61	207.79	13.74	21.98	6.87	8.25
Non-integrated Coarse Segment	90.15	231.82	74.87	172.89	9.02	18.55	4.51	6.95
Non-integrated Fine Segment	70.16	175.41	57.99	128.30	7.02	14.03	3.51	5.26
Non-integrated Tissue Segment	48.91	122.28	39.45	86.65	4.89	9.78	2.45	3.67
TOTALS	3,872.83	5,082.06	2,023.63	2,391.79	387.29	406.57	193.64	152.45
2. Organic Chemicals								
TOTALS[1]	1,980.17	0.0	1,326.72	0.0	186.14	0.0	39.60	0.0
3. Petroleum Refining								
Topping	0.31	1.07	0.27	0.85	0.02	0.02	0.01	0.01
Cracking	57.17	14.24	30.64	6.60	2.86	0.33	1.14	0.11
Petro-chemicals	47.70	13.51	27.47	7.40	2.38	0.31	0.95	0.11
Lube	76.78	25.26	36.78	9.11	3.84	0.58	1.53	0.20
Integrated	36.34	10.69	20.72	5.81	1.82	0.25	0.73	0.09
TOTALS	218.30	64.77	115.88	29.77	10.92	1.49	4.36	0.52
4. Iron and Steel								
By-product Coking	78.62	52.42	39.31	6.81	5.90	1.57	1.18	0.16
Iron Making	0.0	538.17	0.0	21.52	0.0	7.00	0.0	1.08
Steel production -- Electric arc	0.0	914.48	0.0	219.47	0.0	73.16	0.0	5.49
Steel production -- BOF	0.0	8,052.04	0.0	1,771.44	0.0	563.64	0.0	48.31
Steel production -- Open Hearth	0.0	2,610.75	0.0	548.26	0.0	174.92	0.0	13.05
TOTALS	78.62	12,167.86	39.31	2,567.50	5.90	820.29	1.18	68.09
5. Inorganic Chemicals								
TOTALS[1]	11.74	2,395.90	7.86	1,150.03	5.63	693.87	4.04	347.14

TABLE 3-7 (Continued)

Industry	Residuals Generation in 1973 (Million Pounds)		Residuals Discharge in 1973 after In-Place Technologies (Million Pounds)		Residuals Discharge in 1973 after Applying BPT (Million Pounds)		Residuals Discharge in 1973 after Applying BAT (Million Pounds)	
	BOD	TSS	BOD	TSS	BOD	TSS	BOD	TSS
6. Plastics and Synthetics								
TOTALS[1]	335.05	241.51	224.48	115.92	33.50	26.56	6.70	2.41
7. Textile Mills								
Wool Scouring	219.61	302.94	219.61	302.94	21.96	33.32	10.98	9.09
Wool Raw Stock	29.90	12.86	29.90	12.86	2.99	1.41	1.49	0.39
Wool Finishing	34.36	14.77	3.44	1.63	3.44	1.63	1.72	0.44
Woven Mill	9.63	4.95	6.45	2.37	0.96	0.54	0.48	0.15
Adhesive Mill	3.16	12.10	3.16	12.10	0.32	1.33	0.16	0.36
Woven Finishing -- Cotton	221.21	74.93	22.12	8.24	22.12	8.24	4.43	0.75
Woven Finishing -- Other	54.38	18.42	36.44	8.84	5.44	2.03	1.09	0.18
Knit Finishing -- Cotton	27.18	32.61	18.21	15.65	2.72	3.59	0.54	0.33
Knit Finishing -- Other	30.97	37.16	20.75	17.84	3.10	4.09	0.62	0.37
Piece Dyeing and Printing	34.79	12.29	3.48	1.35	3.48	1.35	0.70	0.12
Raw Stock and Yarn Dyeing	28.56	6.70	19.13	3.36	2.86	0.77	0.57	0.07
TOTALS	693.75	529.73	382.69	387.18	69.39	58.30	22.78	12.25
NATIONAL TOTALS FOR ALL INDUSTRIES STUDIED IN-DEPTH (rounded)	7,200	20,600	4,100	6,700	700	2,000	270	600

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[1] Subcategorized by product rather than production process -- see Appendix E for subcategory listings and residuals data.

TABLE 3-8

Residuals Discharge Reduction Capital Costs for Industries Studied In-Depth (Millions of 1975 Dollars)

Industry	Replacement Value of Existing Facilities (1973)	Incremental Capital Costs of BPT Technology	Incremental Capital Costs of BAT Technology
Pulp and Paper Mills			
Sulfite Segment	200	157	42
Groundwood Segment	147	203	50
Soda Segment	13	21	4
Bleached Kraft Segment	948	394	253
Unbleached Kraft Segment	215	129	63
NSSC Sodium Segment	48	67	14
NSSC Ammonia Segment	7	10	1
NSSC Kraft Segment	108	33	19
Deinked Segment	33	72	12
Paperboard from Waste Segment	105	333	72
Non-integrated Coarse Segment	64	159	25
Non-integrated Fine Segment	84	157	54
Non-integrated Tissue Segment	53	90	27
TOTALS	2,033	1,831	643
Organic Chemicals			
TOTALS[1]	364	1,425	1,409
Petroleum Refining			
Topping	16	59	93
Cracking	145	286	580
Petrochemicals	49	102	184
Lube	72	146	255
Integrated	44	78	172
TOTALS	327	673	1,286
Iron and Steel			
By-product Coking	62	154	113
Iron making	22	75	84
Steel production-electric arc	208	407	299
Steel production-BOF	414	918	598
Steel production-Open hearth	144	331	209
TOTALS	853	1,887	1,305
Inorganic Chemicals			
TOTALS[1]	366	564	147
Plastics and Synthetics			
TOTALS[1]	454	298	195
Textile Mills			
Wool Scouring	0	73	0
Wool Raw Stock	0	51	7
Wool Finishing	20	25	8
Woven Mill	32	59	22
Adhesive Mill	0	32	7
Woven Finishing-Cotton	66	212	120
Woven Finishing-Other	12	32	19
Knit Finishing-Cotton	18	46	38
Knit Finishing-Other	42	21	35
Piece Dyeing and Printing	35	7	22
Raw Stock and Yarn Dyeing	26	30	37
TOTALS	255	428	320
NATIONAL TOTALS INDUSTRIES STUDIED IN-DEPTH (rounded)	4,700	7,200	5,000

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[1] Subcategorized by product rather than production process -- see Appendix E for subcategory listings and residuals data.

GENERAL INDUSTRY STUDIES

All industries other than those studied in depth are analyzed as described in this section and are grouped under the 41 categories shown earlier. Four-digit SIC categories are used as the basic unit of analysis and all results are aggregated under the 41 categories. First, the categories are defined by SIC and then the coverage in the NRDI analysis is described. Next are the description of the general methodology used, which is very similar to the in-depth industry study method--once residuals generation per plant has been estimated--and an outline of some of the more important assumptions. The section concludes with three summary tables, with formats almost identical to those in the in-depth industry section.

NRDI Coverage of General Industry Study Categories

The categories selected for general industry study cover three industries studied in depth by NCWQ: fruits and vegetables, part of metal finishing (electroplating), and miscellaneous organic chemicals. These three industries are designated by 17 four-digit SIC categories. The remaining 38 general industry categories are identified by 394 four-digit SIC categories. Table 3-9 shows the four-digit SICs identified in each category and the SICs included in the NRDI analysis. As shown, the NRDI analysis covers only a portion of 21 categories[a] (not including fruits and vegetables, metal finishing, and miscellaneous organic chemicals), encompassing 91 out of 115 four-digit SICs in these categories.

Table 3-10 further describes the NRDI coverage of the general industry categories by presenting the percent of total process water intake and number of establishments covered in each category. In this case the 1972 census was used, because the most serious disclosure problems relate mostly to the major water users discussed in the in-depth study section.

Industry categories were excluded, either partly or totally, for several reasons. Ten categories were excluded either because of lack of data on such factors as residuals generation concentrations and product output, or because of the inability to estimate the cost and effect on residuals discharges of RDR technologies (in-plant, reuse, and recycle technologies) not included in the set of available unit process RDR technologies. These 10 industry categories are: soap and detergent; transportation; miscellaneous food and beverages; phosphates; timber products; furniture and fixtures; beet sugar; fiberglass, auto and laundries; and paint and ink. Five additional categories were not investigated because NCWQ estimated a low total cost for BPT and BAT technologies for these categories. These are steam

TABLE 3-9

Four-Digit SIC Categories Associated With NCWQ General Industry Categories (1972 SIC Manual)

NCWQ Categories	Four-Digit SIC Categories
Ore Mining & Dressing	1011, 1021, 1031, 1094, 1041, 1044, 1051, 1061, 1092, 1099
Coal Mining	1111, +1112, 1211, +1213
Petroleum & Gas Extraction	1311[1], 1321[1], 1381[1], 1382[1], 1389[1]
Mineral Mining & Processing	1411, *1422, *1423, *1429, 1442, 1446, *1452, *1453, 1454, 1455, 1496, 1459, 1499, *1479, 1472, 1473, *1474, 1475, 1476, 1477, 1492
Fish Hatcheries	*0921
Meat Products & Rendering	2016, 2017[2], 2011, 2013, 2077[3]
Dairy Products	2021, 2022, 2023, 2024, 2026
Grain Mills	2046, 2043, 2041, 2044, 2045, *2047, 2048
Cane Sugar Processing	2061, 2062
Beet Sugar Processing	2063
Seafood	2091, 2092, 2077[3]
Timber Products	+2411, +2421, +2426, +2429, +2431, +2435, +2436, +2491, +2492, +2499
Furnitures & Fixtures	+2511, +2512, +2517, +2521, +2531, +2541
Builders Papers	2661[4]
Paint & Ink	+2851, +2893, *2711, *2721, *2731, *2732, *2741, *2751, *2752, *2753, *2754, *2761, *2771, *2793, *2794, *2795, *3951, *3952, *3953, *3955
Soap & Detergent	*2841
Phosphates	+2819, +2874
Fertilizer	2873, 2874
Paving & Roofing	2951, *1611, 2952, 3996
Rubber	3011, 3021, 3031, 3069, 3293, 2822, *7534
Leather Tanning	3111
Glass	3211, 3221, 3229, 3231
Cement	3241
Structural Clay	*3251, *3253, *3255, *3259
Pottery	3261, 3262, 3263, 3264, +3269
Concrete, Gypsum	+3271, +3272, +3273, 3275, +3274, 3297
Asbestos	3292, +3293
Fiberglass	+3296
Ferroalloy	3313

Key: * Not included in NRDI General Industry Inventory because of insufficient data.
+ Not included in NRDI General Inventory because not covered by NRDI Unit Treatment Processes.

TABLE 3-9 (Continued)

NCWQ Categories	Four-Digit SIC Categories
Non-Ferrous Metals	3331, 3332, 3333, 3334, 3341
Transportation	*4011, *4013 *4212, *4213, *4214, *4231, *4463, *4469, *4511, *4521, *4582, *4583, *4742, *4784
Water Supply	*4941
Steam Supply	*4961
Auto & Other Laundries	*7218, *7211, *7213, *7214, *7542, *7217, *7215, *7219, *7216
Foundries	*3321, *3322, *3325, *3361, *3362, *3369
Non-Ferrous Mill Products	*3356, *3357
Miscellaneous Food & Beverages	2017[2], *2051, *2052, *2061, +2062, +2063, *2065, *2066, *2067, *2074, *2075, *2076, 2077, *2083, +2084, *2085, *2087, +2095, +2097, *2098, *2099, *2079, +5141, +5142, +5143, *5144, +5145, +5146, +5147, +5148, +5149, *2086
Machinery	*3079, *3411, *3412, *3421, *3423, *3425, *3429, *3431, *3432, *3433, *3441, *3442, *3443, *3444, *3446, *3448, *3449, *3451, *3452, *3462, *3463, *3465, *3466, *3469, *3471, *3479, *3492, *3483, *3484, *3489, *3493, *3494, *3495, *3496, *3497, *3498, *3499, *3511, *3519, *3523, *3524, *3531, *3532, *3533, *3534, *3535, *3536, *3537, *3541, *3542, *3544, *3545, *3546, *3547, *3549, *3551, *3552, *3553, *3554, *3555, *3559, *3561, *3562, *3563, *3564, *3565, *3566, *3567, *3568, *3569, *3572, *3573, *3574, *3576, *3579, *3581, *3582, *3585, *3586, *3589, *3592, *3599, *3612, *3613, *3621, *3622, *3623, *3624, *3629, *3631, *3632, *3633, *3634, *3635, *3636, *3639, *3641, *3643, *3644, *3645, *3546, *3647, *3648, *3651, *3652, *3661, *3662, *3671, *3672, *3673, *3674, *3675, *3676, *3677, *3678, *3679, *3691, *3692, *3693, *3694, *3699, *3711, *3713, *3714, *3715, *3721, *3724, *3728, *3731, *3732, *3743, *3751, *3761, *3764, *3769, *3792, *3795, *3799, *3811, *3822, *3823, *3824, *3825, *3829, *3832, *3841, *3842, *3843, *3851, *3861, *3873, *3911, *3914, *3915, *3931, *3942, *3944, *3949, *3951, *3952, *3953, *3955, *3961, *3962, *3963, *3964, *3991, *3993, *3995, *3996, *3999
Electroplating	3471, 3479
Fruits & Vegetables	2032, 2033, 2034, 2035, 2037, 2038
Miscellaneous Organic Chemicals	2831, 2833, 2834, 2861, 2879, 2891, 2892, 2895, 2899

1. Covered under two-digit SIC 13.
2. 2017 is classified under two NCWQ Industry Categories: Meat Products & Rendering and Miscellaneous Food Beverages.
3. 2077 is classified under three NCWQ Industry Categories: Meat Products & Rendering, Seafoods, and Miscellaneous Food and Beverages.
4. 2661 is classified under two NCWQ Industry Categories: Builders Papers and Asbestos.

Key: *Not included in NRDI General Industry Inventory because of insufficient data.
+Not included in NRDI General Inventory because not covered by NRDI Unit Treatment Processes.

Total number of 4-digit SIC categories: 411
Total number of 4-digit SIC categories in NCWQ General Industry categories: 394
Total number of 4-digit SIC categories included in NRDI: 91
Total number of 4-digit SIC categories included in Machinery Category (none of which is included in NRDI): 171

TABLE 3-10

NRDI General Industries Coverage

	Total Process Water Intake for All SICs in Category for 1973[1] (Billions of Gallons)	Total No. of Estab. in All SICs in Category with Water Intake[1] (≥20 Million Gallons in 1973[1])	NRDI Coverage Percent of Reported Process Water Intake	NRDI Coverage Percent of Reported Total No. of Estab. in Category
Ore Mining and Dressing	11.1	147	100	100
Coal Mining	NA	277	100	100
Petroleum and Gas Extraction	9.1	632	100	100
Mineral Mining and Processing	126.1	630	95	73
Meat Products and Rendering	63.6	537	100	100
Dairy Products	1.3	479	100	100
Grain Mills	13.3	100	83	76
Cane Sugar Processing	12.2	65	29	37
Beet Sugar	5.2	52	0	0
Canned and Preserved Seafood	2.2	66	86	71
Misc. Food and Beverages	43.4	331	0	0
Timber Products	8.9	122	0	0
Furniture and Fixtures	0.1	6	0	0
Builders Paper	8.9	22	100	100
Paint and Ink	NA	19	0	0
Soap and Detergent	1.5	27	0	0
Phosphates	31.9	92	0	0
Fertilizer	17.6	180	100	100
Paving and Roofing	1.2	51	100	100
Rubber	8.8	203	100	100
Leather Tanning	NA	52	100	100
Glass	9.6	176	100	100
Cement	11.3	117	100	100
Concrete, Gypsum	18.3	179	0	38
Asbestos	9.2	67	0	55
Fiberglass	2.0	32	0	0
Ferroalloy	52.9	226	0	9
Machinery	123.8	1,124	0	0
Transportation	NA	NA	NA	NA
Water Supply	NA	NA	NA	NA
Auto and Other Laundries	NA	NA	NA	NA
Foundries	3.8	212	0	0
Fish Hatcheries	NA	NA	NA	NA
Structural Clay	0.2	10	0	0
Pottery	0.7	31	100	100
Steam Supply	NA	NA	NA	NA
Non-ferrous Metals	14.1	87	100	100
Non-ferrous Mill Products	7.6	103	0	0
Fruits and Vegetables	125.1	493	100	100
Electroplating	0.9	161	100	100
Misc. Organic Chemicals	29.7	270	100	100
TOTALS	775.6	7,378	58	63

[1] Source: U.S. Department of Commerce (1975): 1972 Census of Manufactures.

supply, fish hatchery, non-ferrous mill products, structural clay products, and foundries. Two categories, machinery and mechanical products, and water supply, were not investigated because of lack of data and the absence of EPA guidelines for these categories. Exclusion of these two categories is unfortunate because NCWQ has estimated high BPT and BAT costs for them. The consequences of their exclusion from the NRDI data base are discussed in the last section of this chapter.

General Method

The methodology for the general industry studies is based upon the following general assumptions:

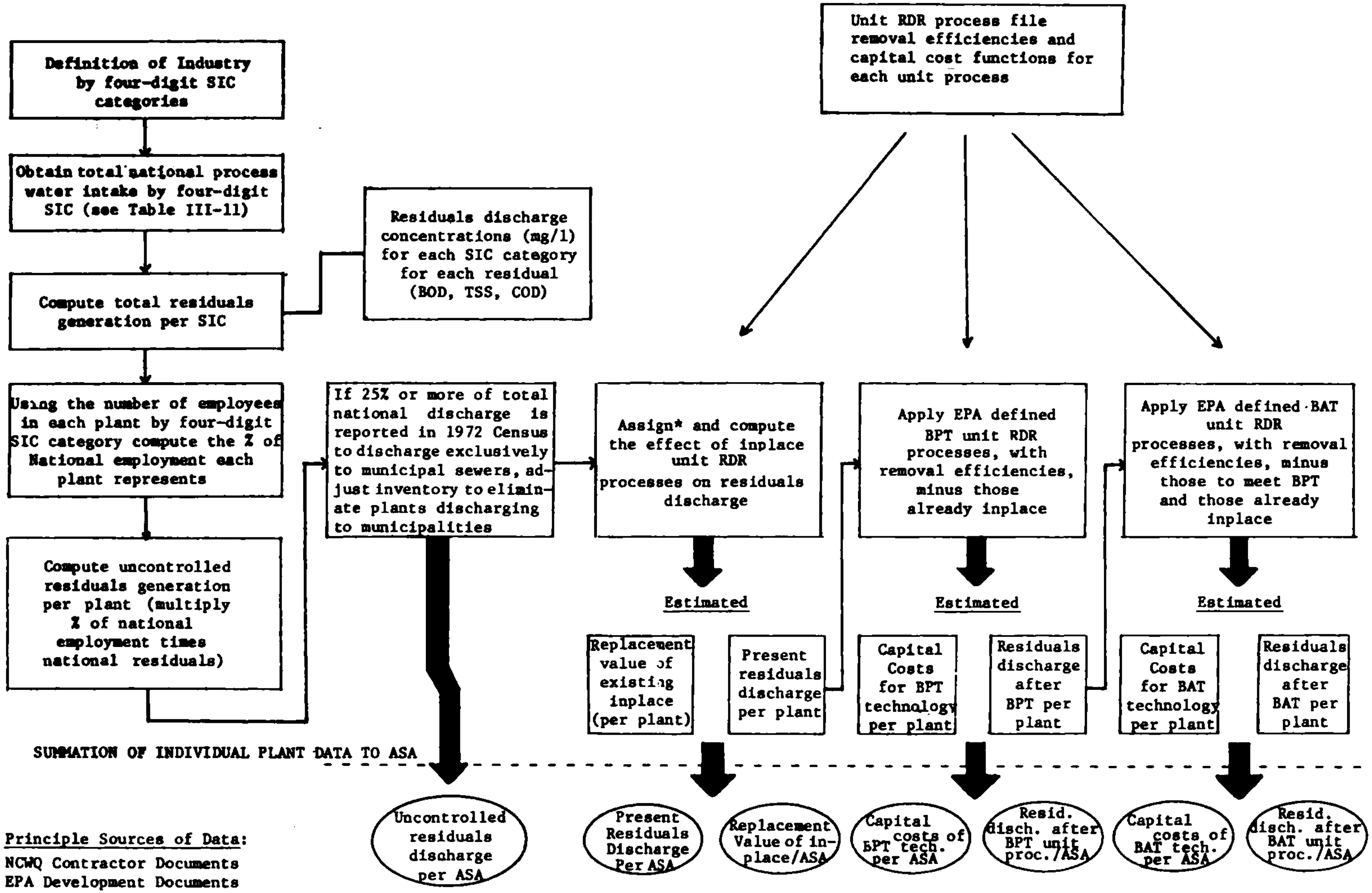
1. residuals generation is directly proportional to employment;
2. all plants in a four-digit SIC category have the same RDR technologies in place;
3. predominant product process, product specifications, and differences in age of equipment are not significant for all plants in a four-digit SIC category; and
4. plants having less than 20 employees have negligible residuals generation and costs for residuals discharge reduction and can therefore be omitted from the analysis.

The general method, shown in Figure 3-2, is very similar, once residuals generation per plant has been computed, to the method used for analyzing industries studied in depth. The only plant-specific data involved in this analysis are employees per plant and plant location. All other information is national level data which are disaggregated to the plant level by plant employee share of the national total within an SIC category.

The first step in the method, definition of industry categories consisting of one or more four-digit SICs, has already been explained in the previous section. The entire analysis is performed by four-digit SIC category and not until the last is information by SIC aggregated to the appropriate industry category. The second step is to estimate total national residuals generation for each SIC and to distribute it among individual plants on the basis of employment.[9] Generation is estimated based upon 1972 process water intake, which is used as an estimate of wastewater discharge. Residuals generation concentrations are taken from several sources. Table 3-11 displays for each SIC the data used and their sources. No attempt has been made to assign unique residuals generation concentrations to process subcategories within a four-digit SIC category.

FIGURE 3-2

General Methodology For Analyzing The General Industries Category



Principle Sources of Data:

NCWQ Contractor Documents
EPA Development Documents
Industry Associations Publications
County Business Patterns (1972)

*Inplace residuals reduction technologies are either assigned by plant, when data exists or as an industry base level by assumption.

TABLE 3-11

Estimated National Residuals Generation Data by Four-Digit SIC Categories for Industries Studied In-General

SIC Number	Name	National Residuals Generation				Source			
		WW 10^6 BGY	BOD mg/l	TSS mg/l	COD mg/l	Wastewater		Residuals Generation	
						Document	Page Number	Document	Page Number
1011	Iron Ore	235.4	0	200,000	0	CW68	2 - 6	DD	578
1021	Copper Ore	109.9	0	167,000	0	CW68	2 - 6	DD	596
1031	Lead & Zinc Ore	9.2	0	250,000	0	CW68	2 - 6	DD	597
1041	Gold	237.6	0	250,000	0	CW68	2 - 6	DD	609
1044	Silver Ores	2.8	0	290,000	0	CW68	2 - 6	DD	628
1051	Bauxite Ore	1.3	0	161	0	DD	631	DD	632
1061	Ferroall Ore	0.1	0	0	7,464	DD	645	DD	646
1092	Mercury Ore	0.1	0	154,000	0	DD	668	DD	669
1094	U. R. V. Ores	6.4	0	500,000	20	CW72	2 - 30	DD	680
1099	Misc. Ores	6.8	0	25	0	CW72	2 - 30	DD	686
1111	Anthracite Mining	9.9	0	450	0	CW 68	2 - 6	DD	56 - 60
1211	Bituminous Mining	24.2	0	450	0	CW68	2 - 6	DD	56 - 60
13	Oil and Gas Extraction	11.0	234	334	382	CW72	2 - 13*	BTL	3 - 14
1411	Dimension Stone	0.3	0	5,000	0	CW68	2 - 6	DD	200
1422	Crushed and broken limestone	41.4	0	60,000	0	CW68	2 - 6	DD	203
1423	Crushed and broken granite	2.9	0	60,000	0	CW72	2 - 30	DD	203
1429	Crushed and broken stone	4.4	0	60,000	0	CW68	2 - 6	DD	203
1442	Sand & Gravel	85.7	0	11,992	0	CW72	2 - 30	DD	208
1446	Industrial Sand	20.1	0	68,000	0	CW72	2 - 30	DD	200
1452	Bentonite	0	0	0	0	DD	46	N/A	N/A
1453	Fire Clay	0	0	0	0	DD	46	N/A	N/A
1454	Fullers Earth	0.1	0	32	0	DD	46	DD	54
1455	Kaolin and Ball Clay	6.9	0	20,000	0	CW72	2 - 30	DD	60
1459	Feldspar	0.5	0	75	0	CW68	2 - 6	DD	71
1472	Barite	21.3	0	50,000	0	DD	198	DD	198
1473	Fluorspar	0.7	0	1,200	0	DD	198	DD	63
1474	Potash, soda, and borate minerals	4.2	0	0	0	CW72	2 - 30	N/A	N/A
1475	Phosphate Rock	239.3	0	59	0	CW68	2 - 6	DD	110
1476	Rock Salt	0.6	0	2,000	0	CW72	2 - 30	DD	102

*Bureau of Census, correspondence

Key: DD = EPA Development Document
BTL = Battelle
EA = EPA Economic Analysis
CW = Census of Manufactures: Water Use in Manufacturing
NCA = National Canners Association

TABLE 3-11 (Continued)

SIC Number	Name	National Residuals Generation				Source			
		WW 10^6 BGY	BOD mg/l	TSS mg/l	COD mg/l	Wastewater		Residuals Generation	
						Document	Page Number	Document	Page Number
1477	Sulfur	14.9	0	211	0	CW68	2 - 6	DD	123
1479	Chemical and Fertilizer Mining	4.6	0	515	0	CW72	**	DD	139
1492	Gypsum	7.3	0	1,100	0	DD	223	DD	223
1496	Talc, soapstone, and pyrophyllite	1.5	0	71,000	0	DD	97	DD	97
1499	Nonmetallic minerals	0.2	0	16,500	0	DD	105	DD	105
2011	Meatpacking plants	36.1	1,234	954	0	CW72	4 - 66	DD	39 - 43
2013	Sausages and other Prepared Meats	3.2	601	354	1,330	CW72	4 - 66	DD	39 - 53
2016	Poultry Dressing Plants	25.1	476	333	952	CW72	4 - 66	DD	48 - 54
2017	Poultry and Egg Processing	25.1	476	333	952	CW72	4 - 66	DD	48 - 54
2021	Butter	1.0	999	499	0	CW67	7 - 23	DD	48 - 52
2022	Cheese	1.2	883	283	0	CW72	4 - 66	DD	48 - 52
2023	Condensed and Evaporated Milk	1.6	554	256	0	CW67	7 - 23	DD	48 - 52
2024	Ice Cream	0.7	1,668	400	0	CW67	7 - 23	DD	48 - 52
2026	Fluid Products	11.7	930	388	0	CW67	7 - 23	DD	48 - 52
2032	Canned Specialties	11.7	1,050	640	0	CW67	7 - 23	NCA	2 - 4
2033	Canned Fruits and Vegetables	20.5	1,050	640	0	CW72	4 - 66	NCA	2 - 4
2034	Dehydrated Fruits, Vegetables, Soups	5.3	1,050	640	0	CW72	4 - 66	NCA	2 - 4
2035	Pickles, Sauces, and Salad Dressings	1.4	0	1,050	640	CW67	7 - 23	NCA	2 - 4
2037	Frozen Fruits and Vegetables	27.0	1,051	640	0	CW72	4 - 66	NCA	2 - 4
2038	Frozen Specialties	3.4	1,051	640	0	CW72	4 - 66	NCA	2 - 4
2041	Flour and other Grain Mill Products	0.9	379	354	800	CW72	4 - 66	DD	63
2043	Cereal Breakfast Foods	1.0	1,189	311	2,269	CW72	4 - 66	DD	40
2046	Wet Corn Milling	9.1	1,637	831	2,844	CW72	4 - 66	DD	50
2047	Dog, Cat, and Other Pet Foods	1.4	1,130	845	0	CW72	4 - 66	DD	441
2061	Raw Cane Sugar	8.6	490	5,940	0	CW72	4 - 66	DD	111 - 122
2062	Cane Sugar Refining	3.6	85	310	0	CW72	4 - 66	DD	104 - 105
2063	Beet Sugar	5.2	850	3,210	0	CW72	4 - 66	DD	28
2077	Animal and Marine Fats and Oils	0.9	640	336	2,391	CW72	4 - 66	DD	45
2091	Canned and Cured Fish and Seafoods	1.7	1,124	578	2,049	CW68	7 - 23	DD	79 - 160

**Estimated as remainder of water intake for SIC 147

Key: DD = EPA Development Document EA = EPA Economic Analysis CW = Census of Manufactures: Water Use in Manufacturing NCA = National Canners Association

TABLE 3-11 (Continued)

SIC Number	Name	National Residuals Generation				Source			
		WW 10^6 BGY	BOD mg/l	TSS mg/l	COD mg/l	Wastewater		Residuals Generation	
						Document	Page Number	Document	Page Number
2092	Fresh or frozen packaged fish	1.9	871	1,148	2,351	CW72	4 - 66	DD	79 - 160
2661	Building paper and board mills	17.7	247	842	0	CW72	4 - 68	DD	24
2822	Synthetic Rubber	15.1	153	398	1,177	CW67	7 - 25	DD	57
2831	Biological Products	0.3	288	767	480	CW72	4 - 68	DD	I - 7
2833	Medicinals and botanicals	2.6	1,890	47	3,579	CW72	4 - 68	DD	I - 7
2834	Pharmaceutical preparations	3.9	555	33	1,010	CW67	7 - 25	DD	I - 7
2861	Gum and wood chemicals	2.0	1,154	979	1,604	CW72	4 - 68	DD	I - 10
2873	Nitrogenous fertilizers	6.7	N/A	N/A	N/A	CW72	4 - 68	N/A	N/A
2874	Phosphatic fertilizers	10.9	N/A	N/A	N/A	CW72	4 - 68	N/A	N/A
2879	Agricultural chemicals, nec	4.6	1,199	1,441	3,143	CW68***	7 - 25	DD	I - 13
2891	Adhesives and sealants	1.1	3,778	3,214	1,087	CW72	4 - 68	DD	I - 18
2892	Explosives	11.7	3,584	734	17,317	CW72	4 - 68	DD	I - 21
2895	Carbon black	4.0	0	0	0	CW72	4 - 68	DD	I - 23
2899	Chemical preparations, nec	8.0	4,482	3,813	12,025	CW72	4 - 68	DD	I - 18
2951	Paving mixtures and blocks	0.5	0	1,300	0	CW72	4 - 68	DD	38
2952	Asphalt felts and coatings	2.6	0	128	0	CW68	7 - 25	DD	39
3011	Tires and inner tubes	5.4	7	45	71	CW72	4 - 68	DD	52
3021	Rubber and plastics footwear	0.2	12	13	42	CW68	7 - 25	DD	78
3031	Reclaimed rubber	0.1	9	19	45	DD	83	DD	83
3069	Fabricated rubber products, nec	3.1	254	1,962	937	CW72	4 - 68	DD	87
3111	Leather tanning and finishing	13.5	1,591	2,360	3,860	CW68	7 - 25	DD	44 - 45
3211	Flat glass	8.4	2	15	15	CW68	7 - 25	DD	74
3221	Glass containers	3.1	5	24	50	CW72	4 - 70	DD	74
3229	Pressed and blown glass, nec	4.7	5	24	50	CW72	4 - 70	DD	74
3231	Products of purchased glass	1.6	24	62	862	CW72	4 - 70	DD	60
3241	Cement, hydraulic	11.3	1,100	1,000	0	CW72	4 - 70	DD	40
3261	Vitreous plumbing fixtures	0.1	0	4,835	0	CW68	7 - 5	DD	V - 52
3262	Vitreous china food utensils	0.2	0	119	0	CW72	4 - 70	DD	V - 64
3263	Fine earthenware food utensils	0.1	0	119	0	CW72	4 - 70	DD	V - 64
3264	Porcelain electrical supplies	0.4	0	7,900	0	CW72	4 - 70	DD	V - 86

***Estimated as remainder of water intake in SIC 287

Key: DD = EPA Development Document
EA = EPA Economic Analysis
CW = Census of Manufactures: Water Use in Manufacturing
NCA = National Canners Association

TABLE 3-11 (Continued)

SIC Number	Name	National Residuals Generation				Source			
		WW 10^6 BGY	BOD mg/l	TSS mg/l	COD mg/l	Wastewater		Residuals Generation	
						Document	Page Number	Document	Page Number
3275	Gypsum products	2.9	0	48	0	CW68	7 - 26	DD	V - 109
3292	Asbestos products	5.0	2	550	36	CW68	7 - 26	DD	46
3293	Gaskets, packing and sealing devices	1.1	12	13	42	CW68	7 - 26	DD	62 - 64
3297	Nonclay refractories	3.1	9	19	16	CW68	7 - 26	DD	V - 119
3313	Electrometallurgical products	1.3	0	200	0	CW68	7 - 26	DD	19
3331	Primary copper	14.1	0	14	12	CW68	4 - 70	DD	92
3332	Primary lead	5.5	0	15	8	CW68	7 - 26	DD	41 - 45
3333	Primary zinc	4.2	0	82	32	CW68	7 - 26	DD	50
3334	Primary aluminum	23.5	0	37	13	CW68	7 - 26	DD	43
3341	Secondary nonferrous metals	1.0	0	480	536	CW68	7 - 26	DD	48
3471	Plating and polishing	6.7	23	137	0	CW68	7 - 26	DD	98
3479	Metal coating and allied services	0.5	0	0	0	CW68	7 - 26	DD	98
3996	Hard surface floor coverings	0.7	0	11	0	CW72	4 - 74	DD	39

Key: DD = EPA Development Document   EA = EPA Economic Analysis   CW = Census of Manufactures: Water Use in Manufacturing   NCA = National Canners Association

The third step is to estimate existing in-place RDR, BPT, and BAT technologies as series of unit RDR processes that can reasonably be assumed to be uniformly applicable to all plants in an SIC category. Uniform in-place unit process RDR technologies for each SIC were estimated primarily using Table 9 in the 1972 Census of Manufactures (U.S. COM 1975). The procedure is basically the same as that explained for the organic chemical, inorganic chemical, and plastic and synthetic industries. In some cases, EPA development documents were used. BPT and BAT technology assumptions were taken exclusively from EPA development documents. Table 3-12 summarizes the technology assumptions. The remaining steps cf computing RDR costs and related residuals discharges per plant and aggregating to the desired levels are the same as for the in-depth studies. The same set of unit processes used for the in-depth studies, shown in Table 3-5, are used here for the general industry categories.[10]

Summaries of Industries Studied In General

The following Tables 3-12, 3-13, and 3-14 summarize, respectively, RDR technology assumptions, residuals generation and discharge, and RDR costs.

TABLE 3-12

Summary of Technology Assumptions For Industries Studied In General

	Related Four-Digit 1972 SIC Categories Included by NAS	Technology Assumptions		
		RDR Unit Processes In-Place 1973	BPT RDR Unit Processes	BAT RDR Unit Processes Incremental to BPT
Ore Mining & Dressing	1011	EA, EA	CH, EA, EA	
	1021	Nothing in place	CH, EA, EA	
	1031	EA, EA	CH, EA, EA	
	1041	Nothing in place	CH, EA, EA	
	1044	EA, EA	CH, EA, EA	
	1051	Nothing in place	CH, EA, EA	
	1061	EA, EA	CH, EA, EA	
	1092	Nothing in place	CH, EA, EA	
	1094	Nothing in place	CH, EA, EA, IO	
	1099	EA, EA	CH, EA, EA	
Coal Mining	1111	Nothing in place	NE, CH, EA	
	1211	EA, EA	NE, CH, EA	
Petroleum & Gas Extraction	13[1]	Nothing in place	FL	
Mineral Mining & Processing	1411	Nothing in place	EA, EA	
	1442	Nothing in place	EA, EA	
	1446	Nothing in place	EA, EA	
	1454	Nothing in place	EA, EA	
	1455	EA, EA	CH, EA, EA	
	1459	Nothing in place		
	1472	EA, EA	CH, EA, EA	
	1473	EA, EA	CH, EA, EA	
	1475	EA, EA	EA, EA	
	1476	Nothing in place	EA, EA	
	1477	EA, EA	FL, EA	
	1492	Nothing in place	EA, EA	
	1496	Nothing in place	CH, EA, EA	
	1499	Nothing in place	EA, EA	MU
Fish Hatcheries				
Meat Products & Rendering	2011	SC, FL, PR, XA, LA	SC, NE, FL, PR, XA, LA	MU
	2013	SC, FL, PR	SC, NE, FL, PR, XA, LA	MU
	2016-2017[2]	SC, FL, PR, XA, LA	SC, NE, FL, PR, XA, LA	MU
	2077[3]	SC, PR	SC, NE, FL, PR, XA, LA	MU
Dairy Products	2021	Nothing in place	XA, LA	MU
	2022	Nothing in place	XA, LA	MU
	2023	Nothing in place	XA, LA	MU
	2024	Nothing in place	XA, LA	MU
	2026	Nothing in place	XA, LA	MU

TABLE 3-12 (Continued)

	Related Four-Digit 1972 SIC Categories Included by NAS	Technology Assumptions		
		RDR Unit Processes In-Place 1973	BPT RDR Unit Processes	BAT RDR Unit Processes Incremental to BPT
Grain Mills	2041	PR	PR,XA, LA	MU
	2043	PR	SI, LA	MU
	2044[4]			
	2045[4]			
	2046	NE, FL, XA, LA	NE, FL, XA, LA	MU
	2048[4]			
Cane Sugar Processing	2062	Nothing in place	PR, XA, LA	MU
Beet Sugar Processing				
Seafood	2091	Nothing in place	SC, EQ, XA, LA	FL
	2092	Nothing in place	SC, EQ, XA, LA	FL
Timber Products				
Furniture and Fixtures				
Builders Paper	2661[5]	Nothing in place	PR, AE, LA	MU
Paint & Ink				
Soap & Detergent				
Phosphates				
Fertilizer	2873	PR	AS, PR, LA	TW
	2874	PR	AS, PR, LA	TW
Paving & Roofing	2951	PR	SI, LA	TW
	2952	PR	PR, LA	TW
	3996	SI	SI, LA	TW
Rubber	2822	Nothing in place	EQ, SI, AE, LA	CA
	3011	Nothing in place	OI, FL, LA	
	3021	Nothing in place	OI, AE, LA	NE
	3031	OI, NE	OI, NE	
	3069	Nothing in place	NE, SI, AE, LA	
	3293	Nothing in place	OI, NE, LA	
Leather	3111	NE, PR	NE, PR, AE, LA	MU
Glass	3211	Nothing in place	OI, LA	
	3221	Nothing in place	OI, LA	FL
	3229	PR	OI, PR	MU
	3231	Nothing in place	OI	MU
Cement	3241	EA	PR, EA, LA	
Structural Clay				
Pottery	3261	Nothing in place	SI, LA	TW
	3262	Nothing in place	SI, LA	TW
	3263	Nothing in place	SI, LA	TW
	3264	Nothing in place	SI, LA	TW

TABLE 3-12 (Continued)

	Related Four-Digit 1972 SIC Categories Included by NAS	Technology Assumptions		
		RDR Unit Processes In-Place 1973	BPT RDR Unit Processes	BAT RDR Unit Processes Incremental to BPT
Concrete, Gypsum	3275	Nothing in place	PR, LA	
	3297	AE	PR, AE, LA	
Asbestos	3292	PR	SI, LA	TW
Fiberglass				
Ferroalloy	3313	PR	NE, SI, CY, LA	MU
Non-Ferrous Metals	3331	Nothing in place	NE, PR, LA	
	3332	PR	NE, SI, LA	TW
	3333	PR	NE, SI, LA	TW
	3334	PR	SI, LA	TW
	3341	PR	NE, SI, LA	TW
Transportation				
Water Supply				
Steam Supply				
Auto & Other Laundries				
Foundries				
Non-Ferrous Mill Products				
Miscellaneous Food & Beverages				
Machinery				
Electroplating	3471	NE	EQ, NE, SI, CY, MU, LA	EV
	3479	NE	EQ, NE, SI, CY, MU, LA	EV
Fruits & Vegetables	2032	SC, PR	SC, PR, XA	MU, CL
	2033	SC, PR	SC, PR, XA	MU, CL
	2034	SC, PR	SC, PR, XA	MU, CL
	2035	SC, PR	SC, SI, XA	MU, CL
	2037	SC, PR	SC, PR, XA	MU, CL
	2038	SC, PR	SC, PR, XA	MU, CL
Miscellaneous Organic Chemicals	2831	EQ, NE, PR	EQ, NE, PR, AC, GR, VA, LA	MU, CA
	2833	EQ, NE, PR	EQ, NE, PR, AC, GR, VA, LA	MU, CA
	2834	EQ, NE, PR	EQ, NE, PR, AC, GR, VA, LA	MU, CA
	2861	EQ, NE, PR	EQ, NE, PR, AC, GR, VA, LA	MU, CA
	2879	EQ, NE, PR	EQ, NE, PR, AC, GR, VA, LA	MU, CA
	2891	EQ, NE, PR	EQ, NE, PR, AC, GR, VA, LA	MU
	2892	EQ, NE, PR, AC, GR, VA	EQ, NE, PR, AC, GR, VA, LA	MU, CA
	2895	EQ, NE, PR, AC, GR, VA	EQ, NE, PR, AC, GR, VA, LA	MU
	2899	EQ, NE, PR	EQ, NE, PR, AC, GR, VA, LA	MU

1. Covered under two-digit SIC 13.
2. 2017 is classified under two NCWQ Industry Categories: Meat Products and Rendering and Miscellaneous Food and Beverages.
3. 2077 is classified under three NCWQ Industry Categories: Meat Products and Rendering, Seafoods, and Miscellaneous Food and Beverages.
4. Water use insignificant, SIC not included in NRDI study.
5. 2661 is classified under two NCWQ Industry Categories: Builders Paper and Asbestos.

TABLE 3-13

Summary of Estimated 1973 Residuals Generation and Discharge For Industries Studied In General

Industry	Residuals Generation in 1973 (Million Pounds)		Residuals Discharge in 1973 After In-Place Technologies (Million Pounds)		Residuals Discharge in 1973 After Applying BPT (Million Pounds)		Residuals Discharge in 1973 After Applying BAT (Million Pounds)	
	BOD	TSS	BOD	TSS	BOD	TSS	BOD	TSS
1. Ore Mining & Dressing	0.0	1,090,555.0	0.0	688,863.7	0.0	8,724.5	0.0	8,724.5
2. Coal Mining	0.0	127.3	0.0	40.4	0.0	5.1	0.0	5.1
3. Petroleum & Gas Extraction	10.7	15.2	10.7	15.2	6.4	3.0	6.4	3.0
4. Mineral Mining & Processing	0.0	30,745.2	0.0	21,104.4	0.0	885.1	0.0	884.3
5. Fish Hatcheries	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
6. Meat Products & Rendering	250.3	187.9	30.3	8.0	25.2	6.3	12.6	1.8
7. Dairy Products	41.1	16.7	41.1	16.7	10.3	5.8	5.1	1.6
8. Grain Mills	104.2	52.7	19.1	5.0	17.1	4.1	8.6	1.2
9. Cane Sugar Processing	15.3	164.4	11.1	83.7	6.6	46.5	0.4	4.1
10. Beet Sugar Processing	36.9	139.2	9.2	48.7	6.2	23.4	2.5	7.5
11. Seafood	24.5	19.5	24.5	19.5	6.1	6.8	3.7	1.4
12. Timber Products	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
13. Furniture & Fixtures	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
14. Builders Papers	19.2	65.3	19.2	65.3	3.2	11.0	1.6	3.1
15. Paint & Ink	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
16. Soap & Detergent	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
17. Phosphates	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
18. Fertilizer	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
19. Paving & Roofing	0.0	5.9	0.0	2.8	0.0	1.8	0.0	1.9
20. Rubber	22.1	70.1	22.1	70.1	2.8	7.4	1.4	4.3
21. Leather Tanning	60.4	89.7	40.5	43.0	10.1	15.1	5.1	4.2
22. Glass	0.7	3.1	0.6	2.6	0.6	2.6	0.4	1.4
23. Cement	103.7	94.2	103.7	18.8	69.5	9.0	69.5	9.0
24. Structural Clay	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
25. Pottery	0.0	30.5	0.0	30.5	0.0	8.9	0.0	2.8
26. Concrete, Gypsum	0.1	1.5	0.0	1.3	0.0	0.6	0.0	0.6
27. Asbestos	0.0	11.0	0.0	5.3	0.0	3.2	0.0	3.0
28. Fiberglass	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
29. Ferroalloy	0.0	2.2	0.0	1.0	0.0	0.6	0.0	0.2
30. Non-Ferrous Metals	0.0	16.3	0.0	8.7	0.0	5.0	0.0	5.0
31. Transportation	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
32. Water Supply	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
33. Steam Supply	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
34. Auto & Other Laundries	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
35. Foundries	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
36. Non-Ferrous Mill Products	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
37. Miscellaneous Food & Beverages	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
38. Machinery	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
39. Electroplating	0.3	1.6	0.3	1.6	0.1	0.1	0.0	0.0
40. Fruits & Vegetables	410.7	255.6	275.2	122.7	68.8	42.6	34.4	11.9
41. Miscellaneous Organic Chemicals	729.7	368.8	289.7	150.5	73.3	40.7	22.8	8.8

TABLE 3-14

Residuals Discharge Reduction Capital Costs for Industries Studied In General (Millions of 1975 Dollars)

Industry	Replacement Value of Existing RDR Facilities (1973)	Incremental Capital Costs of BPT Technology	Incremental Capital Costs of BAT Technology
1. Ore Mining and Dressing	18.0	74.4	0.0
2. Coal Mining	5.4	39.6	0.0
3. Petroleum and Gas Extraction	0.0	138.0	0.0
4. Mineral Mining and Processing	16.5	29.4	4.6
5. Fish Hatcheries	No Data	No Data	No Data
6. Meat Products and Rendering	512.0	74.5	160.0
7. Dairy Products	0.0	52.1	93.5
8. Grain Mills	46.8	5.5	22.1
9. Cane Sugar Processing	8.6	36.3	40.9
10. Beet Sugar Processing	26.5	29.9	26.0
11. Seafood	0.0	64.8	41.2
12. Timber Products	No Data	No Data	No Data
13. Furniture and Fixtures	No Data	No Data	No Data
14. Builders Paper	0.0	52.6	16.0
15. Paint and Ink	No Data	No Data	No Data
16. Soap and Detergent	No Data	No Data	No Data
17. Phosphates	No Data	No Data	No Data
18. Fertilizer	61.7	118.1	94.6
19. Paving and Roofing	76.6	4.2	2.3
20. Rubber	0.3	240.0	86.3
21. Leather Tanning	23.9	89.0	16.9
22. Glass	38.8	12.9	75.5
23. Cement	1.2	68.1	0.0
24. Structural Clay	No Data	No Data	No Data
25. Pottery	0.0	29.8	20.1
26. Concrete, Gypsum	2.0	32.0	0.0
27. Asbestos	16.1	3.6	3.5
28. Fiberglass	No Data	No Data	No Data
29. Ferroalloy	9.8	35.3	7.8
30. Non-Ferrous Metals	67.3	35.7	26.5
31. Transportation	No Data	No Data	No Data
32. Water Supply	No Data	No Data	No Data
33. Steam Supply	No Data	No Data	No Data
34. Auto and other Laundries	No Data	No Data	No Data
35. Foundries	No Data	No Data	No Data
36. Non-Ferrous Mill Products	No Data	No Data	No Data
37. Miscellaneous Food & Beverages	No Data	No Data	No Data
38. Machinery	No Data	No Data	No Data
39. Electroplating	4.0	260.7	65.8
40. Fruits and Vegetables	223.0	117.2	200.0
41. Miscellaneous Organic Chemicals	803.0	1320.0	751.0
Totals (rounded)	2,000	3,000	1,800

INDUSTRY STUDY LIMITATIONS AND INTERPRETATION OF COST ESTIMATES

The limitations of the NRDI industry studies may be classified into three categories: residuals estimation, cost estimation and regionalization. There are limitations which apply: (1) generally to both in-depth and in-general study categories; (2) specifically to each study category; and (3) to each industry individually. Industry RDR cost estimates, because of their importance, are discussed here in detail. NRDI estimates are compared to those from other sources--NCWQ and EPA. For each industry category where NRDI estimates differ significantly from NCWQ and/or EPA, an attempt is made to explain the differences.

Estimation of Residuals Generation and Discharge

A major limitation of the NRDI industry studies is that only total wastewater, BOD, and TSS are considered. (The RDR costs, however, cover reducing the discharges of more than BOD and TSS, because EPA RDR technology trains are used. How much of the costs apply to other residuals is not known.) Other perhaps more important residuals, such as heavy metals, toxics, and nutrients, have not been included. Although some data on other residuals in industry are available (see Chapter 10), the data were neither sufficiently accurate nor sufficiently complete to permit analysis within NRDI.

Estimates in the in-depth studies of total wastewater and BOD and TSS residuals generation and discharge after RDR technologies are applied are more accurate than the corresponding estimates in the general studies. Even so, the absolute accuracy of residuals estimation in the in-depth studies is difficult to ascertain. For example, to assume that all plants in an industry are operating at capacity, which they are not, tends to overestimate residuals generation. On the other hand, to assume that all RDR facilities operate at design efficiencies, which they do not, tends to underestimate residuals discharge. (Whether or not these two opposite effects tend to compensate is unknown.) The residuals generation coefficients themselves are, at best, rough averages and are not adjusted for the effects of plant size, plant site, age of production facilities, regional differences in factor prices, and so on. Nevertheless, despite all of the caveats, consensus is that: (1) the plant inventories, residuals generation coefficients, and RDR process removal efficiencies used are the best available at this time; and (2) that the annual residuals discharges estimated are reasonable for the in-depth studies.

By definition, the industries which are studied in general are considerably less accurately defined than the industries studied in depth. General industry residuals generation data are also, therefore, less accurately estimated. NRDI estimates, as those of other sources, should be viewed with a high degree of skepticism and should only be considered order of magnitude estimates. However, one desirable attribute of the NRDI general industry residuals estimates is the consistent manner in which they are computed. Wastewater discharge data for each general industry are taken from the same source, the 1972 Census of Manufactures (U.S. COM 1975), and the same assumption is made for each, namely, that process water intake is equal to wastewater discharge. Using imputed Census wastewater data and typical discharge concentrations from EPA development documents results in general industry estimates which tend to be low, because plants using less than 20 million gallons per year are excluded from the Census.

Regionalization

The NRDI regionalization of both industry residuals discharges and RDR cost data is believed to be the most accurate available to date. For the in-depth studies the data are plant specific and the regionalization of residuals and RDR costs therefore is performed "from the bottom up." The industries studied in depth represent the majority of total industrial residuals generation and RDR costs. For industries studied in general, national residuals estimates are disaggregated, based upon employees/plant, to specific plants, and then RDR costs are computed at each plant. Regionalization is again developed by aggregating from individual plant data. The assumption that residuals generation is a function of employment has been used before and, while less than perfect, is the only basis available. Nevertheless, the regionalization for the industries studied in general, from the top down, is considerably less accurate than the bottom up approach used in the in-depth studies.

Interpretation of NRDI Industry RDR Cost Estimates

There are several important limitations of the NRDI industry RDR cost estimates. These limitations can be divided into two categories: (1) those which generally tend to overestimate costs; and (2) those which definitely underestimate costs.

There are four important limitations which generally tend to result in overestimated costs. First, the NRDI estimates represent only end-of-pipe options; no in-plant options, often costing less, are considered. Second, total process wastewater discharge is, with few exceptions, run through all unit RDR processes included in an RDR technology train whereas, in reality, each wastewater flow would be modified only as necessary. Third, most of the cost functions used were developed based upon the cost of unit process RDR technologies designed for municipal systems.

Unit process costs are generally greater for RDR systems for municipalities than for industries. Fourth, regional differences in unit process usage were not included. The use of cheaper aerated stabilization basins which are typically used in certain regions instead of activated sludge systems would reduce costs. The interesting observation is that, although the aforementioned limitations definitely push costs upward, the NRDI estimates are comparable when compared to other sources (U.S. EPA and/or NCWQ) for the same RDR trains applied to the same inventories. This leads to the conclusion that, given the inherent variability in the cost functions and costing procedures available at this time, the NRDI end-of-pipe estimates are as reasonable as those from other sources.

There are four important limitations which make the NRDI total industry cost estimate lower than the corresponding estimates by NCWQ and EPA. First, NRDI does not compute pretreatment costs for plants discharging directly to municipalities. NRDI computes residuals discharges and RDR costs for direct surface water dischargers only. Second, because at this stage of its development NRDI only analyzes BOD and TSS residuals, the RDR costs for other residuals, thermal discharges specifically, are not computed. Third, NRDI excludes several industries, in both in-depth and in-general categories, from analysis. Fourth, in NRDI, specific sequences of unit processes, as specified by EPA, are applied as BPT and BAT. But for some industries the NCWQ contractors and industry associations have argued that the specified technology will in fact not achieve the specified effluent limitations. Thus, additional processes have been added, thereby increasing costs. Such adjustments are not made in NRDI. Table 3-15 compares the NCWQ, EPA, and NRDI cost estimates. The following section describes the reasons for these limitations and presents what are considered reasonable cost adjustments to the NRDI estimates to account for them.

Residuals Discharges and Pretreatment Costs for Industrial Discharges to Municipal Treatment Plants

Residuals discharges to publicly owned treatment plants (POTPs) vary considerably among industries. Some industries, such as textiles and metal finishing, discharge more than 50 percent of their residuals into POTPs. Other industries, such as iron and steel and nonferrous metals, discharge virtually none of their residuals into POTPs. The amount of wastewater discharged into POTPs is estimated for each industry on the basis of 1972 Census data and is presented in Appendix E.

Industrial residuals discharged into POTPs usually contain BOD and TSS which are compatible with POTPs. However, other industrial residuals discharges are

TABLE 3-15

Comparison of Aggregate Capital Cost Estimates for Industry (1973 Production) to Apply BPT and BAT Technology
(1975 Dollars x 10^6)

	BPT			BAT		
	NCWQ	EPA	NRDI	NCWQ	EPA	NRDI
INDUSTRIES NCWQ STUDIED IN-DEPTH:						
Studied In-Depth in NRDI						
Inorganic Chemicals	520	419	560	247	N/A	150
Iron and Steel	2,910	1,564	1,900	949	N/A	1,300
Organic Chemicals	4,290	3,092	2,723	3,640	N/A	2,125
Petroleum Refining	1,050	1,624	680	1,180	N/A	1,290
Plastics and Synthetics	160	480	270	286	N/A	170
Pulp and Paper	2,640	2,506	1,820	798	N/A	640
Textiles	537	131	428	300	N/A	320
Subtotal	12,067	9,816	--	7,700	N/A	5,995
Studied In-General in NRDI						
Miscellaneous Organic Chemicals	736	N/A	1,323	571	N/A	751
Fruits and Vegetables	443	173	117	161	N/A	200
Metal Finishing[a]	14,140	174	260	14,100	N/A	68
Subtotal	15,319	--	1,700	14,832	N/A	1,019
Not Studied in NRDI						
Steam Electric Power	3,740	1,576	N/A	2,030	N/A	0
Feedlots	2,205	58	N/A	493	N/A	N/A
Subtotal	5,945	1,634	N/A	2,523	N/A	N/A
TOTAL	33,371	--	--	25,055	N/A	--
INDUSTRIES NCWQ STUDIED IN-GENERAL:						
Group C						
Studied In-General in NRDI						
Ore Mining and Dressing	610	88	75	0	N/A	0
Coal Mining	1,700	0	40	0	N/A	0
Petroleum and Gas Extraction	234	158	139	1,070	N/A	0
Minerals Mining and Processing	730	0	30	0	N/A	5
Canned and Preserved Seafood	55	38	64	105	N/A	41
Leather Tanning and Finishing	119	67	89	73	N/A	17
Subtotal	2,838	263	362	1,248	N/A	63
Not Studied in NRDI						
Miscellaneous Food and Beverages	5	N/A	N/A	5	N/A	N/A
Machinery and Mechanical Products	3,900	1,460	N/A	3,900	N/A	N/A
Water Supply	1,200	1,000	N/A	100	N/A	N/A
Subtotal	5,105	--	N/A	4,005	N/A	N/A
TOTAL	8,553	—	—	5,253	N/A	—
Group B						
Studied In-General in NRDI						
Meat Products and Rendering	130	287	75	240	N/A	160
Dairy Products	79	402	52	51	N/A	93
Grain Mills	56	19	5	13	N/A	22
Cane Sugar	153	24	36	170	N/A	40
Beet Sugar	90	6	30	60	N/A	26
Builders Paper and Board	120	6	52	0	N/A	16
Fertilizer	64	10	118	60	N/A	95
Rubber Processing	220	157	240	48	N/A	86
Ferroalloy	48	14	35	13	N/A	8
Nonferrous Metals (Bauxite, Al)[a]	75	92	35	120	N/A	26
Subtotal	1,035	1,017	1,630	885		572
Not Studied in NRDI						
Transportation	1,200	N/A	N/A	140	N/A	N/A
Subtotal	1,200	N/A	N/A	140	N/A	N/A
TOTAL	2,235	—	—	885	N/A	—

TABLE 3-15 (Continued)

	BPT			BAT		
	NCWQ	EPA	NRDI	NCWQ	EPA	NRDI
Group A						
Studied In-General in NRDI						
Paving and Roofing Materials	6	6	4	4	N/A	2
Glass	36	9	13	57	N/A	75
Cement	34	28	68	9	N/A	0
Pottery and Related Products	3	19	30	4	N/A	20
Concrete, Gypsum, and Plaster[b]	100	45	32	0	N/A	0
Asbestos	4	5	4	9	N/A	4
Subtotal	183	112	151	83	N/A	101
Not Studied in NRDI						
Fish Hatcheries and Farms	50	N/A	N/A	47	N/A	N/A
Timber Products Processing	14	71	N/A	25	N/A	N/A
Furniture and Fixtures	8	5	N/A	0	N/A	N/A
Paint and Ink Formulation	23	11	N/A	0	N/A	N/A
Soap and Detergent	11	20	N/A	1	N/A	N/A
Phosphate	110	19	N/A	26	N/A	N/A
Structural Clay Products	5	N/A	N/A	0	N/A	N/A
Insulation Fiberglass	14	15	N/A	0	N/A	N/A
Steam Supply	Negli.	N/A	N/A	Negli.	N/A	N/A
Auto and Other Laundries	25	N/A	N/A	21	N/A	N/A
Foundries	180	307	N/A	0	N/A	N/A
Non-Ferrous Mill Products	260	7	N/A	0	N/A	N/A
Subtotal	700	--	N/A	120	N/A	N/A
TOTAL	883	--	--	203	N/A	--
TOTAL FOR ALL INDUSTRIES STUDIED IN-GENERAL	11,671	4,395	2,212	6,380	N/A	736
GRAND TOTAL FOR ALL NCWQ INDUSTRIES	45,042	--	--	31,435	--	--

NOTES:

a - No Bauxite in NRDI; its estimated cost is $68 million.

b - NRDI does not include all SICs.

incompatible with a POTP; therefore, industrial activities must pretreat these residuals before an industry can discharge into a municipal system. These incompatible residuals can have detrimental effects by damaging the treatment plants or reducing or disrupting the performance of the system, thereby increasing the residuals discharges from the treatment plants.

Industrial dischargers bear two types of costs when they discharge into municipal systems. The first type is a user charge paid to POTPs for treating compatible industrial residuals, i.e., payment for utility service rendered. Industries are usually required to pay their share of capital and operation and maintenance costs based on flow and pounds of residuals. While these costs may be significant for some industries, these costs are not included in the NRDI industry costs of applying BPT and BAT. The ST and BPWTT costs reflect the costs for both domestic and industrial waste flows in POTPs. Thus, including in BPT and BAT costs the user charge payments of industries to municipalities would result in double counting the resource costs to the nation for point source RDR. Assuming that industrial flow is approximately 20 percent of total flow in POTPs, and that municipalities actually implement user charge systems which reflect the actual capital and O&M costs of industrial use of municipal systems, the industrial share of 1977 ST costs would be about $6.0 billion and of 1983 BPWTT costs would be $1.6 billion.

The second type of cost borne by industrial dischargers into POTPs is the cost for removing incompatible residuals. Examples of residuals which fall into this category are acids, toxics--including some which cannot be removed in typical municipal systems--heavy metals, non-degradable organics, excess grease, and oil. Most of the industries studied in depth and many of those studied in general discharge incompatible residuals into POTPs and must bear a cost if they remove them before they discharge into POTPs. Since these costs are not included in either ST and BPWTT costs or the BPT and BAT costs for direct dischargers, these costs are legitimate costs to the nation's industrial activities for application of BPT and BAT technology.

While these costs are legitimate costs to meet BPT and BAT requirements and should be included in analysis, they are very difficult to estimate for three reasons. First, EPA has not clearly defined the residuals which they consider to be incompatible with POTPs. In the latest regulations, EPA states that "the pretreatment standards themselves were not clearly understood by many segments of the general public."[11] Second, many professionals in the field think that at least some so-called incompatible residuals, heavy metals for example, are, in limited quantities, compatible with POTPs and are effectively removed by these treatment facilities. If so, industries should not have to bear pretreatment costs for incompatible residuals and their only costs would be the user charges. Third, the magnitude of current discharges of incompatible residuals into POTPs cannot be estimated with much confidence. There is a scarcity of information on the number of establishments by industrial category discharging incompatible residuals into POTPs, and on the amount and type of residuals discharged per establishment. For example, the number of establishments in the metal finishing industry has been estimated to be 20,000 by EPA, 70,000 by NCWQ, and 170,000 by critics of the NCWQ contractor report. In light of these three limitations, any estimate of pretreatment costs for industry is only an order-of-magnitude approximation of the actual costs.

Since NCWQ estimated very large pretreatment costs for metal finishing, textiles, and fruits and vegetables, an attempt is made to estimate pretreatment costs for these three industries using the NRDI data base. These estimates are shown in Table 3-16.

The pretreatment costs for metal finishing are estimated by applying the BPT technology sequence of unit processes defined by EPA for electroplating industries[12] to the amount of flow estimated, 85 percent of total industry flow in SICs 3471 and 3479, discharged into POTPs. The additional costs for the metal finishing industry for pretreatment of incompatible residuals are estimated to be about $1.5 billion. The pretreatment costs for textiles are estimated by applying the BPT technology defined for each industry subcategory to the plants in each subcategory discharging to POTPs. It is estimated that 52 percent of the total industry flow is discharged to POTPs. The costs for the textiles industry for pretreatment are estimated to be about $0.2 billion. The pretreatment costs for the fruits and vegetables industry are estimated to be about $0.07 billion.

TABLE 3-16
Pretreatment Costs for Selected Industries for BPT

		10^9 1975$	
Industry	NRDI	NCWQ[1]	EPA[2]
Metal Finishing	$1.5	$11.3	$1.1
Textiles	.2	.4	.04
Fruits and Vegetables	.07	.2	.00
TOTAL	$1.77	$11.9	$1.14

1 NCWQ (1975) pp. II-107 and II-118.
2 Gianessi and Peskin (1975) Tables 1 and 2.

In summary, industrial dischargers into POTPs bear two types of costs. One cost represents a user charge paid to municipalities for treating compatible residuals. While these costs are legitimate for industry, they are included in the municipal costs for ST and BPWTT, which include both domestic and industrial flows. The other cost is for pretreatment of incompatible residuals. Industries bear this cost directly to eliminate incompatible residuals in their waste flows to POTPs. A rough estimate of pretreatment costs is $1.8 billion for the three industries identified by NCWQ as bearing the major burden of pretreatment costs. The NRDI estimate is only 15 percent of the NCWQ estimate, but is 55 percent of the EPA estimate.

Residuals Discharges and RDR Costs for Industries Excluded from NRDI

As mentioned earlier in this chapter several industries were not included in NRDI (see Table 3-9). Three of these industries--machinery and mechanical products, water supply, and steam electric--were estimated by NCWQ to have high RDR costs. Machinery and mechanical products and water supply were not included in NRDI for two reasons. First, neither was a major generator of BOD and TSS. A brief analysis using National Bureau of Economic Research (NBER) data (Gianessi and Peskin 1975) showed that, based upon 1968 discharge, BOD and TSS discharges from each of these two industries comprised less than 1 percent of the respective national totals. Second, each of these industries, particularly machinery and mechanical products, required a large research effort to analyze, and in light of their relatively small BOD and TSS discharges the resource investment did not seem warranted. The steam electric industry was not included, as mentioned earlier, because of lack of reliable residuals generation data, and because the industry's primary residual discharge--heat--is not covered in NRDI. Another reason for its exclusion from the analysis is the confusion over how to deal with secondary liquid residuals generation and related RDR costs from gaseous residuals modification processes, i.e., discharge streams from wet scrubbing devices. The problem is to decide what secondary RDR costs[13] should be attributed to water or to air pollution control. Therefore, in order to approximate the RDR costs for these industries the NBER estimates provided to EPA, shown in Table 3-17, are used.

In the NBER study (Gianessi and Peskin 1975), it was estimated that for existing sources in the machinery and mechanical products industry it will cost direct surface dischargers about $1.4 billion (1975 dollars) and municipal dischargers $4.2 billion to meet BPT. For the water supply industry the estimate for existing sources was about $1.1 billion to meet BPT requirements. For steam electric the estimate for existing sources was about $1.3 billion to meet BPT requirements. The costs for direct surface dischargers to meet BAT requirements were not estimated in the NBER report. Consequently, no approximation is made for the costs for direct surface dischargers in these industries to meet BAT.

Table 3-17 summarizes the estimates made for pretreatment costs and the RDR costs of the major industries not included in NRDI to apply BPT technology.

TABLE 3-17

Summary of NRDI Adjusted Total Industry Cost Estimate to Apply BPT Technology (Billions of 1975$)

Category	BPT
Industries NCWQ Studied in Depth	10.1
Industries NCWQ Studied in General	1.9
Pretreatment	1.8
Machinery and Mechanical Products	5.5
Water Supply	1.1
Steam Electric	1.3
TOTAL	21.7
EPA	16.2
NCWQ	45

NOTES

1 It was not possible to obtain unique data on every plant's in-place residuals modification facilities for all industries studied in depth.

2 All directly discharging plants are assumed to discharge to surface water, although in a few cases discharge is to evaporation basins or irrigation systems where some deep percolation may occur.

3 Seven of the eleven industries singled out by NCWQ as requiring in-depth analysis are studied in depth here; for the other three, fruits and vegetables, miscellaneous organic chemicals, and electroplating, a sufficiently large inventory of plants could not be defined to warrant an in-depth study.

4 The only exception to this assumption is made in the petroleum industry. See Characteristics of Individual In-depth Industry Studies, page 36.

5 Replacement value is the cost to construct today those facilities that industrial firms indicate are already in place. This approach is used because of the tremendous difficulties associated with attempting to depreciate the value of existing facilities throughout the nation.

6 The pulp and paper industry inventory comprises 551 out of 600 mills producing as of 1973, and represents roughly 97 percent of total production capacity.

7 The iron and steel inventory does not account for non-integrated production because there are no plant level production data for such production.

8 These categories were estimated by NCWQ to incur high total costs for residuals discharge reduction.

9 Based upon specific employment information for plants with more than 20 employees.

10 For use in the general industry analysis the cost functions are simplified and based only upon flow.

11 Draft Notice of Proposed Rule Making (40CFR, Port 403), Pretreatment Standards for Existing Sources and for New Sources -- General Provisions, July 9, 1975, p. 2.

12 It is assumed that the BPT technology defined for electroplating (metal finishing) is similar to the pretreatment technology needed to remove incompatible residuals in the industry.

13 One argument is that attributing such secondary RDR costs in power plants to water pollution control is no more legitimate than attributing sludge disposal costs to solid waste management.

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CHAPTER 4

ANALYZING MUNICIPAL ACTIVITIES

Municipal activities encompass residential, commercial, institutional, and industrial activities discharging residuals into publicly owned sewage treatment plants (POTPs). The mix of activities varies widely among municipalities. A municipal facilities inventory (MFI) has been designed as a component part of NRDI to estimate residuals generation and discharge and RDR costs for municipalities.

GENERAL CONCEPT

Residuals generation from residential, commercial, institutional, and industrial activities discharging into municipal sewage treatment plants is a function of numerous variables. Some of the more important variables are:

$$RG(M) = f(POP, PCW, CS, CD, LS, I),$$

where

RG(M) = residuals generation in a municipality;
POP = population served;
PCW = per capita water use;
CS = city size;
CD = city density;
LS = life style; and
I = industry served.

The life style variable includes such factors as the use of garbage disposals. The industry-served variable summarizes all variables described in the previous chapter as affecting residuals generation in industrial activities, but also reflects the proportion of total load on the POTP from industrial dischargers. Residuals generation is measured in units of residuals--e.g., pounds of BOD--per capita.

Residuals discharge from municipal activities is also a function of numerous variables, many of which are the same as those for residuals generation. These variables are:

$$RD(M) = f(POP, PCW, LS, CS, CD, I, TRES, PP, EC)$$

where

RD(M) = residuals discharge from a municipality;
TRES = technologies of residuals modification;
PP = pricing policy by municipality, i.e.,

charging scheme imposed on industrial, commercial, institutional, residuals discharges into the municipal system; and

EC = effluent charges and/or effluent standards, such as secondary treatment (ST) and best practicable waste treatment technology (BPWTT) imposed on discharges from the municipal plant(s).

The inclusion of both PP and EC, particularly with respect to the effects of user charges on industrial discharges into municipal systems, is essential because of the potential impact of PP on industrial residuals discharge. The imposition of user charges rather than property taxes as a charge for residuals modification and disposal services has resulted in significant decreases in industrial discharges. User charges on institutional, commercial, and domestic dischargers will also likely result in reduced discharges from those sources. Other variables in the function may be modified by changes in prices, for example, of water, energy, and land. Increase in water price would result in a decrease in water use per capita, and hence in lower wastewater generation. Increase in land price would result in increasing land use densities, which in turn, all other factors remaining constant, would result in lower water use/wastewater discharge per capita. EC, or effluent constraints on the municipality's discharge, whether in the form of effluent charges or effluent standards, is the stimulus for imposing user charges and/or limitations in turn on the individual activities--industrial, residential, commercial, institutional--discharging to the municipal plant.

RDR costs for municipalities are a function of which variables are modified in the RD(M) function. Residual discharges can be modified, for example, by changing the discharges for individual activities as well as by adding additional RDR facilities. The costs of the former are often less than of the latter, because the reduction of industrial discharges can be accomplished in many ways, as indicated in the previous chapter. Similarly, there are methods, other than "waste treatment," for reducing discharges from commercial, institutional, and residential activities. Even limiting the possibility of reducing municipal residuals discharges to conventional waste treatment technologies does not limit the choice to one option nor to one unit cost. Several combinations of unit processes, which meet the effluent limitations, can be applied and these combinations result in different costs.

MUNICIPAL FACILITIES INVENTORY (MFI)

Content of MFI

The 1974 joint State-EPA Survey of Needs (Needs Survey) (U.S. EPA 1975) specified the facilities required for treatment systems to meet the 1983 goals of the Act, and estimated the capital costs involved. The costs for all categories of needs increased from the level reported in the 1973 Survey (U.S. EPA 1973) of about $60 billion to about $340 billion, and for the "conventional" facilities--treatment plants and interceptor sewers--from about $36 billion to about $46 billion. A significant, perhaps major, portion of the former increase is attributable to the expanded scope of the 1974 Survey, to include a category for modification of residuals in stormwaters.

EPA recognized that the increase in the conventional facilities was not only a result of a better understanding on the part of the states of the requirements of P.L. 92-500, but also of the uneven quality of the previous estimates. Some of the states "deviated significantly" from the EPA Survey guidelines, according to the EPA final report.

Given the uncertainties associated with the cost data in the 1974 Needs Survey, an MFI was developed for estimating the costs of applying the specified ST and BPWTT technologies to existing (1973) municipal facilities and to the set of facilities required to serve the estimated 1990 population and associated activities, both reported in the Needs Survey. The MFI provides data on residuals generation and discharges, and generates separate estimates of the costs of ST and BPWTT. Neither of these is an output from the Needs Survey.

Estimating Residuals Generation and Discharge and RDR Costs for 1973 Conditions (No Growth) and after Applying ST and BPWTT Technologies

The Needs Survey reports the existing (1973) municipal sewage treatment facilities that are in place across the nation; the expansion (increases in capacity) and upgrading of these facilities that will take place to meet BPWTT requirements, based upon estimated 1990 populations to be served; and additional entirely new facilities that will also be needed to serve 1990 populations and meet BPWTT requirements. The MFI uses the physical data in the Needs Survey on existing facilities and required new facilities, but makes its own estimation of RDR costs. The method used in the MFI for estimating residuals generation and discharge and RDR costs for 1973 conditions involves seven steps.

1. The Needs Survey data are adjusted to compensate for the sampling of existing plants serving less than 10,000 persons and not in SMSAs. States were asked in the Needs Survey to sample, rather than to make a 100 percent inventory of such plants in the state, and to indicate what percent of the total number of such plants were in the sample. A complete inventory for each state is generated by reproducing the records provided in the survey as many times as necessary to account for the total number of this category of plants in the state. For example, if the sample were a 20 percent sample, then the plant data (ASA location, population served, industrial flow, and so on) in the sample are reproduced five times.

2. ST and BPWTT technologies are specified, in terms of sequences of RDR unit processes, in the same way as for industries. ST is defined as secondary treatment for all facilities, and BPWTT as any additional unit processes more stringent than traditional secondary treatment processes requested in the Needs Survey. Where no specific secondary treatment processes are requested by a facility, an activated sludge process is assumed. A dollar-need specification for tertiary treatment (RDR) is assumed to refer to filtration.

3. Wastewater flow is estimated for each existing municipal plant. Although flow was reported in the Needs Survey for many--but not all--plants, for the sake of consistency flow is estimated for each plant. The current (1973) flow (in MGD) for each plant is estimated by:

$$\text{Current Flow (FC)} = 97.85 \times PC + F(i),$$

where

$$PC = \frac{\text{current population served}}{1{,}000{,}000};$$

$$F(i) = \text{reported industrial flow.}$$

The 97.85 gallons per capita per day residential flow (gpd) is derived by: first, assuming that total per capita (residential + commercial + institutional + industrial) flow currently averages 130 gpd nationally; next, estimating the total flow to municipal systems in the nation and subtracting the national industrial discharge to municipal systems reported in the Needs Survey; and then by dividing the remaining flow by the present population served in the nation. This average per capita figure--representing residential + commercial + institutional discharges--is applied to all municipal systems, large and small, throughout the contiguous U.S., even though there are substantial variations among regions and within regions, as a result of the variables indicated earlier in this chapter.

4. Residuals generation is estimated for each municipality (influents into sewage treatment plants). Where influent concentrations of BOD and TSS are reported in

the Needs Survey, they are used; where they are not reported, the following average concentrations based on the Metcalf and Eddy report to NCWQ (1975) are assumed:

BOD = 200 mg/l;
TSS = 230 mg/l;
N = 40 mg/l; and
P = 10 mg/l.

5. Residuals discharges are estimated for each existing plant, for different levels of RDR. Residuals removal efficiencies for each plant are derived from the sequence of unit process RDR technologies either in place or to be installed to meet the technology requirements specified. The unit process removal efficiencies assumed are indicated in Table 4-1.

6. Collector and interceptor sewer costs are estimated, based on unit costs. Collector costs per capita per population size group are listed in Appendix A. The 1973 collector costs (replacement value) are based upon the population served by existing plants times the appropriate per capita cost. Interceptor costs are accounted for by multiplying, based upon population size group, a factor times treatment plant capital costs. Interceptor capital cost factors are also listed in Appendix A. For 1973 conditions only the replacement value of existing collector and interceptor sewers is estimated. Because there is no growth, there are no collector or interceptor costs after applying ST and BPWTT technologies to 1973 conditions.

7. RDR costs are estimated for existing plants (replacement value) and the additional facilities (capital costs) required at existing plants to meet the ST/BPWTT technology requirements specified. RDR costs are based upon flow and the appropriate unit process cost functions. The unit process RDR technologies used are listed in Table 4-1 and the cost data for each function are provided in Appendix A. Each facility requirement is defined as an RDR technology train of one or more unit processes. The MFI applies each of the specified unit processes sequentially and produces a total cost for the facility as a whole.

Results from the MFI for 1973 Conditions

Municipal facilities for handling residential, commercial, institutional, and industrial liquid residuals in 1973 consisted of 24,200 facilities, as shown in Table 4-2, serving approximately 156 million persons of a total contiguous population of about 210 million.

TABLE 4-1

RDR Processes

Type	Removal Efficiencies (%)			
	BOD	TSS	N	P
Conventional Treatment				
Primary	33.0	52.1	10.0	9.0
Activated sludge	78.6	73.0	20.0	20.0
Trickling filter	78.6	68.2	20.0	10.0
Lagoon	78.6	68.2	20.0	10.0
Disinfection	0.0	0.0	0.0	0.0
Advanced Treatment				
Phosphorus removal	67.0	71.0	0.0	94.0
Nitrification	70.0	57.0	0.0	0.0
Nitrification-Denitrification	0.0	0.0	90.0	0.0
Organics removal	60.0	60.0	0.0	20.0
Polishing lagoon	78.6	68.0	20.0	10.0
Carbon adsorption	50.0	72.0	0.0	50.0

Source: Bechtel (1975).

TABLE 4-2
Municipal Sewage Treatment Facilities in 1973

Size (MGD)	# of Plants	Total 10^3 MGD
<1*	21,822	2.3
1.1 - 5	1,794	3.8
5.1 - 20	447	4.2
20+	146	10.0
TOTAL	24,209	20.3

*Includes facilities with no treatment flow.

The largest category, consisting of 6 percent of the plants, accounts for about 50 percent of the flow, and the smallest category, consisting of 90 percent of the plants, accounts for about 10 percent of the flow.

Residuals generation by municipalities for 1973 is estimated to be about 13.2 billion pounds per year of BOD and about 14.1 billion pounds per year of TSS, as indicated in Table 4-3. Significant investment in discharge reduction facilities by 1973 had reduced the discharge to about 5.8 billion pounds per year of BOD and about 6.0 billion pounds per year of TSS. This reduction is approximately 57 percent of BOD and TSS generation. The replacement value of the RDR facilities which produced this reduction is estimated to be $25.0 billion.

Given the 1973 population served by municipal wastewater treatment plants, residuals discharges would decrease markedly from 1973 conditions after applying ST and BPWTT technologies. BOD discharge is estimated to decrease from 5.8 billion pounds per year to 1.8 billion pounds per year, or 69 percent of 1973 BOD discharge, after applying ST, and to about 0.9 billion pounds per year, or 84 percent of BOD discharge, after applying BPWTT. TSS discharge is estimated to decrease from 6.0 billion pounds per year to 1.7 billion pounds per year, or 72 percent of 1973 TSS discharge after applying ST, and to 0.8 billion pounds per year, or 87 percent of TSS discharge after applying BPWTT.

Given the 1973 population served by municipal wastewater facilities, RDR costs are estimated to increase markedly from 1973 conditions with the application of ST and BPWTT. RDR capital costs are estimated to increase by about $22 billion, or 87 percent of the present in-place replacement value, after applying ST, and by about $7.9 billion or 32 percent of the in-place replacement value after applying BPWTT. The cumulative cost increase (ST + BPWTT) would be about 118 percent of the in-place value.

TABLE 4-3

Municipal Residuals Generation And Discharge and RDR Costs
For 1973 Conditions And After Applying ST and BPWTT

Residuals (Billions of Pounds per Year)							
Generation		1973		ST		BPWTT	
BOD	TSS	BOD	TSS	BOD	TSS	BOD	TSS
13.2	14.1	5.8	6.0	1.8	1.7	.9	.8

Costs (Billions of 1973 $)	1973***	ST	BPWTT
Treatment *	25.0	$21.8	$7.9
Collector **	29.3		

* Includes capital costs for treatment plants and interceptors.
** Incremental collector costs are zero after ST and BPWTT.
*** Replacement value of existing facilities.

Estimating Residuals Generation and Discharge and RDR Costs for 1990 Conditions (Growth) and after Applying ST and BPWTT Technologies

Conditions in 1990 are specified in the Needs Survey as the expansion (increases in capacity) of existing (1973) facilities and the addition of entirely new facilities that will be necessary to serve 1990 populations and associated activities and to meet BPWTT requirements. The method used for estimating residuals generation, residuals discharge, and RDR costs for 1990 conditions is similar to that used for 1973 conditions.

1. The Needs Survey data are adjusted for omissions and inconsistencies. The first adjustment is to compensate for the sampling of existing plants serving less than 10,000 persons and not in SMSAs, as explained in the method for 1973 conditions. The second adjustment is to check on the estimated 1990 population to be served, to insure that it corresponds to the Water Resource Council's OBERS Series E 1990 state projections (U.S. WRC 1974). Analysis showed several state estimates of 1990 populations specified in the Survey to be excessively high and inconsistent with estimates from other sources. State populations specified in the Survey which were greater than OBERS state population estimates were adjusted until they were either equal to or less than the OBERS estimate. If the 1990 population reported to be served by all municipal facilities in a state exceeds the OBERS state population estimate, then: (a) the population to be served by future plants is reduced by 50 percent; and (b) if necessary, the growth of future population to be served per plant is limited to the OBERS growth rate for the particular state. The third adjustment is a check on 1990 needs for all existing and new plants. This step involves either acceptance of unit process RDR technologies specified in the Needs Survey or, where only a dollar need has been specified, an assignment of unit processes to the plant. A dollar need specification for secondary treatment (RDR) is assumed to refer to activiated sludge, and a dollar specification for tertiary treatment (RDR) is assumed to refer to filtration.
2. ST and BPWTT technologies are specified in terms of sequences of unit treatment processes, as for industries. The technologies for 1990 conditions are the same as those specified for 1973 conditions.
3. Wastewater flow is estimated for increases in capacity at each of the existing plants and for each future plant. Future (1990) flow (MGD) for existing plants is estimated by:

$$\text{Future Flow } (FF)E = P(F)/P(C) \times FC$$

where

$$P(F) = \frac{\text{future population served}}{1{,}000{,}000};$$

$$P(C) = \frac{\text{current population served}}{1{,}000{,}000}; \text{ and}$$

$$FC = \text{current flow.}$$

Future (1990) flow (MGD) for new plants is estimated by:

$$FF(N) = P(F) \times 125 \text{ gpd}$$

4. Residuals generation is estimated for existing plants with future needs, and for future plants. For existing plants with future needs, current influent concentrations as reported are used where available; where not available, the average influent concentrations displayed in step four for 1973 conditions are used. For future plants, the same average influent concentrations are used.

5. Residuals discharge is computed for each plant in 1990. Future (1990) residual discharges for existing and new plants are based on increased influents--flows and residuals, and the sequence of unit process RDR technologies specified.

6. Collector and interceptor sewer costs are calculated. The methods used for computing collector and interceptor sewer costs are very similar to the methods used for 1973 conditions. The 1990 collector costs for modifications of existing facilities are based upon the new population to be served times the per capita capital costs for the original size group. For new facilities they are based upon new population to be served times the per capita costs for the new population size group. The 1990 interceptor costs for existing facilities are based upon the new capital cost requirement (plant expansion) times the cost factor for the original population size group. For new facilities they are based upon the new capital cost requirement (plant construction) and the cost factor for the future population to be served.

7. The incremental RDR costs are calculated for additional RDR facilities at existing plants (1973), and total costs of RDR facilities at new plants, to apply the ST and BPWTT technologies specified. The method used is the same as for computing RDR costs for 1973 conditions.

Results from the MFI for 1990 Conditions

Municipal facilities for handling domestic, commercial, institutional, and industrial sewage in 1990 are estimated to consist of approximately the same number of plants as in

1973 but approximately 50 percent more flow, as shown in Table 4-4. However, in contrast to 1973 conditions, the largest category, consisting of 8 percent of the plants, is estimated to account for 57 percent of the flow and the smallest category, consisting of 87 percent of the plants, is estimated to account for 9 percent of the flow.

TABLE 4-4
Municipal Sewage Treatment Facilities Estimated for 1990 Conditions

Size (MGD)	# of Plants	Total 10^3 MGD
< 1*	21,186	2.8
1.1 - 5	2,181	4.8
5.1 - 20	646	6.0
20+	202	18.0
TOTAL	24,215	31.0

*Includes facilities with no treatment flow.

The data on residuals generation and 1973 discharges and the replacement value of capital in-place are the same as those presented previously (Table 4-5).

Assuming a 1990 population served by municipal wastewater treatment plants, residuals discharges decrease markedly from 1973 conditions after applying ST and BPWTT. BOD discharge is estimated to decrease from 5.8 billion pounds per year to 2.8 billion pounds per year, or by 52 percent of 1973 BOD discharge, after applying ST, and to 1.8 billion pounds per year, or by 69 percent of BOD discharge, after applying BPWTT. TSS discharge is estimated to decrease from 6.0 billion pounds per year to 2.7 billion pounds per year, or by 55 percent of 1973 TSS discharge, after applying ST, and to 1.6 billion pounds per year or by 73 percent of TSS discharge, after applying BPWTT.

Assuming a 1990 population served by wastewater treatment plants, the RDR costs are estimated to increase from 1973 conditions after applying ST and BPWTT technologies. Capital costs for treatment are estimated to increase by about $27 billion or 108 percent of the in-place value after applying ST, and by $12.5 billion or 50 percent of the in-place value after applying BPWTT. The cumulative cost increase (ST + BPWTT) would be 158 percent of the in-place value.

LIMITATIONS OF THE ANALYSIS

The MFI provides data on residuals discharges with costs for application of ST and BPWTT. The MFI is preferable to the EPA Needs Survey data (U.S. EPA 1973, 1975) and other sources because the residuals data are available for all

TABLE 4-5

Municipal Residuals Generation And Discharge and RDR Costs
For 1990 Conditions And After Applying ST and BPWTT

Residuals (Billions of Pounds per Year)							
Generation		1973		ST		BPWTT	
BOD	TSS	BOD	TSS	BOD	TSS	BOD	TSS
13.2	14.1	5.8	6.0	2.8	2.7	1.8	1.6

	Costs (Billions of 1973 $)		
	1973***	ST	BPWTT
Treatment *	25.0	$27.0	$12.5
Collector **	29.3	6.0	6.0

* Includes capital costs for treatment plants and interceptors.
** Collector costs are arbitrarily split 50-50 between 1977 and 1983.
*** Replacement value of existing facilities.

facilities and the cost estimation technique is well documented. However, this approach has its limitations, and it generates cost data different from those in the EPA Needs Survey.

The MFI does not use the flow data in the 1974 Needs Survey. These data are available for many facilities and in most cases would provide a more accurate estimate. However, many cases were found where the data were either not available or incorrect. The alternative was chosen of adopting a consistent procedure to estimate flow for all facilities, using the same per capita flow for all plants. Obviously such a procedure meant the exclusion of some more accurate estimates of flows and concentrations that could have been used. The extent to which this procedure may bias national or regional results by underestimating or overestimating flows and/or concentrations is not known.

The MFI uses national average residuals generation coefficients. These average coefficients may or may not reasonably reflect residuals generation at the facilities which did not complete the survey form, or residuals generation at any of those which did. The accuracy of these average coefficients could be improved by developing generation coefficients for each state and for size classes of facilities from the available data, but this was not feasible within the time available.

The MFI has the potential for understating RDR costs in specific instances. The application of uniform statistical cost functions cannot reflect specific engineering difficulties which could result in specific plant costs very different from those based on uniform cost functions, as was true for the industry analyses.

The MFI yields a capital cost estimate different from the one reported in the 1974 Needs Survey. The differences between the 1974 Needs Survey and MFI analyses are best illustrated by contrasting the relevant estimates for the four Needs Survey categories shown in Table 4-6. The MFI estimate for the four categories is $10.4 billion less than the EPA Adjusted Estimate. Estimates for Categories I and II are relatively similar.

TABLE 4-6
Comparison of State, EPA Adjusted, and MFI Capital Cost Estimates

billions of dollars

Category	(A) State Estimate*	(B) EPA Adjusted Estimate*	(C) MFI Estimate**
I	13	13	12
II	20	16	16
IV A	25	17	12
IV B	20	18	13
Totals for I, II, and IV B	53	47	41
Totals for I, II, IV A, and IV B	78	64	53

*These estimates include Puerto Rico, Virgin Islands, and Trust Territories.

**This estimate excludes Puerto Rico, Virgin Islands, and Trust Territories.

NOTE: EPA Adjusted means the result of EPA review and adjustment of the estimates made by the states in the Needs Survey (U.S. EPA 1975).

There are several possible reasons for the differences between the EPA Adjusted Estimate and the MFI estimates for the two categories, IVA and IVB. First, the projected population data for the two estimates may differ. However, the EPA Final Report said that state estimates were corrected to make them consistent with the Census Bureau Series E 1990 population projections (U.S. WRC 1974), the basis of the MFI estimates.

Second, the cost functions for the two estimates might be different. For the most part, the Needs Survey per capita costs for collectors (IVA) are 10 to 15 percent higher than the MFI per capita costs. (See Table 4-7.) The costs per facility for interceptors cannot directly be compared, because the MFI uses a cost factor while the Survey guidelines use a cost per foot of pipe to be installed. A similar approach was not adopted for the MFI because of the poor quality of information on interceptor sewer lengths supplied in the Needs Survey.

TABLE 4-7
Capital Cost Estimates for Treatment and Collectors

TREATMENT
(millions $ 1973)

Type & Size (MGD)	Needs Survey	MFI
Primary		
1	0.8	1.1
10	3.6	4.1
100	16.5	16.3
Activated Sludge		
1	1.2	1.5
10	6.1	5.8
100	32.0	30.0
Trickling Filter		
1	1.2	1.4
10	6.1	5.8
100	32.0	31.4
Activated Sludge plus Phosphorus Removal		
1	1.8	1.6
10	8.8	6.0
100	44.0	32.4

COLLECTOR
(per capita $ 1973)

Type & Size population	Needs Survey	MFI
1,000 - 2,500	570	406
10,000 - 25,000	314	274
50,000 - 100,000	227	210
100,000	200	178

Thus, the major differences between the MFI and EPA adjustments cannot be explained by the data used in both analyses. An alternative explanation is that the EPA adjustments were not a complete evaluation of the state submissions. If the EPA adjustments had reflected the data in the guidelines for the 1974 Survey, the EPA adjusted estimate might have reduced the state estimate by as much as $15 billion.

The MFI also provides a cost estimate different from the one reported by NCWQ. The differences between the MFI and NCWQ are best illustrated by contrasting the relevant estimates for the four Needs Survey categories shown in Table 4-6. The MFI estimate is about $6 billion more than the NCWQ estimate. The MFI estimates are greater than those by NCWQ for three categories and are less than NCWQ for Category II.

Again, there are several possible reasons for the differences between the MFI and NCWQ estimates, but none of them is an adequate explanation. First, the 1990 populations served by facilities for both studies are 210 million. Second, the MFI 1990 projected flow is 31,600 MGD, whereas the NCWQ 1990 projected flow is 36,100 MGD. However, this difference should result in an NCWQ cost higher than MFI. Third, the cost functions for the two studies are the same for three out of four categories. The MFI uses the NCWQ contractor cost functions for treatment needs and both use the same data source for collector sewers. Only the costs per facility for interceptors are different, because the MFI uses a cost factor while NCWQ uses a cost per foot of pipe to be installed, based on the same source supporting Category IVA in the EPA adjusted data.

The most reasonable explanation for the differences between EPA and MFI or MFI and NCWQ is the difficulty of working with a very poor data base. In view of this inadequacy, the differences are not inordinately large. The apparent differences between EPA and MFI in treatment needs (Category I + Category II) is only about $1.5 billion. Similarly, the differences in sewer needs (Category IVA + Category IVB) are not significantly large given the absence of physical data about these categories in the Needs Survey and the use of algorithms to generate a reasonable value. The algorithm used in the MFI was explained in the previous section; the NCWQ does not offer an explanation of the method used to derive its estimate.

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CHAPTER 5

ANALYZING AREAL ACTIVITIES

INTRODUCTION

Areal activities, the other major source of residuals generation and discharge, include combined sewers, urban stormwater, feedlots, irrigated agriculture, non-irrigated agriculture, construction, mining, and silviculture. The areal activities included in NRDI are limited to urban runoff, which integrates combined sewer overflows and urban stormwater, and non-irrigated agriculture. Residuals generation and discharge data for irrigated agriculture, silviculture, feedlot operations, and for other non-agricultural activities are not available on a county-by-county basis and thus are not included in NRDI. Residuals discharges from irrigated agriculture, silviculture, and/or feedlot activities are of significance primarily in a limited group of midwest and western states.

Areal activities are distinguished from municipal and industrial activities in NRDI for several reasons.

First, areal activities are intermittent rather than continuous sources of residuals discharges because their discharge is dependent upon precipitation events. Thus there is considerable controversy about the impact of residuals from these activities on water quality. The increased stream flow associated with rainfall and snowmelt events reduces the concentrations of the residuals discharges--at least after the "first flush"--but the short-run and long-run impacts on aquatic ecosystems are difficult to estimate.

Second, areal activities are diffuse rather than concentrated sources of residuals generation. Discharges from non-irrigated agriculture in general enter surface waters directly, rather than being collected and discharged at a limited number of points. Combined sewer overflows, and in many cases urban stormwater flows, are collected and discharged at a limited number of points, thereby placing a significant load on surface waters at a single point, for the duration of the flow. In effect, the diffuse or areal generation becomes a point source discharge. This is also frequently the case in many feedlot and mining operations. Other components of urban stormwater flow directly enter tributary streams, which in turn are similar to point sources where the tributaries enter the main stream.

Third, the estimates of residuals generation and discharge and associated RDR costs are taken either directly or in slightly modified form from NCWQ contractor reports. These estimates, in contrast to those for municipal and industrial activities, do not represent independent assessments by the staff preparing NRDI.

Fourth, residuals generation and discharge data about areal sources are very limited and are of questionable accuracy. The variability in the data are such that sediment (TSS) estimates for non-irrigated agriculture could vary by as much as ±200 percent for any ASA and for urban runoff could be off by ±1 or 2 orders of magnitude. Thus, these estimates ought not to be accepted with the same confidence as the estimates for point sources studied in depth.

URBAN RUNOFF

General Concept

Residuals generation from urban runoff is a function of numerous variables. Some of the more significant are:

$$RG(U) = f(LA, LU, PD, R, M, LS, CS),$$

where

RG(U) = residuals generation in urban runoff;
LA = land area;
LU = type of land use (i.e., acres of industrial, commercial or residential) and percent of imperviousness;
PD = population density;
R = precipitation intensity and duration;
M = street maintenance;
LS = life style; and
CS = extent of combined storm and sanitary sewers.

The maintenance variable includes such factors as the frequency and method of street cleaning and type of snow removal activity. The life style variable in this case refers primarily to automobile usage. The residuals measured are limited to BOD and TSS.

Residuals discharge from urban runoff is a function of the same variables as residuals generation plus at least two others. These variables are:

$$RD(U) = f(LA, LU, PD, R, M, TRES, EC),$$

where

RD(U) = residuals discharge in urban runoff;

TRES = technologies available for residuals modification; and

EC = effluent constraints, effluent charges, and/or effluent standards.

The inclusion of EC, particularly of effluent standards, is important because dischargers would only reduce their discharges if there was a legal requirement or an economic incentive.

The costs of reducing residuals discharge from urban runoff are a function of which variables are modified in the RD(U) function. Residuals discharges could be modified, for example, by street cleaning programs and reduction in vehicle miles traveled, as well as by the installation of RDR technology. The costs of the former may be less than of the latter.

Urban Runoff Inventory

NRDI for urban runoff includes both combined sewer overflows and urban stormwater. The approach used in NRDI calculates, for all urbanized areas within SMSAs in the U.S.: (1) the annual residuals generation from precipitation; (2) the reductions in annual residuals discharges attained from applying specified RDR technologies; (3) the costs of the RDR technologies applied. The RDR technology/storm event combinations are specified in Table 5-1, and are referred to as RDR levels A and B.

The method for analyzing residuals generation and discharge consists of the following major steps, as illustrated in Figure 5-1:

(1) identify those counties in the U.S. in SMSAs and with a population density equal to or greater than 0.6 people per acre; (there are 172 counties in the U.S. which fall into this category);

(2) estimate annual runoff and annual residuals generation in combined, separate storm sewer, and non-sewered areas for each of these counties using nationwide residuals discharge concentration estimates;

(3) estimate RDR costs and interceptor and collector costs where appropriate, by county for combined, separate storm sewer, and non-sewered areas for both RDR levels;

(4) estimate annual residuals discharges by county per type of sewered area after applying each RDR level; and

(5) sum residuals discharges and RDR cost estimates to appropriate geographic areas--SMSAs, ASAs, WRRs, the nation.

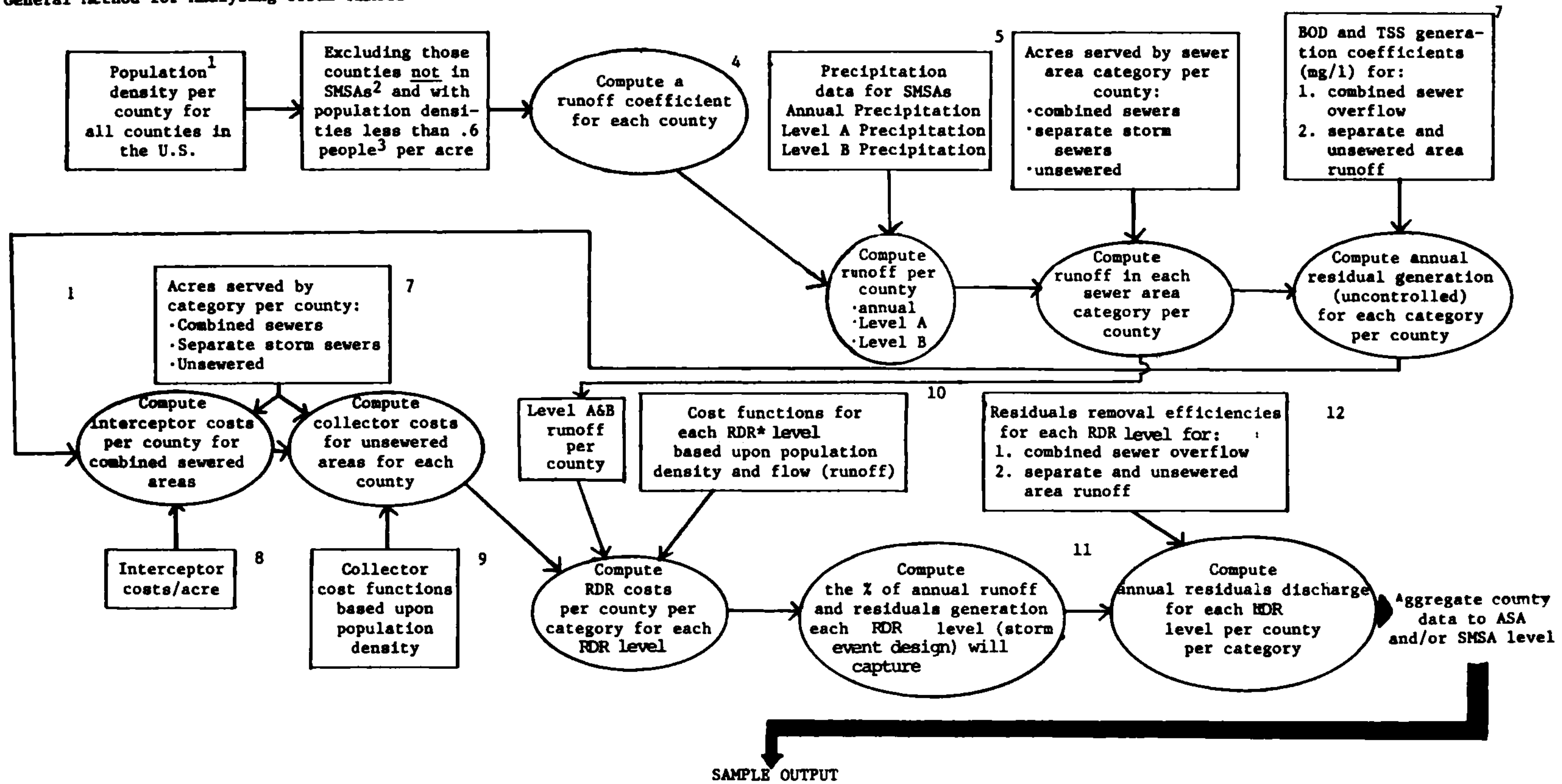
TABLE 5-1

Combinations of Residuals Discharge Reduction Technology - Storm Events For Urban Storm Water Runoff

Residuals Discharge Reduction Level	Storm Event	Average Number of Storms Exceeding Storm Event Per Year	Description	Unit Treatment Process	Removal Efficiencies	
					BOD	TSS
A	2 years - 1 hour	2	Removal of sediment, bacteria, and associated residuals	Screening, primary sedimentation chlorine contact chamber (ST)	35%	60%
B	1 year - 24 hours	<1	Higher degree of treatment than secondary	Screening, primary sedimentation, coagulation and flocculation, secondary sedimentation, filtration (BPWTT)	90%	96%

FIGURE 5-1

General Method for Analyzing Urban Runoff



SAMPLE OUTPUT

ASA Number

		Level A				Level B
Sewered Area Category	Annual Flow	Annual Residuals Discharge		RDR Capital Costs		
		BOD	TSS	CAP.	O&M	
Combined Sewers						
Separate Storm						
Unsewered						

Residuals Discharge Reduction

Note: For footnotes, see next page

Footnotes to Figure 5-1

1 1972 County and City Data Book.

2 Federal Information Processing Standard (FPS) County/SMSA codes for 253 SMSAs in the U.S.

3 The NCWQ contractor--Black, Crow, and Eidsness--specifies 0.6 people/acre as the density below which counties no longer are considered urban in character. The rationale for excluding these counties is that residuals loading, during storm events, more closely resembles other land uses, e.g., pasture or forest lands, than urban.

4 Runoff coefficients per county are estimated by first calculating the percent impervious for each county (I* = 104.59 - 81.27(.974)p, where p = population density), and then using the following equations**: for sewered areas--coefficient = 0.15 + .0075I; for unsewered areas--coefficient = 0.15 + .00375I.
*Graham, P.H., L.S. Costell, and H.J. Mallon (1974) Estimation of imperviousness and specific curb length for forecasting storm water quality and quantity. WPCF Journal, Vol. 47, No. 4: 717-725.
**Heaney, Huber, and Murphy (1975) Nationwide assessment of the cost of controlling pollution from combined sewer overflows, and stormwater runoff from sewered and non-sewered urban areas. Draft, p. 67.

5 Supplied by NCWQ contractor--Black, Crow, and Eidsness.

6 1974 EPA Needs Survey.

7 Mean concentrations <u>estimated</u> from one site study for combined sewer overflow and 17 site studies for separate sewered and unsewered areas.

Nationwide Residuals Discharge Concentrations

	BOD (mg/l)		BOD (mg/l)	
Category	Mean	Range	Mean	Range
Combined sewer	80	53-120	525	90-3,480
Separate sewered and unsewered	27	6-140	525	90-3,480

The combined sewer overflow estimate is for Des Moines, Iowa and is taken from EPA Technology Series, Urban stormwater management and technology - an assessment, December 1974, p. 83. The separate sewered and unsewered estimate is taken from EPA, *op. cit.*, p. 80 and NCWQ Site Studies.

8 Obtained from NCWQ Contractor--Metcalf & Eddy, Inc., Part I of their report, Chapter 6, p. 6.

9 Collector cost functions were taken from Black, Crow, and Eidsness draft document to NCWQ, p. IV-43, and are as follows:
Density 0 - 2.0 people, cost = $1.294/acre,
Density 2.0 - 20.0 people/acre, cost = $(5,175 log 10 [Density] - 263.83)/acre
Density 20.0 people/acre, cost = $6,469/acre.

10 RDR cost functions were taken from Black, Crow, and Eidsness draft document to NCWQ, pp. 38,45 and are as follows:
Capital Costs:
RDR Level A: $[.0545 + .0271 (Density)]/gallon
RDR Level B: $[.12 + .0367 (Density)]/gallon
Operating and Maintenance costs (annual):
RDR Level A: $0.1283/1000 gallons
RDR Level B: $0.2815/1000 gallons

11

RDR Level	Percent Capture of Annual Runoff
A	92
B	98

The reasoning used to arrive at the above percent captured is discussed in the urban runoff limitations section.

12 The removal efficiencies shown in Table 5-1 are the basic efficiencies which were used. These efficiencies are assumed to hold for runoff from areas which are either unsewered or served by separate storm sewers. For combined sewer overflow, they are adjusted downward, shown below, to account for the effect of increased loading (concentrations), since the cost functions used have been developed based upon the lighter residuals loading from unsewered and separate storm sewered areas.

Removal Efficiencies for Treatment
of Overflows from Combined Sewers

Residuals Discharge Reduction Control Level	BOD	TSS
A	11.5%	60%
B	30.0%	96%

While most of the data inputs in NRDI and in the NCWQ reports are similar, the one major difference is that NRDI calculates runoff for each county within SMSAs rather than for each SMSA as a whole, as was done by the NCWQ contractor. The NRDI approach requires using population density data for individual counties from the "County City Data Book" (U.S. COM 1974), rather than population densities for 1970 census land-use categories (central city, urbanized area, outside urbanized area, and inside SMSA) and using the 1974 EPA Needs Survey (U.S. EPA 1975) rather than the American Public Works Association (APWA 1967) data to determine the areas served by sewer systems. A comparison of the estimates of the area not served by combined sewers in each of the common 210 SMSAs[2] with population densities of 0.6 or greater showed that in 139 SMSAs APWA and EPA estimates varied by only plus or minus two (±2) square miles and in 28 by plus or minus ten (±10) square miles. The county-by-county approach in NRDI is necessary to aggregate the results to ASAs or any other aggregation of county units.

Summary of Results

Urban runoff activities are estimated to generate about 3.3 million pounds of BOD and about 60 million pounds of TSS annually as shown in Table 5-2. The areas not sewered generate about 80 percent of the BOD; the areas served by combined sewers generate about 10 to 20 percent of the BOD; and the areas served by separate storm sewers generate about 5 to 10 percent. The 1973 residuals discharges from urban runoff are equal to residuals generation because there is little, if any, RDR technology in place at present.

After applying RDR level A, BOD discharge would decrease from 3.2 million pounds to 2.2 million pounds annually, or by 32 percent of 1973 conditions, and TSS discharge would decrease from 60 million pounds annually to 27 million pounds annually, or by 55 percent of 1973 conditions. The capital costs of residuals modification, exclusive of interceptor and collector costs, are estimated to be about $51 billion. After applying RDR level B, BOD discharge would decrease to 0.4 million pounds annually or 97 percent of the 1973 conditions, and TSS discharge would decrease to 3.5 million pounds annually or 94 percent of 1973 conditions. The capital costs of RDR level B, exclusive of interceptor and collector costs, is estimated to be about $210 billion. Applying RDR level B for urban runoff would result in a decrease of 82 percent of BOD and 87 percent of TSS discharge after the application of RDR level A.

TABLE 5-2

National Totals of NRDI Urban Runoff

AREAS SERVED BY COMBINED SEWER

Annual Residuals Generation						RDR Capital Costs		Annual Residuals Discharge after Modification	
Runoff 10^{12} gal.	BOD 10^9 lbs	TSS 10^9 lbs	RDR Control Level	% of Annual Discharge Modified	Annual Runoff Treated 10^{12} gal.	RDR Technology 10^9 \$	Interceptor 10^9 \$	BOD 10^9 lbs	TSS 10^9 lbs
0.6	0.4	2.8	A	92	0.6	8.9	1.5	.29	1.30
0.6	0.4	2.8	B	98	0.6	26.0	1.5	.06	0.11

AREAS SERVED BY SEPARATE STORM SEWERS

Annual Residuals Generation							Annual Residuals Discharge after Modification	
Runoff 10^{12} gal.	BOD 10^9 lbs	TSS 10^9 lbs	RDR Control Level	% of Annual Discharge Modified	Annual Runoff Treated 10^{12} gal.	RDR Capital Costs 10^9 \$	BOD 10^9 lbs	TSS 10^9 lbs
0.9	0.2	4.0	A	92	0.8	4.3	0.14	1.80
0.9	0.2	4.0	B	98	0.9	14.7	0.02	0.24

AREAS NOT SEWERED

Annual Residuals Generation						RDR Capital Costs		Annual Residuals Discharge after Modification	
Runoff 10^{12} gal.	BOD 10^9 lbs	TSS 10^9 lbs	RDR Control Level	% of Annual Discharge Modified	Annual Runoff Treated 10^{12} gal.	RDR Technology 10^9 \$	Collector 10^9 \$	BOD 10^9 lbs	TSS 10^9 lbs
12.1	2.6	53.0	A	92	11.1	38.1	73	1.80	24.00
12.1	2.6	53.0	B	98	11.9	172.0	73	0.31	3.10

ANNUAL SUMMARY OF NATIONAL TOTALS

Residuals Generation						RDR Capital Costs		Annual Residuals Discharge after Modification	
Runoff 10^{12} gal.	BOD 10^9 lbs	TSS 10^9 lbs	RDR Control Level	% of Discharge Modified	Runoff Treated 10^{12} gal.	RDR Technology 10^9 \$	Collector/ Interceptor 10^9 \$	BOD 10^9 lbs	TSS 10^9 lbs
13.6	3.2	59.9	A	92	12.6	51.2	75	2.20	27.00
13.6	3.2	59.9	B	98	13.4	212.0	75	0.39	3.50

Limitations of NRDI Results for Urban Runoff

Although the design storm method used in NRDI makes possible a straightforward estimation of RDR costs, the results of such a formulation suffer from two limitations. One limitation is the difficulty of estimating the proportion of total annual runoff captured by a system designed for a specific storm event. The second limitation is the difficulty of estimating residuals generation and subsequent discharge, given the range of different surface conditions in urban areas throughout the U.S. and the temporal characteristics of residuals loading, such as residuals concentrations in runoff from combined and separate sewers which exhibit a first flush effect.

A recent study (Heaney et al. 1975) performed jointly by the University of Florida and the American Public Works Association (APWA), and sponsored by EPA, addressed the first limitation. The study contains isoquants[3] relating storage of storm runoff and treatment rates (gallons per minute) for 6 cities,[4] falling in five precipitation regions of the U.S. Using the storage and treatment rates used by the NCWQ contractor[5] and the NRDI computed runoff volume for each storm event at each of the six cities, the isoquants for each of the six cities were used to estimate what proportion of annual flow would be captured for each storm event in each precipitation region. The results of this exercise, unfortunately, proved somewhat inconclusive. For four out of the six cities studied, the uppermost isoquant represents only 80 percent capture of annual runoff; for the remaining two, only 90 percent. Analysis showed that the percent of annual runoff captured, if a 1 year-1 hour storm design criterion was used, exceeded the uppermost isoquant, i.e., was greater than either 80 or 90 percent, in each of the six cities. This result indicates that the proportion of annual runoff captured by each of the two NRDI storm event designs varies, incrementally,[6] from at least 80 percent (probably 90 percent) to 100 percent in each precipitation region. In light of these data, the following percentages of annual runoff captured have been arbitrarily assumed across the nation for the two storm event designs:

Storm Event	Percent of Annual Runoff Captured
2 year - 1 hour	92
1 year - 24 hour	98

It is assumed that all of the annual runoff captured is modified.

Considering the second limitation mentioned above--estimating residuals generation and discharge--it is clear that insufficient empirical research has been performed to enable an accurate estimation of residuals generation. The method used herein (assigning a nationwide mean concentration) is, clearly, a major simplification.

Most researchers agree that BOD and TSS discharges do not correlate linearly with runoff, particularly in the case of combined sewer overflow. The concentration ranges shown in Footnote 7 to Figure 5-1 illustrate that substantial variation exists in the concentrations. The significance of these ranges could not be evaluated, because little is known about relevant conditions, such as time, intensity and duration of last precipitation, and intensity and duration of rainfall during the sampling period. By using annual aggregates some of these variations are damped out, but just how much is unknown. Thus, the residuals generation and discharge estimates computed here may vary by at least one order of magnitude.

NON-IRRIGATED AGRICULTURE

General Concept

Some of the more significant variables of which residuals generation from non-irrigated agriculture is a function are

$$RG(A) = f(K, R, LS, CP, MP, Sd, N, P),$$

where

RG(A) = residuals generation in non-irrigated agriculture;
K = soil erodibility factor;
R = rainfall, intensity and duration or snowmelt;
LS = land slope;
CP = cropping practice;
MP = management practices (i.e., amount tillage);
Sd = sediment delivery factor(i.e., percent);
N = nitrogen concentration in the soil; and
P = phosphorus concentration in the soil.

The first four variables are the basis for calculating gross soil erosion, which is a measure of soil movement on land. The Sd variable determines the proportion of the gross soil erosion which enters surface waters. Other variables, N and P, are the basis for estimates of other residuals. The residuals measured include BOD, TSS, N, and P.

It should be noted that residuals generation from irrigated agriculture, due to erosion, is a function of the same variables as for non-irrigated agriculture. Irrigated agricultural lands yield TSS, BOD, N, and P, because rain falls in those areas as well. However, runoff and the accompanying residuals generation from irrigated lands are less than from non-irrigated lands and do not usually occur during the summer period. Nevertheless, during certain times of the year (e.g., the fall) in arid regions, runoff and residuals generation due to erosion of irrigated agricultural lands are significant.

Residuals discharges from non-irrigated agriculture are a function of the same variables as residuals generation plus at least two others. These variables are:

$$RD(A) = (K, R, LS, CP, Sd, N, P, SC, EC),$$

where

$RD(A)$ = residuals discharge fromnon-irrigated agriculture;
SC = soil conservation practices; and
EC = user charges and/or effluent standards.

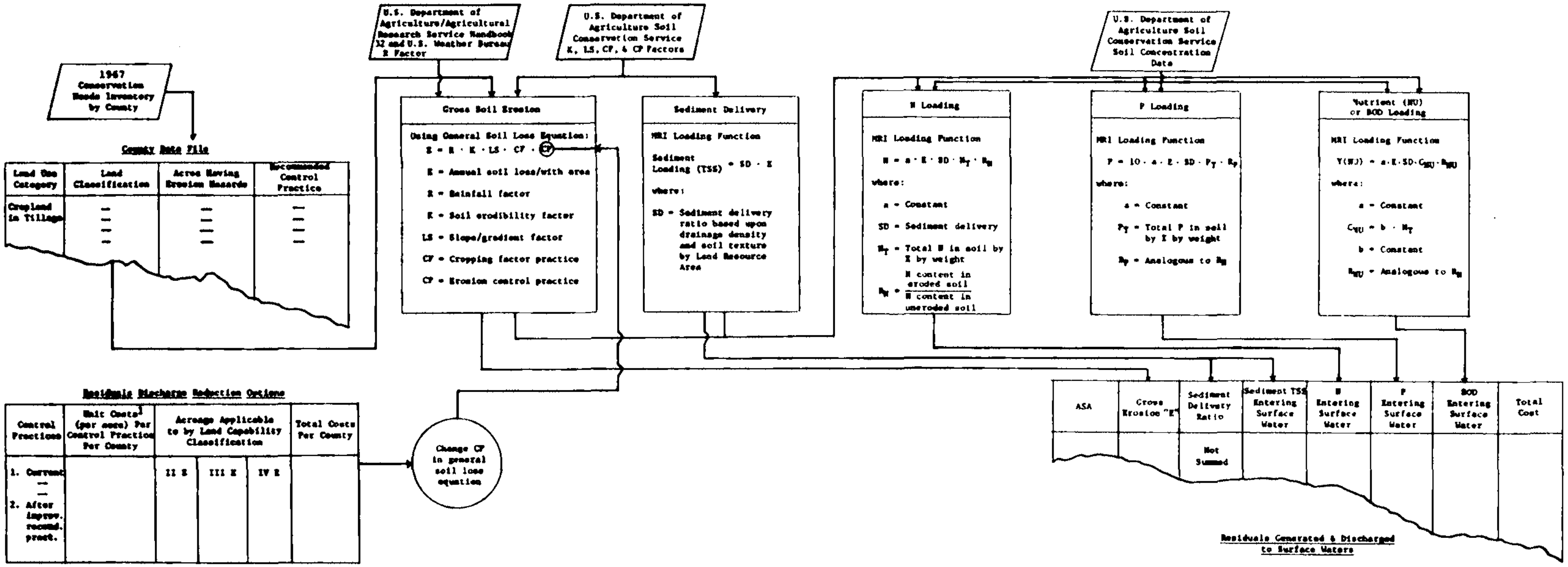
There are numerous erosion control practices, such as contouring and terrace systems. These options will be explained in more detail in the next section.

Non-Irrigated Agriculture Inventory

For non-irrigated agriculture, NRDI uses an adjusted version of the inventory prepared for NCWQ by Midwest Research Institute (MRI). An analysis[7] of sediment loadings obtained using MRI and Iowa State University[8] sediment delivery ratios showed that in areas where measured in-stream suspended sediment data existed, sediment loadings obtained using Iowa State ratios were significantly more accurate than those obtained using MRI[9] ratios. (Both Iowa State and MRI use the 1967 Conservation Needs Inventory [CNI] and the Universal Soil Loss Equation to estimate gross soil erosion.) Consequently, the residuals loadings estimated by MRI are adjusted based upon the Iowa State delivery ratios. The method used by MRI is graphically illustrated in Figure 5-2.

To compute sediment discharge, MRI applied the standard Universal Soil Loss Equation to estimate gross soil erosion (the total amount of eroded material, not necessarily the quantity entering surface waters). Then the amount of gross soil erosion entering surface waters was approximated by applying a sediment delivery ratio. NRDI adjusts the MRI ASA sediment loading estimates (sediment entering surface waters) by multiplying them times the ratio of the Iowa State sediment delivery ratio divided by the MRI delivery ratio for each ASA. Because generation and discharge of all other residuals are assumed to be multiplicative functions of sediment loading, as shown in Figure 5-2, all other residuals are also adjusted.

The residuals generation functions which MRI developed--for N, P, and BOD--are based upon the content of



[1] Unit costs per county are from the agricultural conservation program.

those residuals in the soil (i.e., nutrients) and sediment yields. The assumption is that most of these residuals are removed with the eroded sediment. For a more complete discussion of these functions, the reader is referred to "User's Handbook for Assessment of Water Pollution from Non-Point Resources" (MRI 1974).

Based upon the 1967 CNI, MRI computed residuals discharge by county for those acres of different land classifications indicated as having a potential erosion hazard. This estimate of residuals discharge (adjusted) is defined as "current discharge conditions." Reductions in residuals discharges are estimated for only one new modification level. This level assumes the implementation of the control practices recommended in the CNI for acreage with erosion hazards in each county. Table 5-3 lists typical practices for reducing cropland erosion.

The costs computed by MRI for implementing the CNI recommended control practices are calculated using unit costs taken from the Agricultural Conservation Program (ACP),[10] per conservation practice for each county. All county costs are then summed to the ASA level.

Summary of Results

Cropland in the United States in 1969 was estimated to be about 480 million acres. The acreage of non-irrigated cropland in tillage rotation was estimated to be about 380 million acres. About 40 percent of this land (158 million acres) was listed as needing conservation treatment.

> "The total amount of sediment produced from non-irrigated cropland was estimated to be about 1,800 million tons per year. This is equivalent to about 4.8 tons/acre/year on an average basis. If needed conservation practices were implemented, the sediment delivered would be reduced to 922 million tons per year, or about 2.44 tons/acre/year.
> The total investment cost of conservation treatment was estimated to be $2.0 billion" (MRI 1975).

It should be reemphasized that residuals discharges from irrigated agriculture, silviculture, and feedlots--although not estimated because of lack of data--are considerable.

Limitations of NRDI for Non-Irrigated Agriculture

Given the limited data available to assess non-irrigated agriculture residuals generation and discharge, the reasonableness of the data for each residuals category is assessed in order to contrast these data with data in the other inventories.

TABLE 5-3

Practices for the Control of Cropland Erosion

Erosion Control Practice	Practice Highlights
CULTURAL	
1. No-till plant in prior-crop residues or in killed winter cover crop	Maximum use of crop residues; effective all year and most beneficial in most erodible portions of crop year; reduces man and machine hours; limits fertilizer placement options; requires use of more pesticides; delays warming of tight soils in spring.
2. Other conservation-tillage practices	Same as (1) but to lesser degree.
3. Sod-based rotations	Insignificant soil loss in meadow years; residual effects of meadows reduce runoff and erosion from following row crop; aid in control of some diseases and pests; less use of fertilizer and pesticides than with (1) and (2); meadow years may result in economic loss; soil loss unequally distributed within rotation cycle.
4. Crop rotations that do not include hay	Aid in control of some diseases and pests; may provide more continuous surface cover.
5. Winter cover crop	Reduces winter-time erosion when corn is harvested for silage; burial of substantial crop residues to seed winter cover not recommended; may help dry soil surface in spring.
6. Optimizing timing of field operations	Fall plowing greatly increases winter and early spring erosion hazard; timing of spring operations can decrease extent of soil exposure to rain and may also increase crop yields.
SUPPORTING	
7. Contouring	Benefits are in addition to effect of cultural practices; on slopes from two to eight percent, it cuts soil loss by about another 50 percent; less effective on steeper slopes; makes farming operations more difficult; not feasible when topography is irregular.
8. Contour strip cropping	When rowcrop and hay are in alternate strips, soil loss is about 50 percent of that with the same rotation contoured only; fall seeded grain in lieu of meadow about half as effective; area must be suited for across-slope farming.
9. Contour listing	Minimizes runoff in low-rainfall areas; reduces erosion; hastens soil warming and drying; applicable on pasture and rangeland.
10. Terrace Systems	Reduce slope length and runoff concentration; reduce erosion and conserve moisture; substantial initial cost and some maintenance cost; may slow farming operations.

1. Sediment discharge (TSS): Sediment loading is computed by applying a factor--sediment delivery ratio--times the estimated gross soil erosion for a soil type in an area (county). As stated earlier, gross soil erosion is computed using the Universal Soil Loss Equation. The basic data base used, 1967 CNI, is recognized as the best data base of its type presently available. Therefore, the gross soil erosion components of sediment loadings are reasonable at least to the extent that the Universal Soil Loss Equation is a valid estimation.[11] The major uncertainty in determining sediment loading is introduced when attempting to estimate the portion of gross soil erosion which is delivered to surface waters. Although analysis indicates that the use of Iowa State sediment delivery ratios produces, in the test cases, better estimates of sediment discharges to surface waters than those of MRI, the large discrepancies between them, generally about 100 percent (see Appendix G), indicate that sediment loading estimates may contain considerable error. If a 100 percent error may be expected for sediment loading in an ASA, then at least a 100 percent error would also be expected for the discharges of other residuals by ASA.

2. Phosphorus Discharge: The county soil concentrations of phosphorus used are based upon a 1946 USDA map of phosphoric acid in the top one foot of soil in the U.S. Even if MRI could interpolate from such a national map to the county level, the 1946 phosphorus soil concentrations probably do not bear any resemblance to present concentrations, given the large increase in fertilizer use since that date. Hence, present loadings are likely to be very different from those estimated using 1946 data.

3. Nitrogen Discharge: The nitrogen content in soil is estimated using an empirical expression, proposed by Jenny (1930), based upon temperature and humidity. The basic data (temperature, precipitation, vapor pressure, humidity) necessary to use this expression are fairly reliable and county specific. However, the expression seems to be estimating nitrogen soil content in a "natural soil condition" for an undefined soil condition. As in the case of phosphorus, the nitrogen soil content estimate could be assumed to represent present conditions. Both formulations appear to be missing relevant variables (particularly, fertilizer application rates) to estimate present generation and discharge.

4. BOD Discharge: BOD soil concentration estimates are based upon nitrogen concentrations. The assumption is that BOD concentrations are uniformly twice those of nitrogen. Thus, in the MRI formulation, BOD loading estimates are, at best, only as good as those for nitrogen.

In summary, the results produced may be misleading (see Appendix G) in comparing point sources and non-irrigated agriculture sources of residuals discharge.

NOTES

1 Although the NCWQ contractor estimated residuals discharge reduction costs for 5 RDR levels for four storm events, only the two storm events and corresponding residuals discharge reduction levels included herein were deemed sufficiently reasonable for use in NRDI.

2 NCWQ uses pre-1970 SMSA definitions which do not directly correspond to the present definitions used in NRDI.

3 Isoquants are curves which represent a specific percent of annual runoff treated for different combinations of storage and treatment.

4 Atlanta, Ga.; Denver, Co.; Des Moines, Iowa; Minneapolis, Minn.; San Francisco, Calif.; Washington, D.C.

5 R. Holbrook of Black, Crow and Eidsness indicated that it was assumed that the design storage capacity for each storm event is equal to the runoff volume from the storm event, and that the entire runoff volume would be treated in 24 hours.

6 Clearly, treatment systems designed for larger storm events will control more of annual flow.

7 The analysis was performed by Maurice H. Frere, Soil Scientist, USDA Agricultural Research Service, Chickasha, Oklahoma. See Appendix F for a discussion of Mr. Frere's findings.

8 The method employed by James C. Wade at the Center for Agriculture and Rural Development, Iowa State University is as follows: Step 1, sediment transport ratios were computed for each region where rivers flow through the region. Step 2, the sediment load entering the region was multiplied by the transport ratio to give total sediment transport. Step 3, total sediment transport was subtracted from sediment load exiting the region to give adjusted sediment load. Step 4, adjusted sediment load was divided by total gross erosion to give the sediment delivery ratio.
For a more complete explanation see:
Wade, J.C.(1975) Stream sediment movement, water quality, and agricultural production: A modeling approach to economic and environmental analysis, unpublished Ph.D. dissertation, Iowa State University of Science and Technology, and

Wade, J.C. and E.O. Heady (forthcoming) A national model for sediment water quality and agricultural production. CARD Report, Center for Agricultural and Rural Development, Iowa State University.

9 MRI has developed its own procedure for estimating sediment delivery ratios, which is difficult to assess. See: Draft Final Report to NCWQ, Midwest Research Institute, July 18, 1975, pp. 43-44.

10 The Agricultural Conservation Program (since 1971 named the Rural Environmental Assistance Program) shares the costs of carrying out soil conservation practices with farmers, ranchers, and woodland owners. ACP county level data were used to estimate unit costs for conservation practices for each county.

11 Soil scientists point out that the universal soil loss equation was developed from small plot data and hence its application to counties may introduce considerable error in gross soil erosion estimates (see Appendix F).

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CHAPTER 6

GROWTH ANALYSIS

INTRODUCTION

The primary emphasis in the development of NRDI has been on the estimation of residuals generation and discharge and the RDR costs for present (defined as 1973) conditions. An acceptable conceptual procedure for modeling large geographic areas and availability of data and analytical resources determined the level of effort. However, estimates of residuals and RDR costs are not sufficient to evaluate some of the significant issues mentioned in Chapter 1. Consequently, a limited effort was made to incorporate in NRDI an analysis of growth conditions.

The spatial pattern, types, and intensity of man's activities change over time, and the various NRDI activity inventories are formulated to permit estimating some of these changes and the associated impacts on residuals generation. The activity inventories and four growth options included in NRDI are presented in Table 6-1. The sources of information and estimation procedures used to estimate changes in activities and residuals generation over time (growth) are discussed in the following sections.

AREAL ACTIVITIES

Under all options, areal activities, urban runoff, and non-irrigated agriculture do not change because of lack of adequate information to permit correlation of changes in areal variables with residuals generated. Of the seven variables for urban runoff residuals generation (Chapter 5), five are subject to change over time as a result of man's activities. Land use patterns have changed considerably over the past and can be expected to continue to change in the future. Changes in land use as well as related changes in population density are likely to result in changes in the amount of impervious area. Street maintenance and lifestyle variables may also change. Finally, extent of sewered areas changes as a result of urbanization. While areas served by separate storm and sanitary sewers can be expected to increase in number, it is extremely unlikely that additional areas will be served by combined sewers. The urban runoff model includes residuals from both sewered and unsewered areas in currently urbanized counties. For future years,

TABLE 6-1

Growth Options Used for NRDI Analyses

Activities	Option 1	Option 2	Option 3	Option 4
In-Depth Studied Industries	Wharton*	OBERS**	OBERS*** & ASA	Wharton & OBERS
General Studied Industries	Wharton	OBERS	OBERS & ASA	Wharton & OBERS
Municipal	Needs Survey	Needs Survey	Needs Survey	Needs Survey
Non-Irrigated Agriculture	No Growth	No Growth	No Growth	No Growth
Urban Runoff	No Growth	No Growth	No Growth	No Growth

Sources: *Wharton (1975).
**U.S. WRC (1974a).
***U.S. WRC (1974b).

changes in the variables mentioned above could result in additional urbanization of current urban counties or urbanization of nonurban counties. These effects will depend upon population change, industrial growth, and similar factors. However, data are not available to predict quantitatively changes in residuals generation for urban runoff. Therefore residuals generation and discharge from urban runoff are only computed for present conditions.

All of the variables identified as significant in residuals generation for non-irrigated agriculture can change over time. For example, increases in production resulting from increases in fertilizer usage on existing lands would tend to result in higher N and P concentrations but relatively constant sediment load. However, more sediment generation per unit of output could occur as a result of more intensive cropping of marginal lands with higher erosion potential. While OBERS[1] and other projections of future agricultural activities are available, it is impossible to relate easily these changes to changes in residuals generation. For this reason, non-irrigated agricultural residuals generation and discharge are only computed for present conditions.

Residuals generation from areal activities is subject to change from a variety of factors. Thus, while only point source activities change in NRDI, changes in areal activities could be more significant than point source changes.

MUNICIPAL ACTIVITIES

Growth in residuals generation by municipal activities is influenced by several factors: population growth, population sewered, industrial discharges into municipal systems, and per capita loadings. In estimating the total 1990 flow, the EPA instructed states to limit the population growth factor to the Census Bureau Series E and to use a flow of 125 gallons per capita (U.S. EPA 1975). An examination of the individual submissions reveals a tendency for the sewered population of a state to exceed the total 1990 population for the state based on the Census Bureau Series E projection. Consequently, numerous adjustment techniques have been applied by EPA, NCWQ contractors, and NRDI to revise the Needs Survey estimates of population and related flow.

The NRDI growth estimate for municipal activities is derived from a two-stage process, and was described in detail in Chapter 4. The results of the NRDI estimate techniques and those in the NCWQ contractor study are presented in Table 6-2. The NCWQ contractor used a different adjustment procedure.

TABLE 6-2

Comparison of NCWQ and NRDI Municipal Inventory Data Based On EPA Needs Survey

	1973		1990	
	NCWQ	NRDI	NCWQ	NRDI
Total population (millions)	213	213	256	256
Sewered population (millions)	153	156	210	211
Per capita flow (gcd) (residential, commercial, institutional)	123	99	123	100
Residential, commercial, institutional flow (mgd)	18,800	15,400	25,000	21,000
Industrial flow (mgd)	5,600	4,900	10,300	10,600
Total flow (mgd)	24,400	20,300	36,100	31,600

Source: Metcalf and Eddy Inc. (1975).

Since the adjusted Needs Survey data are only for 1990 flow estimates, estimates for other years are computed in the following manner:

$$R_{EST} = \frac{EST - 1973}{17} (R_{1990} - R_{1973}) + R_{1973}$$

where

R_{EST} = residual generation for year EST;

EST = target estimation year (i.e., 1985);

R_{1990} = residuals generation estimated for 1990; and

R_{1973} = residuals generation computed for 1973.

Units for R are billion gallons per year for flow and million pounds per year for BOD and TSS. The above form is used to estimate RG(M) for all four growth options.

This technique assumes linearity in the growth of flow and associated residuals per ASA from 1973 to 1990. For example, the 1985 estimate is:

$$R_{1985} = R_{1973} + \frac{12}{17} (R_{1990} - R_{1973}).$$

Thus, residuals generation for 1985 is the 1973 estimate plus 12/17 of the incremental change expected between 1973 and 1990.

INDUSTRIAL ACTIVITIES

The NRDI growth estimate for industries studied in depth and in general is based on two-digit SIC growth projections. Different national growth projections were available for use in NRDI from the Wharton Econometric Forecasting Associates (EFA) (Wharton 1975) and from the U.S. OBERS (U.S. WRC 1974a). An ASA growth projection was available from the U.S. OBERS (U.S. WRC 1974b).

The National Wharton EFA projections are based on a large scale macroeconometric model with an imbedded input/output table (Preston and O'Brien 1975). This combination permits consideration of demand and supply simultaneously for 10 to 15 year projections.

A final demand model provides estimates of constant dollar GNP and its disaggregated components, including consumption, investment, exports, imports, and government spending. Key inputs to the consumption functions include income, price, wealth, credit conditions, and tastes. The basic data in the investment sector are obtained from the Department of Commerce and Securities and Exchange Commission Investment Surveys. Government spending, including federal, state, and local sectors, is derived from surveys of these sectors.

A supply model provides estimates of physical output by sector. Production functions, which are available for most sectors, relate inputs, primarily manpower availability, to physical output. The sectors include agriculture, mining, manufacturing (at the two-digit SIC level), transportation, communications, regulated industries, and commercial activities. The government sector output is exogenously determined.

An input/output model links the final demand and supply estimates to the estimated gross sales levels by industrial sector necessary to sustain final demand. The input/output model explicitly includes a mechanism which uses information on relative sector prices.

The Wharton EFA (1975) gross national product (GNP) and gross product output (GPO) data for 1973, and projected data for 1980 and 1985 are displayed in Table 6-3 in 1958 dollars for various industry sectors and for the economy as a whole.

The national OBERS projections (U.S. WRC 1974a) are calculated mainly from the supply side of the economy; (the major exception is the determination of requirements for food and fiber). GNP is projected as the product of projected man-hours worked and output per man-hour. The variables which enter into determination of man-hours worked and output per man-hour in the economy include population, the working age population, labor force participation, military manpower, hours worked per man-year, and GNP per man-year. Projected national population (Census Bureau Series E) is the most significant variable in the total projection process.

While GNP is the most comprehensive and widely used measure of the national economy, OBERS does not estimate GNP on a regional/industry basis. Instead, the OBERS data disaggregated by industrial activity (SIC) and regions are available as personal income. The choice of personal income rather than GNP rested on three considerations. First, personal income has a close and comparatively constant relationship to GNP; second, its regional location is clear; third, it could be measured from available data sources, and the methodology for preparing local area estimates of personal income had already been developed.

The OBERS GNP, GPO, and personal income measured data for 1973, and GNP, GPO, and personal income projected data for 1975, 1980, and 1985 are displayed in Tables 6-4 and 6-5. The GNP and GPO data are in 1958 dollars, and the personal income data are in 1967 dollars.

The regional OBERS projections are the projected national totals distributed regionally in accordance with projected trends in the regional distributions of economic

TABLE 6-3

Wharton Base Year and Projected Output by Industrial Group (1958 10^6 $)

Industrial Groupings	1973	1980	1985
Mining	17.4	13.9	20.3
Metal (10)[1]	1.7	1.0	1.2
Coal (11, 12)	2.3	2.9	4.2
Crude petroleum & natural gas (13)	11.8	8.5	12.4
Nonmetallic, except fuels (14)	1.6	1.5	2.4
Manufacturing	272.4	326.7	387.4
Food & kindred products (20)	23.9	28.3	28.0
Textile mill products (22)	10.2	12.0	14.0
Apparel & other fabric products (23)	8.8	9.1	8.4
Lumber products & furniture (24, 25)	9.8	10.6	12.5
Paper & allied products (26)	10.0	12.1	13.4
Printing & publishing (27)	10.7	14.3	16.1
Chemical & allied products (28)	27.0	32.3	36.8
Petroleum refining (29)	6.7	7.7	8.7
Primary metals (33)	17.4	21.2	29.2
Fabricated metals & ordnance (34, 19)[2]	15.6	18.4	22.6
Machinery, excluding electrical (35)	27.7	32.1	42.2
Electrical machinery & supplies (36)	32.5	39.4	49.4
Motor vehicles & equipment (371)	26.0	29.5	33.2
Transportation equipment, excluding motor vehicle (37 except 371)[3]	12.1	15.9	18.8
Other manufacturing (2, 30-32, 38, 39)	33.9	44.0	54.1
Gross National Product	821.4	1003.2	1174.8

1. Numbers in parentheses are two-digit SIC numbers

2. Includes only SIC 34 rather than SIC 34 and 19 as in OBERS.

3. Includes SIC 37 except 371 plus SIC 19 rather than SIC 37 except 371 as in OBERS.

Source: Wharton (1975) provided to NCWQ.

TABLE 6-4

OBERS Base Year and Projected Output by Industrial Group (1958 10^6 $)

Industrial Groupings	1973	1980	1985
Mining	17.4	19.7	21.2
Metal (10)*	1.7	1.8	1.9
Coal (11, 12)	2.3	2.4	2.5
Crude petroleum & natural gas (13)	11.8	13.7	14.8
Nonmetallic, except fuels (14)	1.6	1.8	2.0
Manufacturing	272.3	313.7	369.2
Food & kindred products (20)	23.9	25.1	27.6
Textile mill products (22)	10.2	9.7	11.0
Apparel & other fabric products (23)	8.8	9.8	11.3
Lumber products & furniture (24, 25)	9.8	11.0	12.7
Paper & allied products (26)	10.0	11.9	13.9
Printing & publishing (27)	10.7	14.5	17.2
Chemical & allied products (28)	27.0	33.6	41.9
Petroleum refining (29)	6.7	7.3	8.5
Primary metals (33)	17.4	16.4	17.1
Fabricated metals & ordnance (34, 19)	15.6	22.3	26.1
Machinery, excluding electrical (35)	27.7	29.3	33.7
Electrical machinery & supplies (36)	32.5	40.7	51.8
Motor vehicles & equipment (371)	26.0	28.6	33.6
Transportation equipment, excluding motor vehicle (37 except 371)	12.1	12.2	13.4
Other manufacturing (2, 30-32, 38, 39)	33.9	41.3	49.4
Gross National Product	821.4	1091.0	1301.0

*Numbers in parentheses are two-digit SIC numbers.

Source: U. S. Department of Commerce Bureau of Economic Analysis, unpublished material based on U.S. WRC (1974b).

TABLE 6-5

OBERS Base Year and Projected Personal Income by Industrial Source (1967 10^6 $)

Industrial Groupings	1973	1980	1985
Mining	6.4	6.5	6.9
Metal (10)*	0.9	1.0	1.0
Coal (11, 12)	1.8	1.8	2.0
Crude petroleum & natural gas (13)	2.6	2.5	2.6
Nonmetallic, except fuels (14)	1.1	1.2	1.3
Manufacturing	174.0	219.3	252.7
Food & kindred products (20)	13.3	16.0	17.4
Textile mill products (22)	6.0	6.7	7.4
Apparel & other fabric products (23)	6.8	8.7	9.8
Lumber products & furniture (24, 25)	8.1	8.9	10.0
Paper & allied products (26)	6.2	8.4	9.7
Printing & publishing (27)	9.3	13.0	15.3
Chemical & allied products (28)	10.8	15.6	18.8
Petroleum refining (29)	2.8	3.4	3.8
Primary metals (33)	14.1	14.3	15.3
Fabricated metals & ordnance (34, 19)	14.9	19.5	22.6
Machinery, excluding electrical (35)	20.3	24.5	28.1
Electrical machinery & supplies (36)	17.1	25.1	30.5
Motor vehicles & equipment (371)	14.1	15.5	18.0
Transportation equipment, excluding motor vehicle (37 except 371)	9.3	11.6	12.8
Other manufacturing (2, 30-32, 38, 39)	20.9	28.1	33.2
Total Personal Income	180.4	225.8	259.6

*Numbers in parentheses are SIC two-digit numbers.

Source: U.S. Department of Commerce, Bureau of Economic Analysis
U.S. WRC (1974b)

activities. The distribution is on the basis of four models: basic industries, except agriculture and armed forces; agriculture; service industries; and population. The basic or export industry model was derived from the "shift-share" technique for regional industrial analysis. The agricultural model is based on an extension of trends of production from a historical base of 1947 to 1970. The service industries model is a multiplier effect which relates service employment or earnings to basic employment or earnings. The population model derives area population from area employment. All these models are explained in detail in U.S. WRC (1974a).

The regional OBERS personal income data for 1975, 1980, and 1985 are too numerous to reproduce in this report (U.S. WRC 1974b). Regional OBERS measured personal income data for industrial categories for 1971 or 1973 are not available, because of disclosure problems.

At this point, a brief comparison of national Wharton and OBERS GNP and GPO projections will provide some insight into the uncertainty of projections for the period 1973 to 1985. Wharton EFA projects a growth in GNP between 1973 and 1985 of 43 percent or an annual rate of 3.3 percent (Table 6-3). OBERS projects a growth in GNP for the same period of 55 percent or an annual growth rate of 3.7 percent (Table 6-4). (The OBERS 1985 projection is based on a linear interpolation between 1980 and 1990, because there is no published estimate for 1985.) The differences between two-digit SIC categories for the two projections is even more striking (comparing Tables 6-3 and 6-4). For example, the Wharton estimate for 1985 output for primary metals (SIC 33) is about 1.7 times greatr than the OBERS estimate, and for textiles (SIC 22), it is about 2.5 times greater. Because of these differences, NRDI has been structured to enable use of either set of projections.

Four industrial growth options are available in NRDI (see Table 6-1). In each option it is assumed that the value added per product in each category in 1983 is the same as it was in 1973. In Option 1, the national Wharton projections at the two-digit SIC level are used in each river basin. In Option 2, the national OBERS projections at the two-digit SIC level are used in each river basin. In Option 3, the OBERS/ASA projections are used at the two-digit SIC level. In Option 4, the OBERS/ASA projections are modified to produce a national total equivalent to the Wharton projection, i.e., the Wharton growth is allocated to river basins using the OBERS data.

Only Option 1, the national Wharton projections at the two-digit SIC level, is used in the following chapter to estimate growth in residuals generation from 1973 to 1983. The NRDI analysis is based on the Wharton EFA rather than the OBERS projection for two reasons. First, NRDI uses the same basic data as NCWQ wherever possible. Since NCWQ used the Wharton EFA rather than the OBERS projection as the official estimate of industrial growth in the U.S. economy, NRDI incorporated the same data, because they were readily available. Second, the Wharton EFA projection appears to give a more realistic projection than the OBERS of U.S. industrial growth over the period 1973 to 1985. Given the economic situation in late 1975, an annual growth rate of 3.3 percent (Wharton EFA) is more plausible than an annual growth rate of 3.7 percent (OBERS).

Capital costs for applying RDR technologies to accomodate new growth are calculated on the basis of the increased flow resulting from the new production or activity. The incremental growth (incremental production 1973 to 1977 and 1973 to 1983) in each industry is assumed to be discharging at New Source Performance Standards (NSPS), which is approximated as the application of BAT technology. This procedure for calculating incremental cost is assumed to overestimate the actual capital costs. Industrial growth in the future will probably use less water per unit output if the past trend reflected in the Census of Water Use in Manufacturing is an accurate estimate of the future trend in water use. In addition, industry would probably accommodate some new growth with the RDR technology installed to handle base year production levels.

NOTE

[1] The acronym OBERS is derived from the names of two principal participants in the forecasting effort--Office of Business Economics (OBE), U.S. Department of Commerce (which has subsequently been renamed) and Economic Research Service (ERS), U.S. Department of Agriculture.

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CHAPTER 7

ANALYZING WATER QUALITY

INTRODUCTION

The preceding chapters have explained the development of a set of activity inventories which, used simultaneously, can produce a fairly complete picture of the residuals generated and discharged into each of the basins of the contiguous U.S. However, knowledge of residuals discharges alone does not permit an estimate of water quality. Even if the quantities of residuals discharged into a basin are quite small, there may be severe water quality problems resulting from discharges into stream segments with minimal flow, or into lakes. Unfortunately, water quality impacts relating to such local conditions cannot currently be analyzed on a national basis.

The purpose of the basin-by-basin analysis presented here is to rank the 99 ASAs according to some index of average water quality. Such a ranking may then be used to identify those basins of the nation that are relatively well off and those that have problems under current conditions, all of which would be significantly affected by different water quality management policies. Because average conditions are determined for each basin and only two water quality parameters are used, the analysis may not reflect a real situation at any given location or time and cannot be used to pinpoint specific water quality problems in sub-basins or stream segments. Nevertheless, the relative ranking provides one basis for allocating WQM efforts.

RESIDUALS DILUTION RANKING INDEX

Background

A number of computational aids and models are available to predict or estimate water quality as affected by discharges of residuals. These systems are characterized by data requirements concerning the quantities, types, and locations of residuals being discharged into a water body, and physical information describing the hydrology of the area under study.

The residuals data needed for the water quality models are identical to those discussed in the activity inventory chapters, with the additional requirement of more specific siting information. Hydrologic data, which vary depending upon the type of water quality estimation to be made, most often include such information as:

- stream flows;
- channel geometry;
- temperature conditions; and
- residuals reaction coefficients (for degradable residuals).

Water quality parameters can be further subdivided into those that measure concentrations of residuals (such as metals or toxics), and those that indirectly indicate the effects of residuals (dissolved oxygen, pH, fish biomass). Some residuals are conservative, meaning that they do not change, except for being diluted, after they enter a watercourse but are carried along with the flow. These residuals are easier to study than nonconservative residuals.

Figure 7-1 illustrates how water quality in a "real" basin is modeled in a sophisticated water quality model and how an actual basin is ranked in NRDI, the latter showing the limited scope of the NRDI analysis. Diagram A, the "real" system, consists of a river system with a main stem and tributaries. At various locations along the network, point and areal discharges sequentially enter the waterway, affecting the water quality when they enter and for some distance downstream. The water quality at any point in Diagram A can be estimated as follows:

$$WQ(X) = f(L, x, r, B),$$

where

$WQ(X)$ = the water quality estimate for the parameter set X;
L = the set of residuals loadings on the system for points tributary to the point on the stream being studied;
x = the location set of the discharges, L;
r = the set of reaction coefficients, r; and
B = the set of other needed hydrological parameters, including flow conditions.

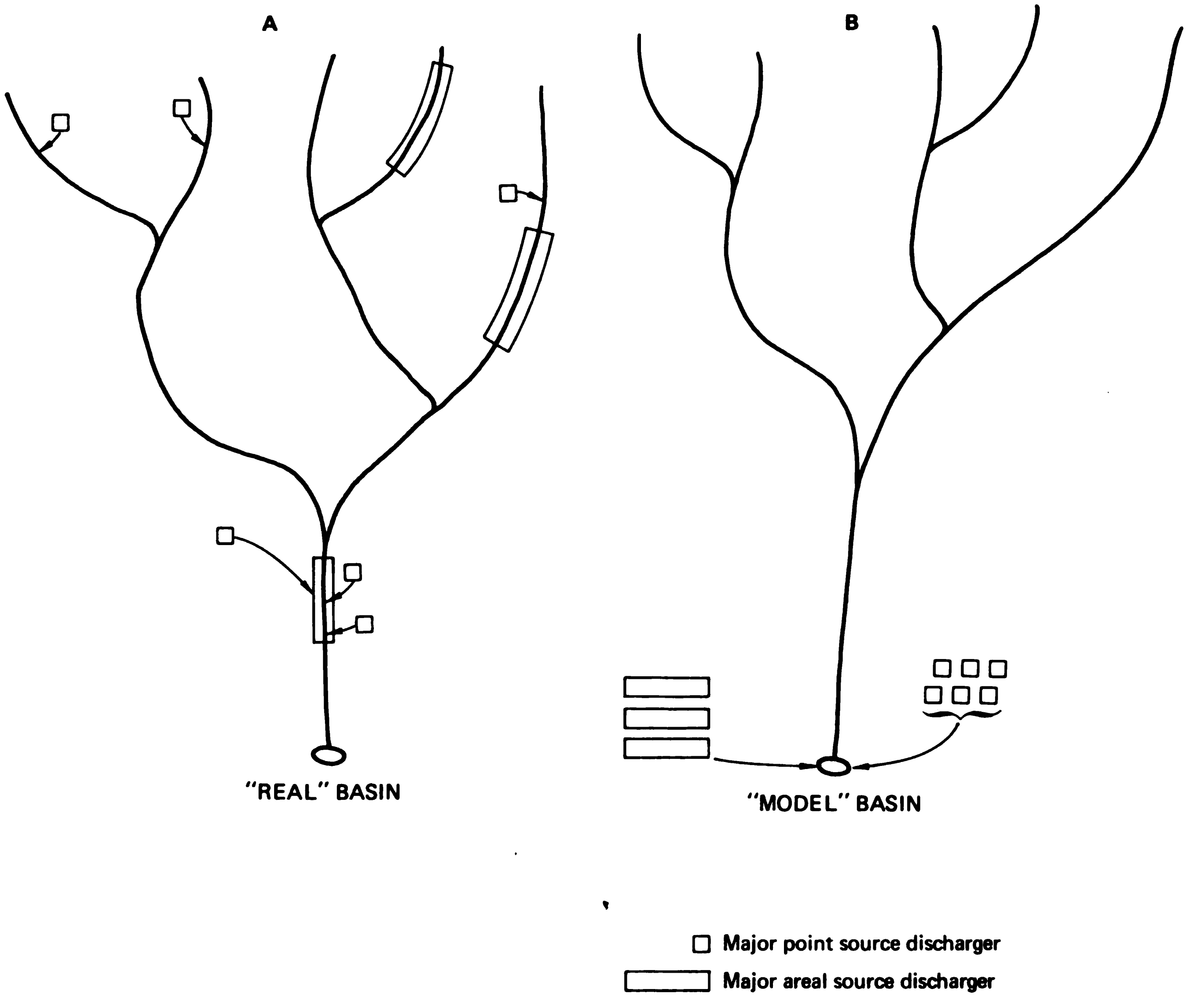
The simplified model shown in Diagram B can be used to measure the relative concentration of residuals in the basin at the basin exit point only. This is computed as follows:

$$C(x) = \frac{L}{Q}$$

where

$C(x)$ = the concentration measure over the parameter set X;

FIGURE 7-1
Real and NRDI Basins



L = the residual loading set for the entire basin;

Q = the total flow (stream or waste water flow, whichever is greater) measured at the basin discharge point, for some specified flow conditions.

The type of model represented in Diagram B will reflect concentrations of conservative residuals at the point of discharge from the basin, but it cannot estimate the concentrations of non-conservative residuals.

NRDI Residuals Dilution Ranking Procedure

The ranking procedure involves making dilution estimates for both BOD and TSS, during low and average stream flow conditions. Under low flow conditions, discharges of residuals from areal sources--urban storm runoff and non-irrigated agriculture--are assumed to be negligible, and only point source discharges are used. For average flow conditions, discharges of residuals from both point and areal sources are included. The dilution estimates of concentrations are computed as follows:

Low flow conditions:

$$\mathrm{BOD(low)} = \frac{\mathrm{BOD(PT)}}{\mathrm{Q(low)}}; \quad \mathrm{TSS(low)} = \frac{\mathrm{TSS(PT)}}{\mathrm{Q(low)}}$$

where

BOD(low) = BOD concentration (mg/l) under low flow conditions;

TSS(low) = TSS concentration (mg/l) under low flow conditions;

BOD(PT) = average daily BOD discharge from point sources (pounds/day), the annual BOD discharge divided by 365;

TSS(PT) = average daily TSS discharge from point sources (pounds/day), the annual TSS discharge divided by 365; and

Q(low) = average daily flow (l/day) in calendar month with the lowest flow (data developed by the U.S. Geological Survey for the Water Resources Council).

Average Flow Conditions:

$$\mathrm{BOD(avg)} = \frac{\mathrm{BOD(A)} + \mathrm{BOD(PT)}}{\mathrm{Q(avg)}}; \quad \mathrm{TSS(avg)} = \frac{\mathrm{TSS(A)} + \mathrm{TSS(PT)}}{\mathrm{Q(avg)}}$$

where

BOD(avg) = BOD concentration (mg/l) under average flow conditions;
TSS(avg) = TSS concentration (mg/l) under average flow conditions;
BOD(A) = average daily BOD discharge from areal sources (pounds/day), the annual BOD divided by 365;
TSS(A) = average daily TSS discharge from areal sources (pounds/day), the annual TSS divided by 365; and
Q(avg) = average annual daily flow (l/day) for ASA (data developed by the U.S. Geological Survey for the Water Resources Council).

The flow data (Q) represent only flow discharged from a single point in most basins and from multiple points in basins on the coast or Great Lakes. For these areas, however, the flow data do not represent the actual volume of water in the oceans or Great Lakes and thus do not reflect the actual dilution capacity of those ASAs with coastal areas. To compensate for this limitation, discharges of residuals from coastal counties and counties adjacent to the Great Lakes are excluded from the ASA totals when computing dilution estimates for ASAs. Coastal counties (defined by the Office of Coastal Zone Management, U.S. Department of Commerce) are those counties where surface waters are subject to tidal action. Figure 7-2 shows the counties excluded.

The actual flow measures may not always be the flow measures used in the dilution calculation. In less than 10 ASAs, the stream low flow is less than the flow from point sources, and this results in greater concentration in the stream than in the waste flow. These ASAs are primarily in the Great Basin and California South Pacific Coast. In ASAs where the point source discharge is greater than the stream low flow, the point source discharge is taken as the stream flow for the dilution estimate.

Results of NRDI Residual Dilution Ranking Index

The results of the dilution analysis for BOD and TSS are presented for 1973 conditions for the 99 ASAS in Tables 7-1 and 7-2 respectively. For the BOD dilution ranking, the concentrations of BOD in mg/l are listed for low and average

FIGURE 7-2
Coastal Counties Excluded from Residuals Dilution Ranking Index

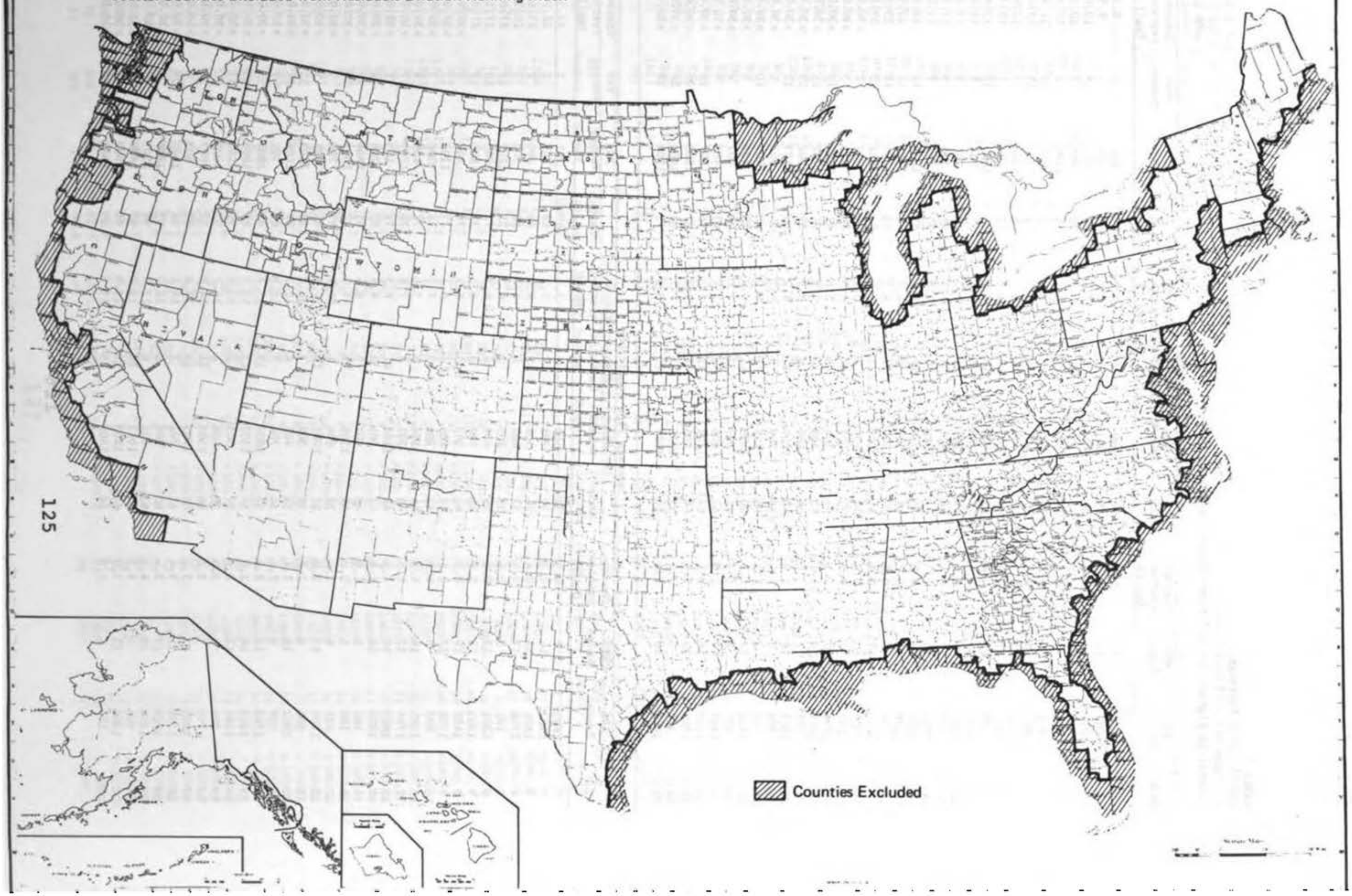


TABLE 7-1
BOD Dilution Rankings
For ASAs for 1973 Conditions
(Lowest to Highest BOD Dilution Concentration)

Low Flow Conditions

Rank	ASA Number	WRR Number	Concentration (mg/l)	Rank	ASA Number	WRR Number	Concentration (mg/l)	Rank	ASA Number	WRR Number	Concentration (mg/l)
1	1707	17	0.0	34	1801	18	2.7	67	402	4	8.5
2	1003	10	0.0	35	301	3	2.7	68	201	2	9.5
3	1001	10	0.0	36	702	7	2.8	69	901	9	10.0
4	1403	14	0.1	37	1104	11	2.9	70	701	7	10.4
5	802	8	0.2	38	1703	17	3.1	71	1106	11	10.4
6	801	8	0.2	39	703	7	3.2	72	1604	16	11.4
7	803	8	0.3	40	401	4	3.5	73	1503	15	12.0
8	1702	17	0.3	41	601	6	3.7	74	1304	13	12.9
9	1101	11	0.3	42	1802	18	3.8	75	104	1	15.3
10	1704	17	0.4	43	1009	10	4.1	76	1803	18	15.6
11	1401	14	0.4	44	408	4	4.2	77	204	2	16.6
12	602	6	0.4	45	1107	11	4.2	78	206	2	17.2
13	1004	10	0.4	46	307	3	4.4	79	503	5	17.7
14	505	5	0.5	47	1502	15	4.6	80	203	2	17.7
15	1002	10	0.6	48	1010	10	4.6	81	1203	12	18.3
16	106	1	0.7	49	504	5	4.7	82	1204	12	25.3
17	704	7	0.8	50	304	3	4.7	83	1204	12	25.3
18	1705	17	0.8	51	102	1	5.1	84	1501	15	29.5
19	1005	10	0.9	52	501	5	5.2	85	202	2	>30.0
20	101	1	0.9	53	1105	11	5.5	86	305	3	>30.0
21	1006	10	1.1	54	306	3	5.6	87	1602	16	>30.0
22	1402	14	1.1	55	303	3	5.8	88	1202	12	>30.0
23	705	7	1.2	56	404	4	5.9	89	1302	13	>30.0
24	1011	10	1.2	57	1706	17	6.2	90	1103	11	>30.0
25	309	3	1.5	58	502	5	6.3	91	103	1	>30.0
26	507	5	1.5	59	205	2	6.9	92	1007	10	>30.0
27	1701	17	1.7	60	1103	11	6.9	93	406	4	>30.0
28	405	4	1.7	61	302	3	7.0	94	407	4	>30.0
29	1303	13	1.8	62	506	5	7.1	95	403	4	>30.0
30	1603	16	2.1	63	1201	12	7.2	96	1807	18	>30.0
31	1301	13	2.1	64	105	1	7.7	97	1805	18	>30.0
32	308	3	2.2	65	1205	12	7.7	98	1804	18	>30.0
33	1008	10	2.6	66	1305	13	8.4	99	1806	18	>30.0

Average Flow Conditions

Rank	ASA Number	WRR Number	Concentration (mg/l)	Rank	ASA Number	WRR Number	Concentration (mg/l)	Rank	ASA Number	WRR Number	Concentration (mg/l)
1.	803	8	0.3	34	502	5	5.1	67	202	2	22.3
2	1403	14	0.3	35	309	3	5.5	68	203	2	22.7
3	1801	18	0.4	36	304	3	6.0	69	206	2	23.4
4	1705	17	0.4	37	602	6	6.2	70	503	5	24.3
5	101	1	0.6	38	205	2	6.3	71	1202	12	27.0
6	1301	13	0.8	39	405	4	6.3	72	1006	10	27.1
7	1303	13	0.8	40	303	3	6.5	73	1805	18	27.3
8	1402	14	0.9	41	307	3	6.5	74	407	4	>30.0
9	1702	17	1.1	42	408	4	6.7	75	1203	12	>30.0
10	802	8	1.2	43	306	3	7.3	76	506	5	>30.0
11	1401	14	1.3	44	504	5	7.4	77	406	4	>30.0
12	1701	17	1.3	45	201	2	7.8	78	1707	17	>30.0
13	1003	10	1.5	46	1104	11	8.3	79	103	1	>30.0
14	1802	18	1.9	47	301	3	8.4	80	1204	12	>30.0
15	102	1	1.9	48	507	5	8.4	81	1804	18	>30.0
16	106	1	2.0	49	1305	13	9.9	82	1009	10	>30.0
17	401	4	2.0	50	104	1	10.4	83	703	7	>30.0
18	1704	17	2.0	51	1001	10	10.6	84	901	9	>30.0
19	801	8	2.2	52	302	3	11.2	85	1103	11	>30.0
20	1502	15	2.4	53	402	4	12.7	86	1106	11	>30.0
21	505	5	2.4	54	704	7	12.8	87	701	7	>30.0
22	1703	17	2.6	55	1002	10	13.0	88	1007	10	>30.0
23	1803	18	2.8	56	1302	13	13.5	89	1008	10	>30.0
24	1107	11	2.9	57	305	3	13.9	90	1102	11	>30.0
25	308	3	3.0	58	404	4	14.1	91	1010	10	>30.0
26	705	7	3.1	59	1105	11	14.8	92	1807	18	>30.0
27	1201	12	3.2	60	1005	10	15.8	93	403	4	>30.0
28	1101	11	3.4	61	702	7	16.4	94	1603	16	>30.0
29	1706	17	3.4	62	204	2	16.7	95	1806	18	>30.0
30	1004	10	4.3	63	601	6	17.4	96	1503	15	>30.0
31	501	5	4.3	64	1011	10	19.2	97	1604	16	>30.0
32	1304	13	5.0	65	1205	12	19.3	98	1602	16	>30.0
33	105	1	5.0	66	1501	15	19.5	99	1601	16	>30.0

TABLE 7-2
TSS Dilution Rankings
For ASAs for 1973 Conditions
(Lowest to Highest TSS Dilution Concentration)

Low Flow Conditions

Rank	ASA Number	WRR Number	Concentration (mg/1)	Rank	ASA Number	WRR Number	Concentration (mg/1)	Rank	ASA Number	WRR Number	Concentration (mg/1)
1	1707	17	0.0	34	308	3	10.9	67	305	3	71.0
2	1001	10	0.0	35	1008	10	11.2	68	1702	17	71.9
3	1801	18	0.2	36	1803	18	11.7	69	1301	13	75.2
4	1704	17	0.4	37	302	3	12.6	70	1204	12	81.9
5	803	8	0.5	38	1105	11	14.4	71	1106	11	>100.0
6	1705	17	0.7	39	703	7	14.7	72	1202	12	>100.0
7	1003	10	0.7	40	1703	17	16.9	73	1205	12	>100.0
8	801	8	0.9	41	1107	11	17.1	74	1102	11	>100.0
9	802	8	1.1	42	306	3	17.4	75	601	6	>100.0
10	704	7	1.6	43	504	5	17.7	76	503	5	>100.0
11	304	3	1.6	44	104	1	18.6	77	403	4	>100.0
12	505	5	2.0	45	405	4	18.8	78	406	4	>100.0
13	1802	18	2.4	46	1002	10	19.3	79	701	7	>100.0
14	1011	10	2.5	47	404	4	18.8	80	202	2	>100.0
15	1101	11	2.9	48	106	1	22.0	81	1701	17	>100.0
16	1006	10	3.5	49	105	1	22.8	82	1402	14	>100.0
17	1706	17	3.5	50	501	5	24.8	83	1103	11	>100.0
18	602	6	3.7	51	901	9	32.2	84	1805	18	>100.0
19	301	3	4.0	52	1203	12	33.2	85	407	4	>100.0
20	102	1	4.2	53	502	5	34.8	86	1502	15	>100.0
21	1009	10	4.8	54	1201	12	40.2	87	401	4	>100.0
22	1104	11	4.8	55	408	4	41.2	88	1304	13	>100.0
23	507	5	5.0	56	1010	10	41.8	89	1007	10	>100.0
24	307	3	6.0	57	506	5	43.2	90	1804	18	>100.0
25	309	3	6.4	58	1303	13	43.3	91	1005	10	>100.0
26	205	2	6.5	59	204	2	44.8	92	1602	16	>100.0
27	705	7	7.0	60	203	2	51.8	93	1806	18	>100.0
28	1305	13	7.3	61	1401	14	52.0	94	1807	18	>100.0
29	702	7	7.4	62	103	1	55.1	95	1601	16	>100.0
30	303	3	7.8	63	206	2	61.8	96	1302	13	>100.0
31	201	2	9.7	64	402	4	62.8	97	1604	16	>100.0
32	1403	14	10.8	65	1501	15	63.0	98	1503	15	>100.0
33	101	1	10.9	66	1004	10	65.8	99	1603	16	>100.0

Average Flow Conditions

Rank	ASA Number	WRR Number	Concentration (mg/1)	Rank	ASA Number	WRR Number	Concentration (mg/1)	Rank	ASA Number	WRR Number	Concentration (mg/1)
1	1706	17	1.4	34	402	4	85.8	67	1701	17	>100.0
2	102	1	3.1	35	1702	17	90.0	68	1101	11	>100.0
3	205	2	7.8	36	206	2	90.9	69	1204	12	>100.0
4	101	1	9.7	37	702	7	92.6	70	401	4	>100.0
5	305	3	12.8	38	203	2	95.7	71	403	4	>100.0
6	1305	13	13.3	39	1805	18	>100.0	72	1011	10	>100.0
7	304	3	14.1	40	502	5	>100.0	73	1801	18	>100.0
8	1705	17	14.2	41	701	7	>100.0	74	1009	10	>100.0
9	1803	18	14.3	42	404	4	>100.0	75	1106	11	>100.0
10	1301	13	28.4	43	1704	17	>100.0	76	1203	12	>100.0
11	303	3	30.5	44	202	2	>100.0	77	1103	11	>100.0
12	802	8	30.9	45	505	5	>100.0	78	1402	14	>100.0
13	201	2	32.5	46	103	1	>100.0	79	1502	15	>100.0
14	104	1	34.3	47	504	5	>100.0	80	1008	10	>100.0
15	803	8	34.8	48	705	7	>100.0	81	1403	14	>100.0
16	301	3	36.2	49	1202	12	>100.0	82	1403	14	>100.0
17	801	8	37.5	50	901	9	>100.0	83	1303	13	>100.0
18	1201	12	41.0	51	601	6	>100.0	84	1010	10	>100.0
19	306	3	41.6	52	406	4	>100.0	85	1304	13	>100.0
20	308	3	47.5	53	1001	10	>100.0	86	1401	14	>100.0
21	507	5	51.4	54	1107	11	>100.0	87	1007	10	>100.0
22	408	4	54.2	55	1104	11	>100.0	88	1102	11	>100.0
23	106	1	56.6	56	1205	12	>100.0	89	1806	18	>100.0
24	405	4	57.9	57	506	5	>100.0	90	1005	10	>100.0
25	302	3	58.3	58	1003	10	>100.0	91	1302	13	>100.0
26	307	3	60.2	59	704	7	>100.0	92	1501	15	>100.0
27	1006	10	61.2	60	503	5	>100.0	93	1807	18	>100.0
28	105	1	70.0	61	602	6	>100.0	94	1707	17	>100.0
29	1802	18	70.1	62	1105	11	>100.0	95	1602	16	>100.0
30	501	5	72.7	63	407	4	>100.0	96	1503	15	>100.0
31	1703	17	72.9	64	703	7	>100.0	97	1604	16	>100.0
32	204	2	82.7	65	1804	18	>100.0	98	1601	16	>100.0
33	309	3	84.6	66	1002	10		99	1603	16	>100.0

ASAs are ranked from lowest to highest TSS dilution concentration (Table 7-2).

Comparison of NRDI Results with those from Other Sources

Characterizing the quality of the nation's water is difficult.[1] Among several reasons for this are the facts that there is no universal set of criteria that can be used as a guide to describe ambient water conditions; and that the lack of extensive baseline data makes reasonable estimates of future water quality difficult.

The U.S. Geological Survey, the Council of Environmental Quality, the Environmental Protection Agency, and other groups are currently involved in efforts to expand the amount of baseline data needed to make projections of levels of future water quality. These new data should improve descriptions of current conditions and make possible more accurate projections of water quality characteristics.

The NCWQ environmental contractors conducted water quality analyses and environmental impact assessments at 41 selected sites throughout the nation. A majority of these sites are segments of various rivers throughout the coterminous U.S., and the rest of them include coastal areas and estuaries and several "standing water" sites, including lakes, reservoirs, and impoundments. Areas in Hawaii, Puerto Rico, and Alaska were also included in NCWQ's work.

NRDI produces estimates of BOD concentrations for the 99 ASAs. Some of the NCWQ site contractors also estimated BOD concentrations. Both data sets show BOD concentrations for current conditions (1973) and after applying BPT and BAT/BPWTT technologies. The NRDI BOD concentrations are estimated for both low flow and average flow conditions. The NRDI low flow estimates are for point sources only, whereas the average flow condition reflects impacts of both point and areal sources.

The NRDI concentrations show averages for entire ASAs, while those estimated by NCWQ reflect specific sites. Thus, concentrations were not expected to be identical; however, a positive correlation was anticipated between these two data sets. It was expected (a) that when the NCWQ data indicated relativly degraded water quality in a river reach, the NRDI data would indicate relatively degraded water quality in the corresponding ASA; and (b) that when the NCWQ data projected improvements in water quality in a river reach, the NRDI data would project similar improvements in the corresponding ASA.

BOD concentrations generated by the NRDI were compared with those produced by NCWQ contractor analyses. A comparison was made between the NCWQ BOD estimates (summer condition) and the NRDI estimates (low flow conditions). A sample of 16 river basins was chosen for this portion of the analysis. Other NCWQ site studies were not included for one or both of the following reasons: (1) they were outlying areas, and sufficient data were not provided by NRDI; or (2) the NCWQ contractor reports included no BOD projections. When rivers alone are considered, the sample represents approximately 80 percent of the rivers assessed by NCWQ. The remaining 20 percent were eliminated for the reasons stated above. Table 7-3 lists the estimated BOD concentrations for each of the 16 river segments and corresponding ASAs for 1973 conditions and after applying BPT/ST and BAT/BPWTT, for both the NCWQ and NRDI analyses.

For 1973 conditions, 50 percent of the basins were positively correlated; that is, both data sets indicated that seven basins were relatively degraded (hi-hi) and that one basin was non-degraded (low-low) under current conditions. For the other eight basins, the two data sets indicated different conditions. Either the NRDI data indicated that water quality was relatively degraded and NCWQ indicated it was relatively non-degraded, or vice versa. After applying BPT/ST technology, the NCWQ and NRDI estimates were positively correlated on seven of the basins and negatively correlated on the other nine basins. In the latter cases, NCWQ more often reported a high BOD concentration where NRDI reported a low BOD concentration. After applying BAT/BPWTT technology, the NCWQ and NRDI estimates were positively correlated for ten basins and negatively correlated for the other six. In these cases, none of the NCWQ projections indicated a low BOD concentration where NRDI indicated a high concentration.

The other comparison between the two sets of data--16 areas--was to see whether they indicated the same trend in the percentage of basins that changed in relative water quality after applying BPT/ST and BAT/BPWTT. (See Table 7-4). For 1973 conditions, the NCWQ data showed that 47 percent of the sample had BOD concentrations in the 0.0 to 2.9 range mg/l compared to 33 percent for the same range as estimated by NRDI. After applying BPT/ST, the NCWQ estimates showed 73 percent of the sample with BOD concentrations in the 0.0 to 2.9 mg/l range compared to 67 percent for NRDI. After applying BAT/BPWTT, both the NCWQ and NRDI data show that 87 percent of the sample is expected to have BOD concentrations in the 0.0 to 2.9 mg/l range. At the other end of the scale, after applying BAT/BPWTT, the NCWQ estimates showed that 100 percent of the sample would achieve a BOD concentration of less than or equal to 5.9 mg/l, whereas NRDI estimates that only 87 percent of the sample would achieve this level, and that the remaining 13 percent would have BOD concentations greater than or equal to 12 mg/l.

The NRDI BOD estimates for the South Platte and Upper Rio Grande ASAs must be viewed skeptically, because the flows are low compared to other ASAs within the same region. For the South Platte ASA (Water Resource Region X) and the Upper Rio Grand ASA (Water Resource Region XIII), the NRDI

TABLE 7-3

Comparison Between NCWQ and NRDI BOD Concentrations for Selected Areas (mg/l)

1973 Conditions			BPT/ST			BAT/BPWTT		
River	NCWQ	NRDI	River	NCWQ	NRDI	River	NCWQ	NRDI
	High	High		High	High		High	High
Boston Harbor	6.3	9.5	Boston Harbor	6.3	2.2	South Platte	3.0	15.9
Connecticut	2.8	6.9	South Platte	4.3	41.5	Trinity	2.0	2.1
Housatonic	6.3	3.5	Trinity	2.0	8.5	U. Rio Grande	2.7	17.5
South Platte	5.7	41.5	U. Rio Grande	3.9	49.9			
Susquehanna	3.4	13.5						
Trinity	12.6	16.4						
U. Rio Grande	3.9	49.9						
	Low	Low		Low	Low		Low	Low
Lo. Columbia	1.7	0.1	Hudson	1.0	1.0	Biscayne Bay	0.6	1.3
			Lo. Columbia	1.1	0.0	Guadelupe	1.2	0.4
			Snake	1.3	0.6	Housatonic	1.3	0.5
						Hudson	1.0	0.7
						Lo. Columbia	1.0	0.0
						Potomac	0.7	1.6
						Snake	1.3	0.2
	High	Low		High	Low		High	Low
Iowa-Cedar	4.1	1.6	Connecticut	2.0	1.1	Boston Harbor	5.0	1.2
Lo. Missouri	3.2	0.8	Guadelupe	2.2	1.3	Connecticut	1.7	0.7
St. Johns	3.2	0.6	Housatonic	2.0	0.7	Iowa-Cedar	2.3	0.4
			Iowa-Cedar	2.4	0.8	Lo. Missouri	2.6	0.3
			Lo. Missouri	3.1	0.3	St. Johns	2.3	0.1
			Saint Johns	3.1	0.1			
	Low	High		Low	High		Low	High
Biscayne Bay	1.1	7.2	Biscayne Bay	0.6	3.0			
Guadelupe	2.3	2.5	Potomac	0.7	3.5			
Hudson	2.0	4.2						
Potomac	1.4	11.9						
High ≥ 2.5 mg/l Low < 2.5 mg/l			High ≥ 2.0 mg/l Low < 2.0 mg/l			High ≥ 1.5 mg/l Low < 1.5 mg/l		

TABLE 7-4

Comparison Between NCWQ and NRDI Relative BOD Concentrations for Selected NCWQ Study Sites

	NCWQ (Summer Cond.)					NRDI (Low Flow Cond.)				
NCWQ Study Sites And Technology Applied	0-2.9 mg/l	3.0-5.9 mg/l	6.0-8.9 mg/l	9.0-11.9 mg/l	≥ 12 mg/l	0-2.9 mg/l	3.0-5.9 mg/l	6.0-8.9 mg/l	9.0-11.9 mg/l	> 12 mg/l
Connecticut										
1973	x							x		
BPT/ST	x					x				
BAT/BPWTT	x					x				
Snake										
1973	x					x				
BPT/ST	x					x				
BAT/BPWTT	x					x				
Hudson										
1973	x					x				
BPT/ST	x					x				
BAT/BPWTT	x					x				
St. John (Maine)										
1973		x				x				
BPT/ST		x				x				
BAT/BPWTT	x					x				
Iowa-Cedar										
1973										
BPT/ST										
BAT/BPWTT										
South Platte										
1973		x								x
BPT/ST		x								x
BAT/BPWTT		x								x
Biscayne Bay										
1973	x							x		
BPT/ST	x						x			
BAT/BPWTT	x					x				
Guadelupe-San Antonio										
1973	x					x				
BPT/ST	x					x				
BAT/BPWTT	x					x				
Potomac										
1973	x								x	
BPT/ST	x						x			
BAT/BPWTT	x					x				
Lower Missouri										
1973		x				x				
BPT/ST		x				x				
BAT/BPWTT	x					x				
Susquehanna										
1973		x								x
BPT/ST	x*					x				
BAT/BPWTT	x*					x				

TABLE 7-4 (continued)

NCWQ Study Sites And Technology Applied	NCWQ (Summer Cond.)					NRDI (Low Flow Cond.)				
	0-2.9 mg/l	3.0-5.9 mg/l	6.0-8.9 mg/l	9.0-11.9 mg/l	≥12 mg/l	0-2.9 mg/l	3.0-5.9 mg/l	6.0-8.9 mg/l	9.0-11.9 mg/l	≥ 12 mg/l
Trinity										
1973					x					x
BPT/ST	x							x		
BAT/BPWTT	x					x				
Housatonic										
1973			x				x			
BPT/ST	x					x				
BAT/BPWTT	x					x				
U. Rio Grande										
1973		x								x
BPT/ST	x									x
BAT/BPWTT	x									x
Boston Harbor-Charles										
1973			x						x	
BPT/ST			x			x				
BAT/BPWTT		x				x				
Lower Columbia										
1973	x					x				
BPT/ST	x					x				
BAT/BPWTT	x					x				
TOTALS AND PERCENTAGES										
1973	7-47%	5-33%	2-13%	0-0%	1-7%	5-33%	2-13%	2-13%	2-13%	4-28%
BPT/ST	11-73%	3-20%	1-7 %	0-0%	0-0%	10-67%	2-13%	1-7 %	0-0 %	2-13%
BAT/BPWTT	13-87%	2-13%	0-0 %	0-0%	0-0%	13-87%	0-0 %	0-0 %	0-0 %	2-13%

*Not available - extrapolated

low flow estimates are approximately 1 and 4 percent, respectively, of the average low flows for all ASAs in those WRRs. In addition, 85 percent of the BOD generated in the South Platte ASA and 98 percent of the BOD generated in the Upper Rio Grande ASA comes from municipal sources. These discharges combined with the low flows described above yield the high BOD concentrations in the areas even after the application of BAT.

In summary, the NRDI residuals dilution ranking index for selected ASAs indicates relative water quality rankings similar to the the NCWQ data for approximately one-half the sites. Neither NRDI nor NCWQ estimates of current conditions compare well with EPA data for a more limited set of rivers (U.S. EPA 1974). Both the NRDI and NCWQ BOD estimates indicate the same general trend in improvements in water quality. The NCWQ estimates show that, after applying BPT/ST technology, 73 percent of the rivers would have BOD concentrations ranging from 0.0 to 2.9 mg/l, while the NRDI estimates show that 67 percent would have concentrations in the same category. After applying BAT/BPWTT technology, both the NCWQ and NRDI estimates show that 87 percent of the rivers would have BOD concentrations in the least degraded category.

NOTE

1 For a more complete discussion, see V.E. McKelvey, Water Quality--Is it Getting Better or Worse? Presented at the 7th International Water Quality Symposium, April 23, 1974. Washington, D.C.

LITERATURE CITED

U.S. Environmental Protection Agency (1974) National Water Quality Inventory--Report to Congress.

CHAPTER 8

EVALUATING THE RESULTS OF APPLYING BPT/ST AND BAT/BPWTT

INTRODUCTION

To provide a comprehensive assessment of the WQM strategy contained in P.L. 92-500, this chapter summarizes relevant data from the preceding chapters, integrating estimates of residuals generation, residuals discharge, and RDR costs for municipal, industrial, and areal source activities. The data used to analyze the different activities in making this assessment are not of equal validity. For estimating residuals and costs for industrial and municipal activities the data are relatively well documented and appear in many sources, such as NCWQ contractor reports, EPA development documents, and trade association reports. The data used for areal source activities--urban runoff and non-irrigated agriculture--are extracted with some modification from NCWQ contractor reports which are not as detailed as the NCWQ contractor reports on industrial activities. Consequently, considerable caution should be maintained when making point/nonpoint (areal) source comparisons.

It should also be reemphasized that, although most of the data used for the analysis of industrial and municipal activities were taken from EPA and/or NCWQ documents, the NRDI approach to estimating residuals discharge reduction and RDR costs, especially for industrial activities, is different from the approach of either EPA or NCWQ. For example, in analyzing industrial activities NRDI applies specified RDR unit process removal efficiencies and associated costs functions to individual plants, while EPA and NCWQ primarily use unit costs and residuals removal efficiencies based upon model plant data for each industrial category. Consequently, caution should also be exercised when comparing the NRDI results with those of EPA and/or NCWQ. (See Chapters 3 and 4 for a more complete discussion.) These differences in approach, however, do not affect the interregional comparisons.

NATIONAL SUMMARIES

These summaries present residuals generation and discharge data and RDR costs in aggregates that are readily comparable with other sources, particularly EPA and NCWQ. The section displays residuals generation, discharge, and costs for major activity categories and indicates how the relative importance of those activity categories, as dischargers, changes with the application of BPT/ST and BAT/BPWTT to point sources as promulgated in P.L. 92-500. The section also describes the magnitude of the essentially uncontrolled BOD, TSS, P, and N residuals discharges from areal sources, and compares their magnitudes with those from controlled point sources.

Residuals Generation, Residuals Discharge, and RDR Costs: Point Sources

As shown in Table 8-1, municipal activities in 1973 generated about 60 percent of the point source BOD but only about 1 percent of point source TSS. Industrial activities generated about 40 percent of the point source BOD and about 99 percent of point source TSS. Mining activities alone accounted for about 96 percent of the industrial generation of TSS. Manufacturing--industrial minus mining--generated about three times as much TSS as municipal dischargers.

As of 1973, both industrial and municipal activities are estimated, through the significant capital investment shown in Table 8-2, to have achieved some reduction in the discharge of BOD and TSS residuals generated (see Table 8-1). Industrial activities have reduced their BOD discharges by 45 to 50 percent and TSS discharges by 35 to 40 percent, with an estimated capital investment of about $6 billion. Municipal activities have reduced their BOD discharges by 55 to 60 percent, and TSS discharges by 55 to 60 percent, with a much larger capital investment of an estimated $30 to $35 billion. The relative shares of BOD discharges for 1973 sources are slightly different from the relative shares for BOD generation, with industrial activities accounting for 40 to 45 percent and municipal for 55 to 60 percent of the total discharge. The relative shares of TSS discharged are the same for both generation and discharge.

The projected residuals discharges and RDR costs with the application of BPT/ST technology show a considerable difference between industrial and municipal activities. A projected investment of $11.6 billion is estimated for industrial activities to reduce their residuals discharges to about 0.9 billion pounds of BOD and 12.6 billion pounds of TSS, which represent reductions in residuals discharges of 3.4 billion pounds, and 710 billion pounds, respectively, or 80 and 98 percent respectively of their 1973 discharges. For municipal activities, the estimated investment is $28.4 billion to limit their residuals discharges to about 1.8 billion pounds of BOD and 1.7 billion pounds of TSS, which represent reductions in residuals discharges of 4 billion

TABLE 8-1

Estimates of 1973 BOD and TSS Generation and Discharge and Discharge after Applying BPT/ST and BAT/BPWTT (10^9 pounds per year)

	BOD				TSS			
	1973 Generation	1973 Discharge	BPT/ST Discharge	BAT/BPWTT Discharge	1973 Generation	1973 Discharge	BPT/ST Discharge	BAT/BPWTT Discharge
Point Sources (PS)	21.2	10.1	2.7	1.3	1,160	729	14.3	13.4
% of National Total	68	51	22	12	45	34	1	1
Industrial	8.0	4.3	0.9	0.4	1,150	723	12.4	12.3
% of PS	38	43	33	31	99	99	88	93
Municipal	13.2	5.8	1.8	0.9	14.1	6.0	1.7	0.8
% of PS	62	57	67	69	1	1	12	7
Areal Sources (AS)	9.8	9.8	9.8	9.8	1,430	1,430	1,430	1,430
% of National Total	32	49	78	88	55	66	99	99
Urban Runoff	3.3	3.3	3.3	3.3	59.9	59.9	59.9	59.9
% of AS	34	34	34	34	4	4	4	4
Non-Irrigated Agriculture	6.5	6.5	6.5	6.5	1,370	1,370	1,370	1,370
% of AS	66	66	66	66	96	96	96	96
National Totals	31.0	19.9	12.5	11.1	2,600	2,160	1,450	1,450

TABLE 8-2

Estimated Capital Costs for Application of BPT/ST and BAT/BPWTT Technology to 1973 Conditions: National Totals for Point Sources

Activity	Replacement Value of Existing Waste Treatment Facilities (10^9 1975$)	% of Total	Capital Costs of Additional Facilities to Apply BPT/ST (10^9 1975$)	% of Total	Capital Costs of Additional Facilities to Apply BAT/BPWTT (10^9 1975$)	% of Total
Industries						
Pulp and Paper	1.9		1.8		.6	
Organic Chemicals	.3		1.3		1.3	
Petroleum Refining	.3		.7		1.3	
Iron and Steel	.8		1.9		1.3	
Inorganic Chemicals	.3		.6		.2	
Plastics and Synthetics	.4		.3		.2	
Textiles	.2		.5		.3	
Mining	.0		.3		.0	
All other	1.9		2.7		1.8	
INDUSTRY	6.1	15	10.1	27	6.8	38
Municipalities	32.5	85	28.4	63	10.3	62
TOTAL*	38.6	100	38.5	100	17.1	100

* Applies to the point source category only.

pounds, and 4.3 billion pounds, respectively, or 70 and 72 percent respectively of the 1973 discharges. The larger reduction achieved by industrial activities means that industrial activities after applying BPT technology would account for only 33 percent of point source BOD and 88 percent of point source TSS. Municipal activities after applying ST technology would account for 67 percent of point source BOD and 12 percent of point source TSS.

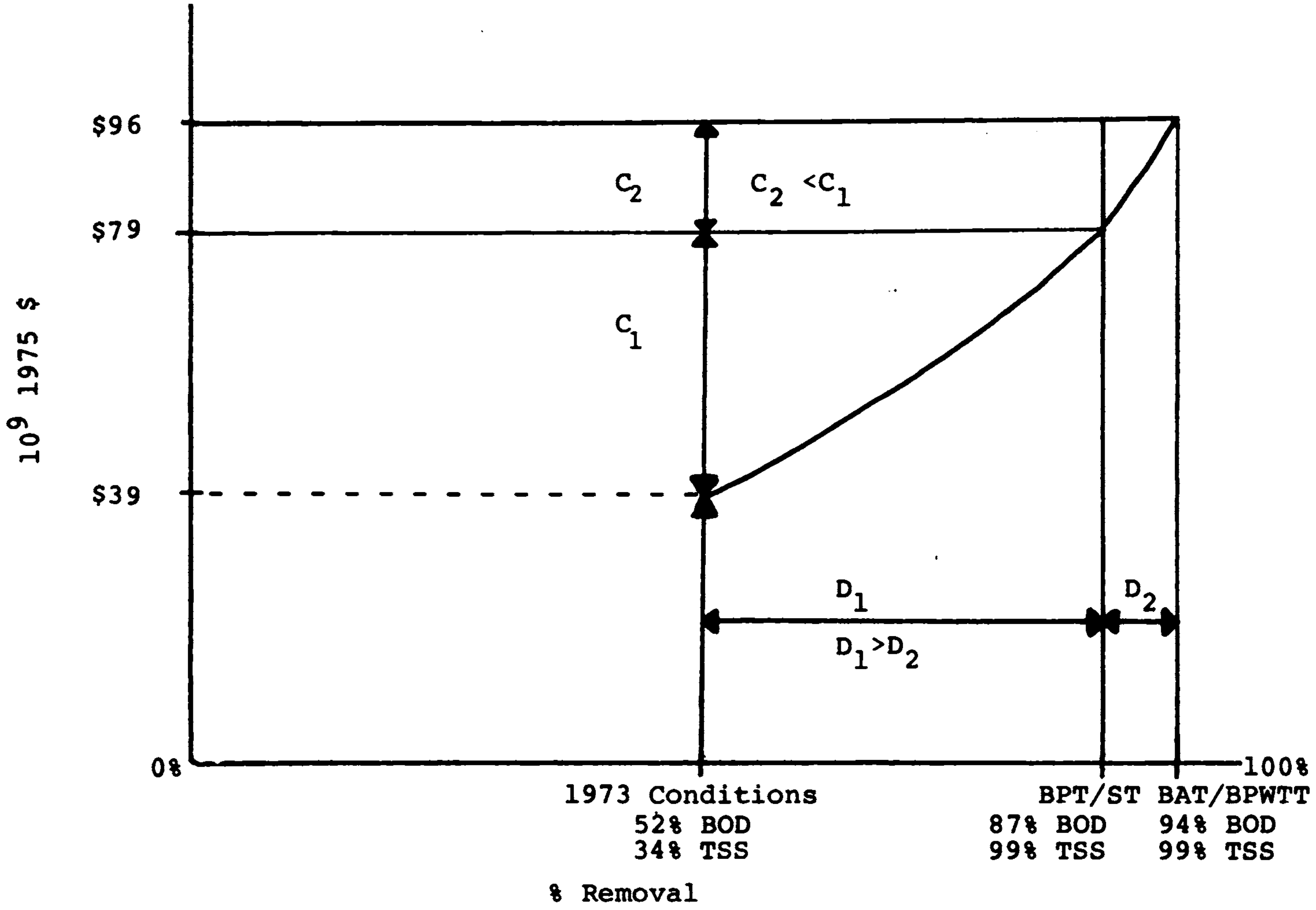
The projected residuals discharges and RDR costs associated with the application of BAT/BPWTT technology show a remarkable similarity to those corresponding to the application of BPT/ST. An estimated investment of $7.0 billion will be needed for industrial activities to reduce their residuals discharges to about 0.4 billion pounds of BOD and 12.5 billion pounds of TSS, which represent reductions in residuals discharges by 0.5 billion pounds and by 0.1 billion pounds, respectively, corresponding to 55 and 1 percent of their BPT discharge. For municipal activities, the investment is estimated at $10.3 billion to reduce their residuals discharges to about 0.9 billion pounds of BOD and 0.8 billion pounds of TSS, representing reductions of 0.9 billion pounds of BOD and 0.9 billion pounds of TSS, respectively, corresponding to 50 and 53 percent respectively of the ST discharges. After applying BAT/BPWTT technology, municipal sources would account for approximately twice as much point source BOD discharge as industrial activities and one-sixth of the point source TSS discharge as industrial activities. Both activities would be more comparable in TSS discharge if the TSS discharge of 10.0 billion pounds from mining activities were excluded from the industrial total.

While applying BPT technology to industrial activities would result in a considerable reduction in residuals discharges for the RDR capital investment, applying BAT technology would not accomplish the same degree of reduction of BOD and TSS for comparable costs, as indicated in Tables 8-1 and 8-2. But it should be emphasized that BAT and BPWTT are oriented to other residuals as well as BOD and TSS. Similarly, applying ST technology to municipal activities would result in a considerable reduction in residuals discharges for the capital investment, but applying BPWTT technology would not accomplish the same degree of reduction for a comparable cost.

The results described in the preceding paragraph are illustrated in Figure 8-1. The curve, based on data in Tables 8-1 and 8-2, relates the investment to reduce residuals discharges (the vertical axis) to the residuals removal achieved (the horizontal axis). The increment in capital costs to move from 1973 conditions to BPT/ST for point sources is about $40.0 billion, corresponding to C1; the removals of BOD and TSS residuals associated with these costs are about 35 and 65 percent, respectively, corresponding to D1. The increment in capital costs to move

FIGURE 8-1

Estimated Point Source Incremental Capital Costs to Apply BPT/ST and BAT/BPWTT Technology for Reduction of BOD and TSS Discharges



from BPT/ST to BAT/BPWTT for point sources is $17.1 billion, corresponding to C2; the removals of BOD and TSS residuals associated with these costs are about 7 and virtually 0 percent, corresponding to D2. Because the costs represent the joint costs of removing BOD, TSS, and other residuals simultaneously, no real unit costs--dollars per pound of BOD or TSS removed--can be calculated.

Nevertheless, a general conclusion can be drawn about the effectiveness of capital investment in applying BPT/ST in terms of residuals removal efficiency, because most RDR unit processes at this level are primarily for BOD and TSS removal. A comparison of Tables 8-1 and 8-2 shows that for a $10.1 billion investment to apply BPT to industrial activities about 3.4 billion pounds per year of BOD and about 710 billion pounds per year of TSS will be removed; applying ST to municipal activities will require an investment of about $28.4 billion and is estimated to remove about 4.0 billion and 4.3 billion pounds per year of BOD and TSS, respectively, For applying BPT/ST, the investment in RDR technology for industrial activities will generally reduce BOD and TSS discharges more, and at lower cost, than the corresponding investment in RDR technology for municipalities. This is not the case for BAT/BPWTT, particulary for industrial activities, where the RDR unit processes required in addition to BPT/ST processes are primarily for removing residuals other than BOD and TSS.

Residuals Discharge: Uncontrolled Areal Sources

The 1972 Act, as it has been implemented, focuses on reducing residuals discharges from municipal and industrial activities. However, there are areal activities which generate BOD and TSS and other residuals which affect water quality. This section presents a reasonably comprehensive view of BOD and TSS residuals from the four major types of activity--municipal, industrial, non-irrigated agriculture, and urban storm runoff.

Residuals generation in 1973 is estimated to be 31 billion pounds per year of BOD and 2.6 x 10^3 billion pounds of TSS, as shown in Table 8-1. Point sources were clearly the dominant source of BOD residuals generation, accounting for approximately 68 percent of the national total. Within their respective categories, i.e., point and nonpoint, municipal and non-irrigated agriculture were the larger sources. However, point sources of TSS were of the same order of magnitude as areal sources of TSS generation. Within their respective categories, industrial and non-irrigated agriculture were clearly the largest generators of TSS.

The 1973 RDR technology in place for point sources reduced the potential discharges to actual discharges for all sources of about 20 billion pounds of BOD and about 2.2

x 10^3 billion pounds of TSS. The 50 to 55 and 35 to 40 percent reduction in BOD and TSS residuals discharges, respectively, achieved by point source activities, clearly modified the relative importance of the different activities as sources of BOD and TSS residuals. BOD discharges from point sources in 1973, 10.1 billion pounds, were approximately equal to BOD discharges from areal sources, 9.8 billion pounds. TSS discharges from point sources, 720 billion pounds, were about half the TSS discharges from areal sources, 1.4 x 10^3 billion pounds.

Applying BPT/ST technology to point sources is estimated to reduce total BOD discharge to about 12.5 billion pounds and TSS discharge to 1.4 x 10^3 billion pounds. Point sources of BOD, discharging about 2.7 billion pounds, would then account for only about 20 percent of the national BOD discharge total. Areal sources are estimated to account for the other 80 percent, about one third from urban runoff, and two thirds from non-irrigated agriculture. Point sources of TSS, discharging 14.3 billion pounds, are estimated to account for only about 1 percent of the national TSS discharge total. Areal sources, almost exclusively non-irrigated agriculture, are estimated to account for about 99 percent.

Applying BAT/BPWTT technology to point sources is estimated to reduce total BOD discharge to 11 billion pounds. Total TSS discharge is estimated to remain at about 1.4 x 10^3 billion pounds. Point sources of BOD, discharging about 1.3 billion pounds, would then account for only about 12 percent of the national BOD discharge total. Point sources of TSS, discharging about 13.4 billion pounds, would again account for only about 1 percent of the national TSS discharge total. Areal sources, assuming no reduction in discharges from those sources, would clearly dominate the national totals of BOD and TSS discharges.

Magnitude of N and P Discharges from Municipal and Non-Irrigated Agriculture Activities

The other residuals considered in NRDI are P and N. The coverage of these residuals is only partial, because the data for P and N discharges from industrial and urban runoff activities were either very limited or non-existent. Consequently, the discussion is limited to two sources of these residuals: municipal and non-irrigated agricultural activities. Residuals generation in 1973 by these two sources is estimated at 3.8 million pounds per year of P and 3.9 million pounds per year of N, as shown in Table 8-3. Municipal activities are estimated to account for 2.5 billion pounds of P and for 0.6 billion pounds of N, and non-irrigated agriculture for the remaining 1.3 billion pounds of P and for 3.3 billion pounds of N.

TABLE 8-3

Estimates of 1973 N & P Generation and Discharge and Discharge After Applying BPT/ST and BAT/BPWTT to 1973 Conditions: Municipal and Non-Irrigated Agriculture Activities

(10^9pounds)

		Municipal	% of Total	Non-Irrigated Agriculture	% of Total	Total
P	1973 Generation	2.5	66	1.3	34	3.8
	1973 Discharge	1.8	58	1.3	42	3.1
	BPT/ST Discharge Discharge	1.6	55	1.3	45	2.9
	BAT/BPWTT Discharge	1.0	38	1.3	62	2.3
N	1973 Generation	.6	15	3.3	85	3.9
	1973 Discharge	.5	13	3.3	87	3.8
	BPT/ST Discharge	.4	11	3.3	89	3.7
	BAT/BPWTT Discharge	.4	11	3.3	89	3.7

The 1973 RDR technology in place for municipal activities reduced the potential discharge from municipal and non-irrigated agricultural activities to 3.1 billion pounds of P and 3.8 billion pounds of N. These reductions did not appreciably affect the relative importance of activities as sources of P and N residuals.

Applying ST/BPWTT would affect the total discharge of P and the balance between the two sources considered herein. Application of ST is estimated to reduce the 1973 municipal discharges of P from 1.8 to 1.6 million pounds, and the 1973 municipal discharges of N from 0.5 to 0.4 billion pounds. Municipal activities would remain the predominant source of P and non-irrigated agriculture would remain the predominant source of N. However, applying BPWTT technology, which is defined as advanced treatment often designed to remove P, would further reduce the municipal discharge of P to 1.0 billion pounds, a decrease of 0.6 million pounds, but would not reduce the municipal discharge of N. Applying BPWTT and assuming no control on discharges from non-irrigated agricultural activities, the latter would become the major source of P as well as N.

The emphasis so far in the implementation of P.L. 92-500 on reducing discharges from point sources, ignores significant discharges of ostensibly the same residuals from areal sources. However, residuals discharges from these sources would not have the same impact on water quality as residuals from point sources. As explained earlier, residuals discharges of BOD and TSS from urban runoff activities occur during storm events, which also increase stream flow and thus the capability of assimilating residuals. This combination usually results in a temporary impairment of water quality. Similarly, discharges of BOD and TSS from non-irrigated agricultural activities occur during storm events and usually are diffuse rather than concentrated in nature, which may mitigate their impact. However, discharges from areal sources of nutrient residuals, P and N, which like TSS are conservative, could be as significant as discharges of the same residuals from point sources in that they accumulate in receiving waters and might well be available to stimulate algae growth. But the lack of knowledge of both short- and long-run effects, makes it impossible to determine which sources of residuals are most important in terms of impacts on ambient water quality.

EVALUATING THE REGIONAL IMPLICATIONS OF APPLYING BPT/ST AND BAT/BPWTT TECHNOLOGIES: ASA AGGREGATION

Aside from the effects on activity categories, particularly industries, the spatial distribution of both the costs of, and changes in residuals discharges resulting from applying BPT/ST and BAT/BPWTT technologies, is of prime importance. Showing regional variation of costs and changes in residuals discharges illustrates that application of uniform technology does not necessarily result in uniformly improved water quality, and that the same improvement in water quality can be achieved with substantially different capital costs. In addition, only by disaggregating to regions can the importance of areal (nonpoint) activities as sources of residuals be assessed in relation to that of point sources.

NRDI permits several levels of geographic aggregation (county, ASA, WRR, and so on). One level of aggregation--the ASA--is presented in this chapter. The county is the lowest level of aggregation and the highest level of geographic specificity NRDI can produce, but is obviously too disaggregated to be operational for national policy analysis. The WRR, on the other hand, while revealing major geographic differences, lacks sufficient regional specificity to illustrate the interregional effects of national policies. (Appendix B contains three tabular summaries of WRR aggregation.) For example, the Middle Atlantic WRR contains the Upper Hudson, Lower Hudson, Delaware, Susquehanna, Upper Chesapeake, Lower Chesapeake, and Potomac basins. All of these areas are likely to experience very different changes in residuals discharges, RDR costs, and water quality after applying BPT/ST and BAT/BPWTT technologies. Summarizing data from these basins into a single WRR masks important interregional differences which need to be considered in national policy formulation. ASAs, like WRRs, also suffer from a lack of regional specificity, but to a considerably lesser degree. Summarizing ASA data by the use of histograms, and mapping the data to indicate the geographic distribution of residuals discharges and costs, is believed to be specific enough for national policy analysis.

Residuals Discharge from Point Sources by ASA

The relative contributions of municipal and industrial activities to the total BOD discharges from point sources in 1973 varied considerably among ASAs. Municipal activities in 63 ASAs are estimated to have accounted for 50 percent or more of the total point source BOD discharged within each of the ASAs, as shown in Figure 8-2. In two ASAs, municipal activities are estimated to have accounted for 50 percent or more of the total point source TSS discharge, as shown in Figure 8-3. Industrial activities in 36 ASAs accounted for 50 percent or more of the total point source BOD discharges, and in 97 ASAs accounted for 50 percent or more of the total point source TSS discharges.

After application of BPT/ST, it is estimated that the relative contributions of residuals discharges by municipal and industrial activities will not change significantly from

FIGURE 8-2

Histograms of Percent of Annual BOD Discharge per ASA, Activities, Attributed to Municipal Activities

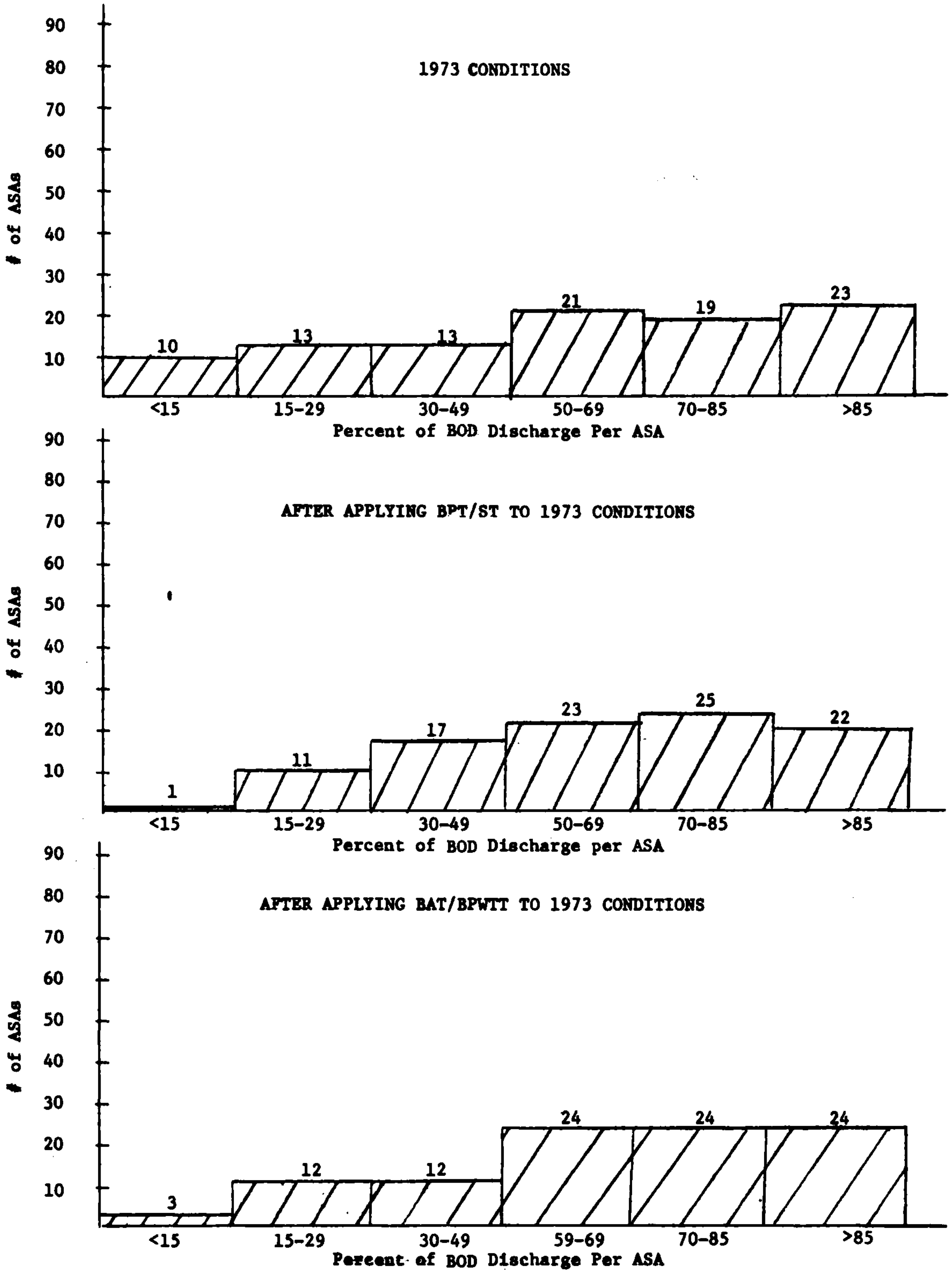
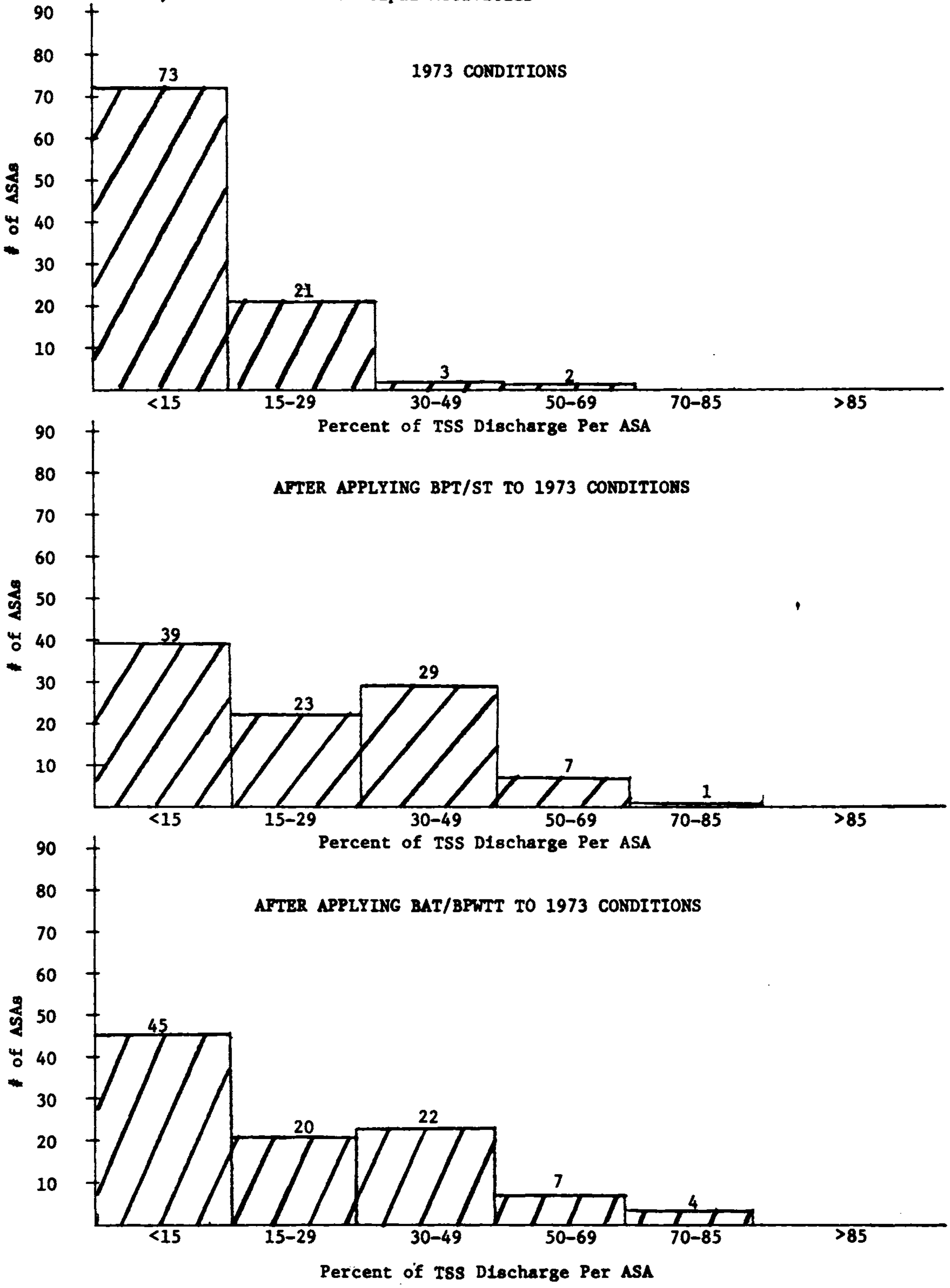


FIGURE 8-3

Histograms of Percent of Annual TSS Discharge per ASA, from Municipal and Industrial Activities, Attributed to Municipal Activities



1973 conditions. Municipal activities in 70 ASAs instead of 63 ASAs would account for 50 percent or more of total point source BOD discharged in each of those ASAs, and in 8 ASAs would account for 50 percent or more of the total point source TSS (Figures 8-2 and 8-3). Conversely, industrial activities in 29 instead of 36 ASAs would account for 50 percent or more of the total point source BOD discharge, and in 91 ASAs would account for 50 percent or more of the total TSS point source discharge.

After application of BAT/BPWTT, the relative contributions of residuals discharges by municipal and industrial activities are estimated to change even less than they would change between 1973 and BPT/ST conditions. Municipal activities are estimated to be slightly more dominant, accounting for 50 percent or more of the total point source BOD discharges in 72 ASAs, and would account for 50 percent or more of the total point source TSS in 11 ASAs (Figures 8-2 and 8-3). Conversely, industrial activities would be slightly less important, accounting for 50 percent or more of the total point source BOD in 27 ASAs, and remaining the dominant point source of TSS, accounting for 50 percent or more of the TSS in 88 ASAs.

A geographical illustration of the relative contributions of BOD discharge from municipal and industrial activities for 1973 conditions and after applying BPT/ST and BAT/BPWTT is shown in Figure 8-4. The map illustrates those particular ASAs where municipal activities are larger dischargers of BOD than industrial activities in 1973 and after applying BPT/ST and BAT/BPWTT. A similar map is not presented for comparing TSS discharges because, in most ASAs, TSS discharges from industrial activities are greater than those from municipal activities.

Capital Costs for Reducing Residuals Discharges from Point Sources

The replacement values of RDR facilities in industrial and municipal activities vary considerably in magnitude among ASAs, but municipal activities accounted for more of the replacement value in most ASAs. Municipal activities in 90 ASAs (and industrial activities in the remaining 9 ASAs), accounted for 50 percent or more of the total replacement value of point source RDR facilities, as shown in Table 8-4.

FIGURE 8-4

ASAs In Which Municipal Annual BOD Discharge in 1973 and after Applying BPT/ST and BAT/BPWTT Is 50% or More of Total Point Source Annual BOD Discharge

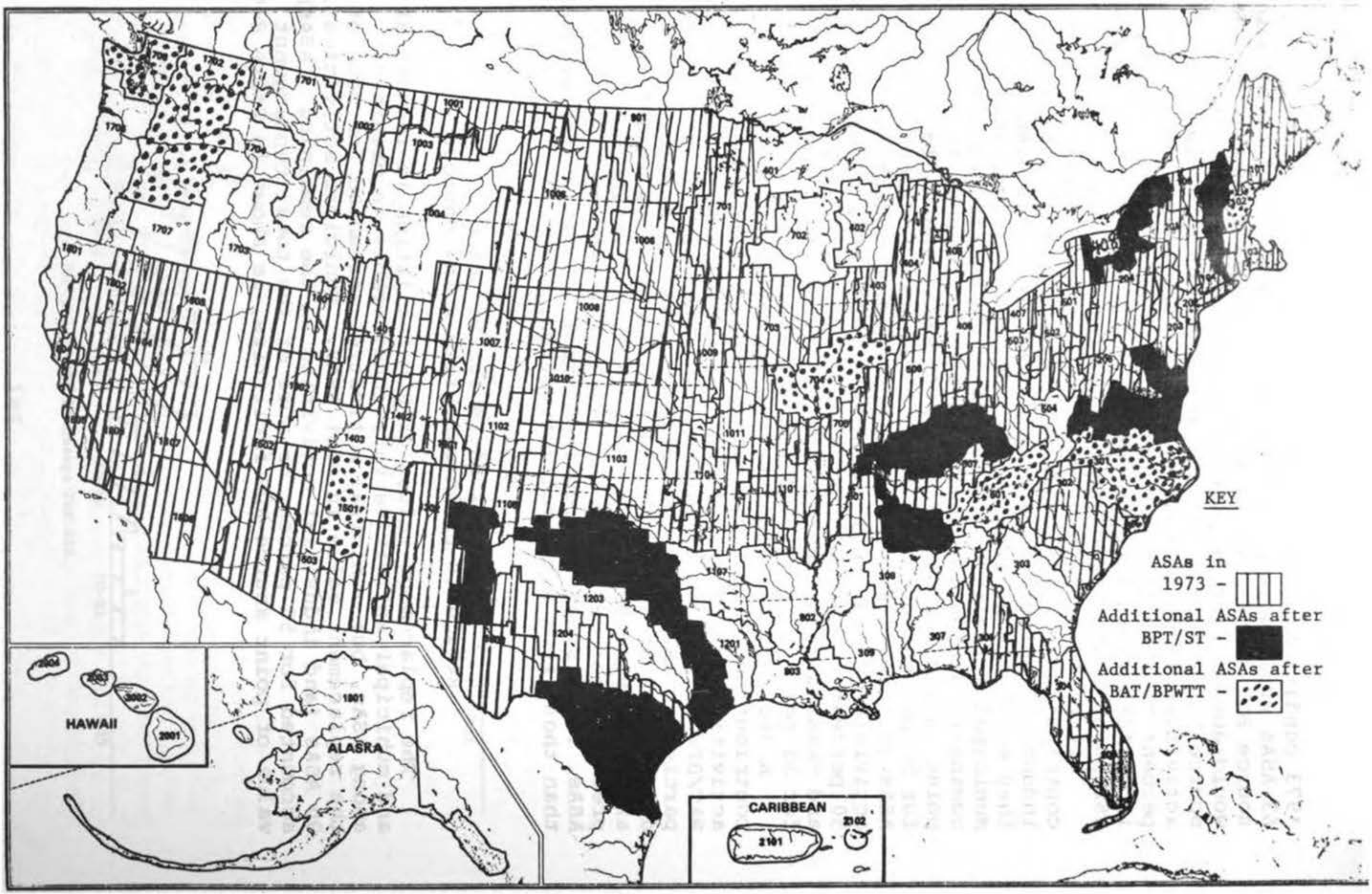


TABLE 8-4

Numbers of ASAs in which either Industrial or Municipal Activities Accounted for 50 Percent or More of 1973 Replacement Value, BPT/ST and BAT/BPWTT RDR Costs

	1973	BPT/ST	BAT/BPWTT
Municipal	90	60	58
Industrial	9	39	41
Total	99	99	99

The estimated capital costs of reducing residuals discharges by applying BPT/ST technology vary considerably among the 99 ASAs. In 60 ASAs municipal costs to achieve ST are greater than industrial costs to meet BPT. The estimated capital costs of reducing residuals discharges for applying BAT/BPWTT technology also show considerable variation among the 99 ASAs. In 58 ASAs municipal costs to apply BPWTT would be greater than industrial costs to apply BAT.

Regional Significance of Uncontrolled Residuals Discharges

This section examines urban runoff and non-irrigated agriculture as sources of BOD and TSS residuals discharge, and the distribution of P and N residuals by ASAs.

In 1973, it is estimated that urban runoff and non-irrigated agriculture were larger sources of BOD and TSS discharges than point sources in only 2 ASAs and 36 ASAs, respectively, as shown in Figures 8-5 and 8-6. Urban runoff is estimated to have been a larger source of BOD discharge than municipal activities in 17 ASAs. Urban runoff and non-irrigated agriculture are estimated to have been larger sources of TSS discharge than point sources in 31 ASAs and 82 ASAs, respectively.

After applying BPT/ST, point sources would account for more BOD and TSS discharges than either urban runoff or non-irrigated agriculture in considerably fewer ASAs than for 1973 conditions. Urban runoff and non-irrigated agriculture are estimated to be larger sources of BOD discharge than point sources in 35 ASAs and 54 ASAS, respectively, as shown in Figures 8-5 and 8-6. Urban runoff is estimated to be a larger source of BOD discharge than municipal activities in 20 ASAs in comparison with 17 ASAs for 1973 conditions. Urban runoff and non-irrigated agriculture are estimated to be larger sources of TSS discharge than point sources in 43 ASAs and 91 ASAs respectively, compared to 31 ASAs and 82 ASAs for 1973 conditions.

FIGURE 8-5

Histograms of Percent of Annual BOD Discharge per ASA, from Urban and Point Sources Attributed to Urban Runoff

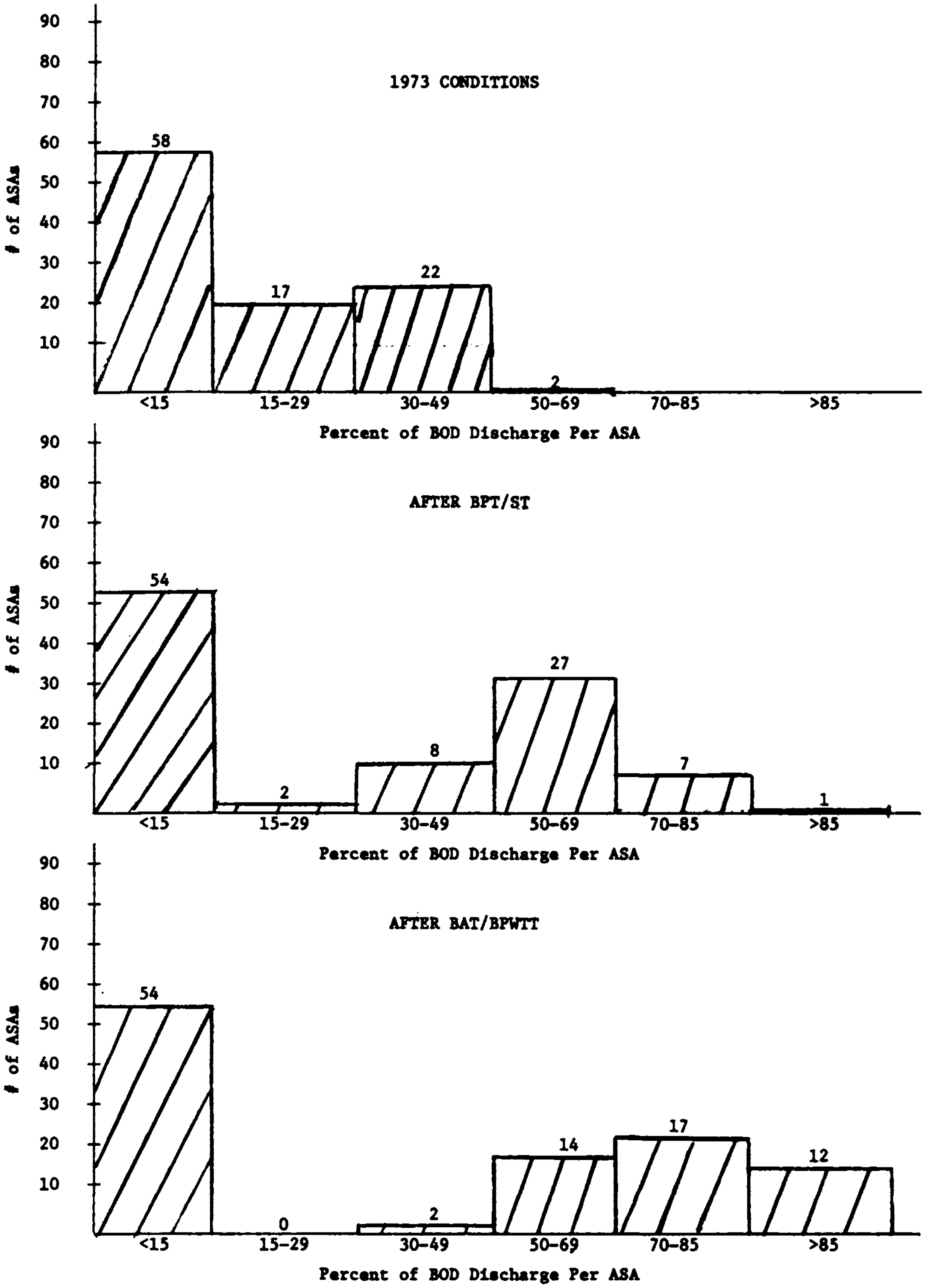
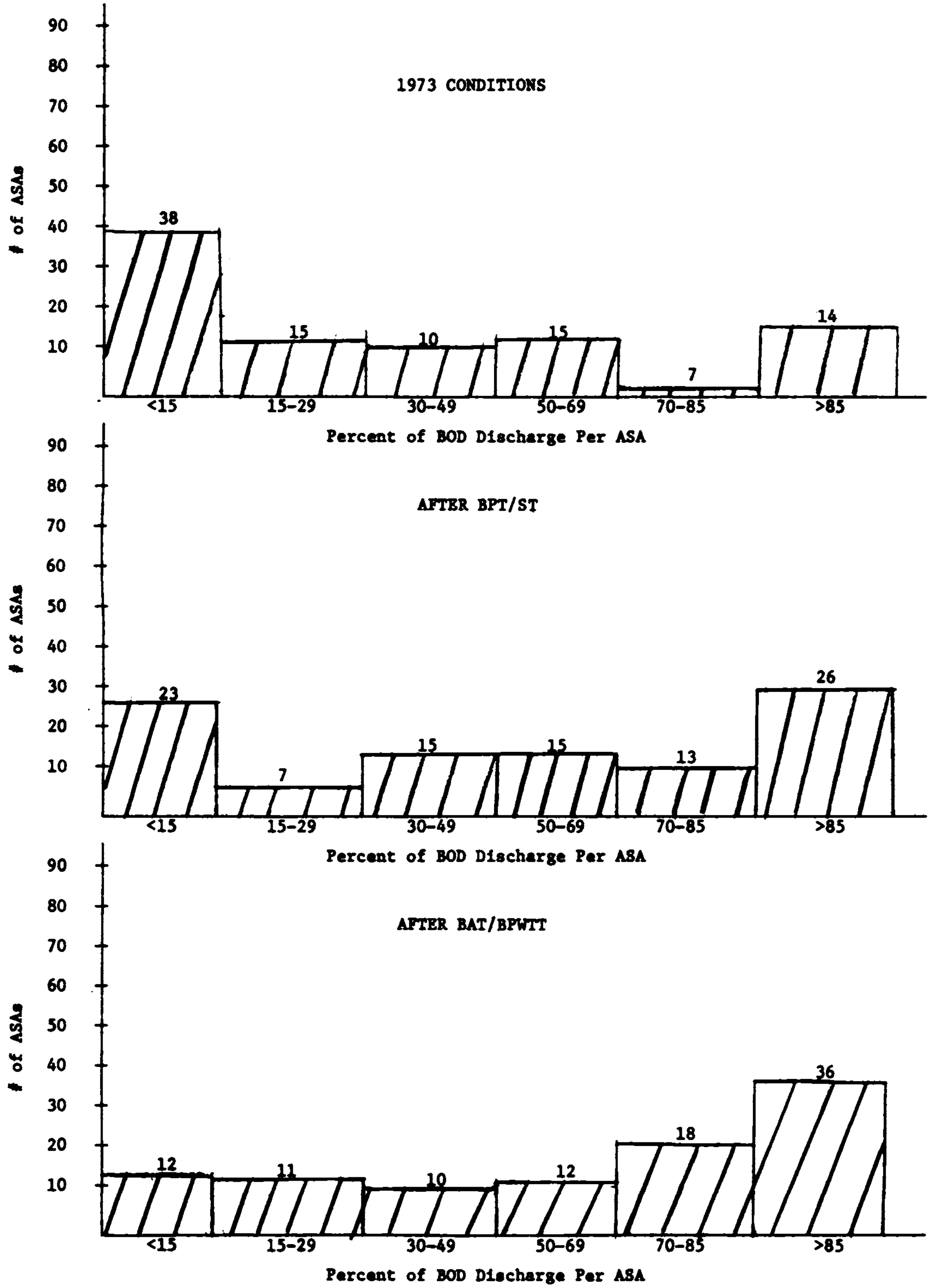


FIGURE 8-6

Histograms of Percent of Annual BOD Discharge per ASA, from Non-Irrigated Agriculture and Point Sources, Attributed to Non-Irrigated Agriculture



After applying BAT/BPWTT, point sources would account for more BOD and TSS discharge than either urban runoff or non-irrigated agriculture in even fewer ASAS than after applying BPT/ST. Urban runoff and non-irrigated agriculture are estimated to be larger sources of BOD discharge than point sources in 43 ASAs and 66 ASAs, respectively, compared to 35 ASAs and 54 ASAs, after applying BPT/ST. Urban runoff is estimated to be a larger source of BOD discharge than municipal activities in 34, in comparison with 20 ASAs after applying BPT/ST. Urban runoff and non-irrigated agriculture are estimated to be larger sources of TSS discharge than point sources in 44 ASAS and 92 ASAs, respectively, compared to 43 ASAs and 91 ASAs after applying BPT/ST.

Geographic illustrations of the relative contributions of BOD discharges from urban runoff and point sources and from non-irrigated agriculture and point sources are shown in Figures 8-7 and 8-8, respectively. The maps illustrate the particular ASAs where urban runoff and non-irrigated agriculture are larger sources of BOD discharge than point sources in 1973 and after applying BPT/ST and BAT/BPWTT.

P and N Discharges from Municipal and Non-irrigated Agriculture Activities

In 1973 the proportions of P and N residuals discharges attributable to municipal activities and to non-irrigated agriculture varied from area to area. From these two sources, non-irrigated agriculture was estimated to account for 50 percent or more of the discharges of P in 42 ASAs as shown in Figure 8-9. Municipal activities were larger sources of P discharges in 57 ASAs, concentrated primarily in the East and far West. Non-irrigated agriculture accounted for 50 percent or more of the discharges of N in 75 ASAs, as shown in Figure 8-10. Municipal activities were larger sources of N discharges in 24 ASAs, primarily concentrated on the East Coast.

The application of BPT/ST technology would not appreciably change the 1973 pattern of relative contributions of P and N discharges. Non-irrigated agriculture is estimated to account for 50 percent or more of P discharges in 47 rather than 42 ASAs (Figure 8-9). Municipal activities are estimated to be larger sources of P discharges in 52 rather than 57 ASAs. Non-irrigated agriculture is estimated to account for 50 percent or more of N discharges in 80 compared to 75 ASAs for current conditions (Figure 8-10). Municipal activities are estimated to be larger sources of N discharges in 19 rather than 24 ASAs, still primarily concentrated on the East Coast.

The application of BAT/BPWTT technology would appreciably change the geographic pattern of the relative contributions of P discharges, but not of N discharges.

FIGURE 8-7

ASAs In Which Urban Runoff Is Estimated To Be A Larger Source of Annual BOD Discharge Than Point Sources

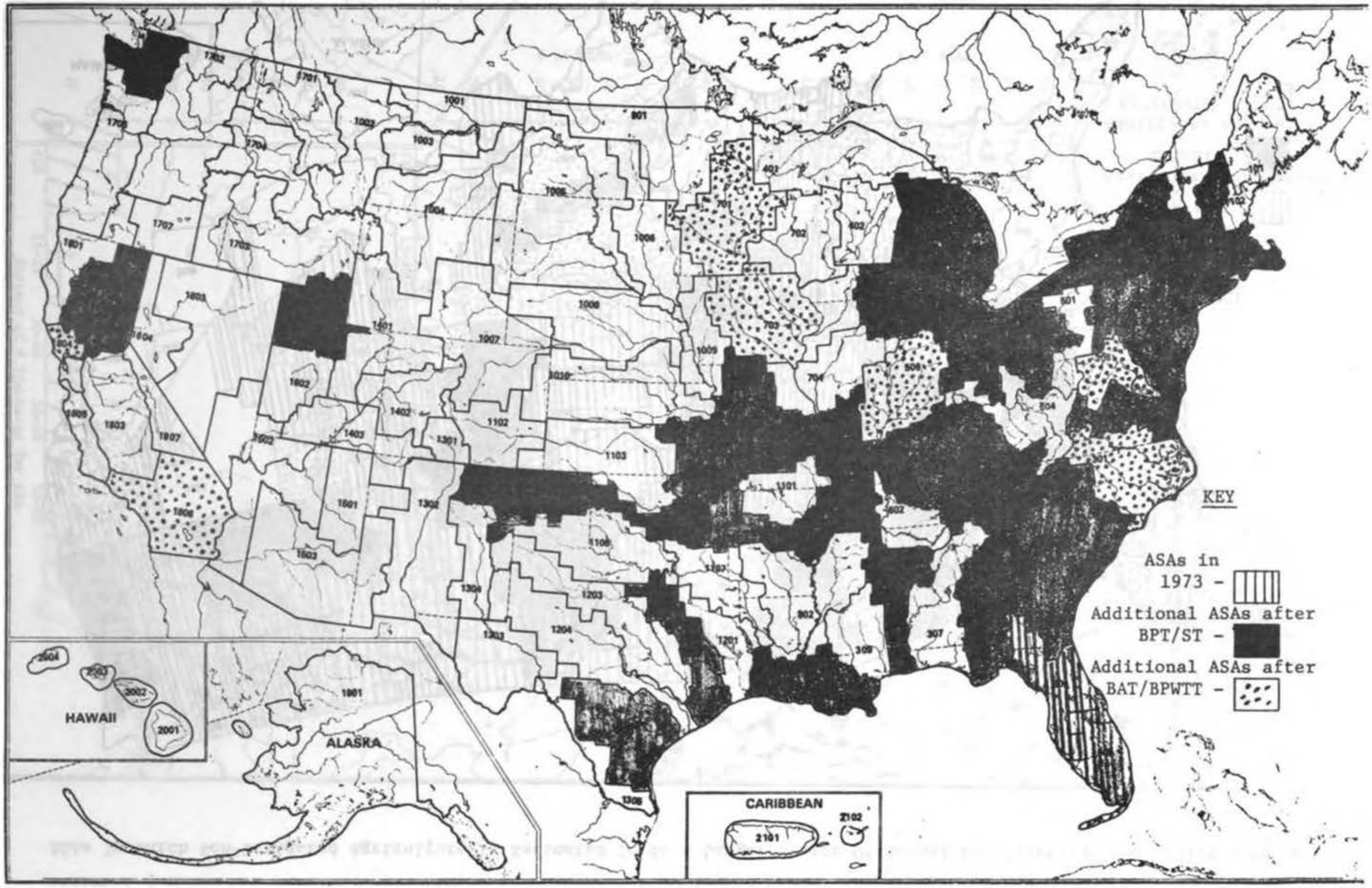


FIGURE 8-8

ASAs In Which Non-Irrigated Agriculture Is Estimated To Be A Larger Source Of Annual BOD Discharge Than Point Sources

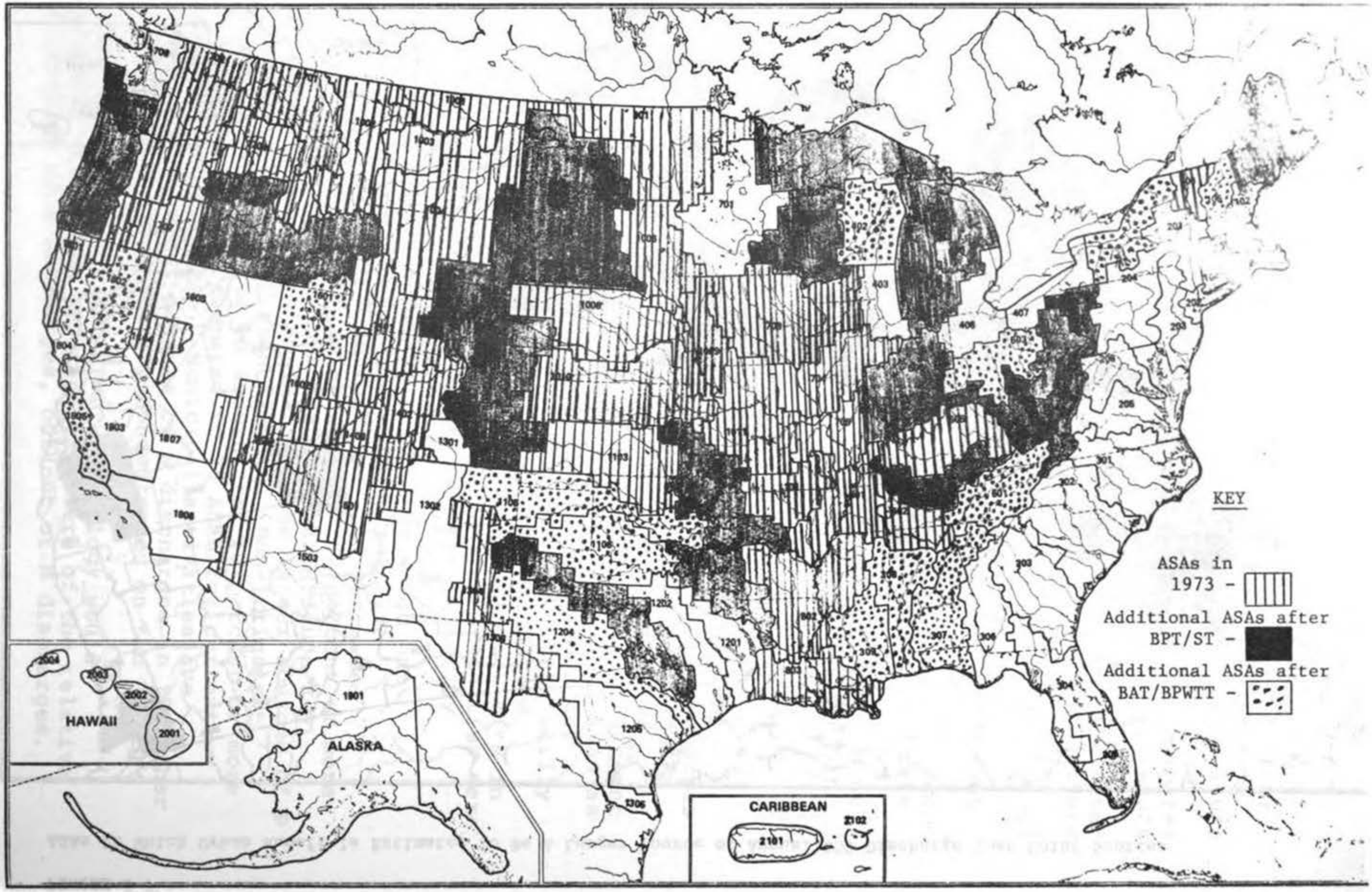


FIGURE 8-9

Histograms of Percent of Annual P Discharge per ASA, from Municipal and Non-Irrigated Agriculture, Attributed to Non-Irrigated Agriculture

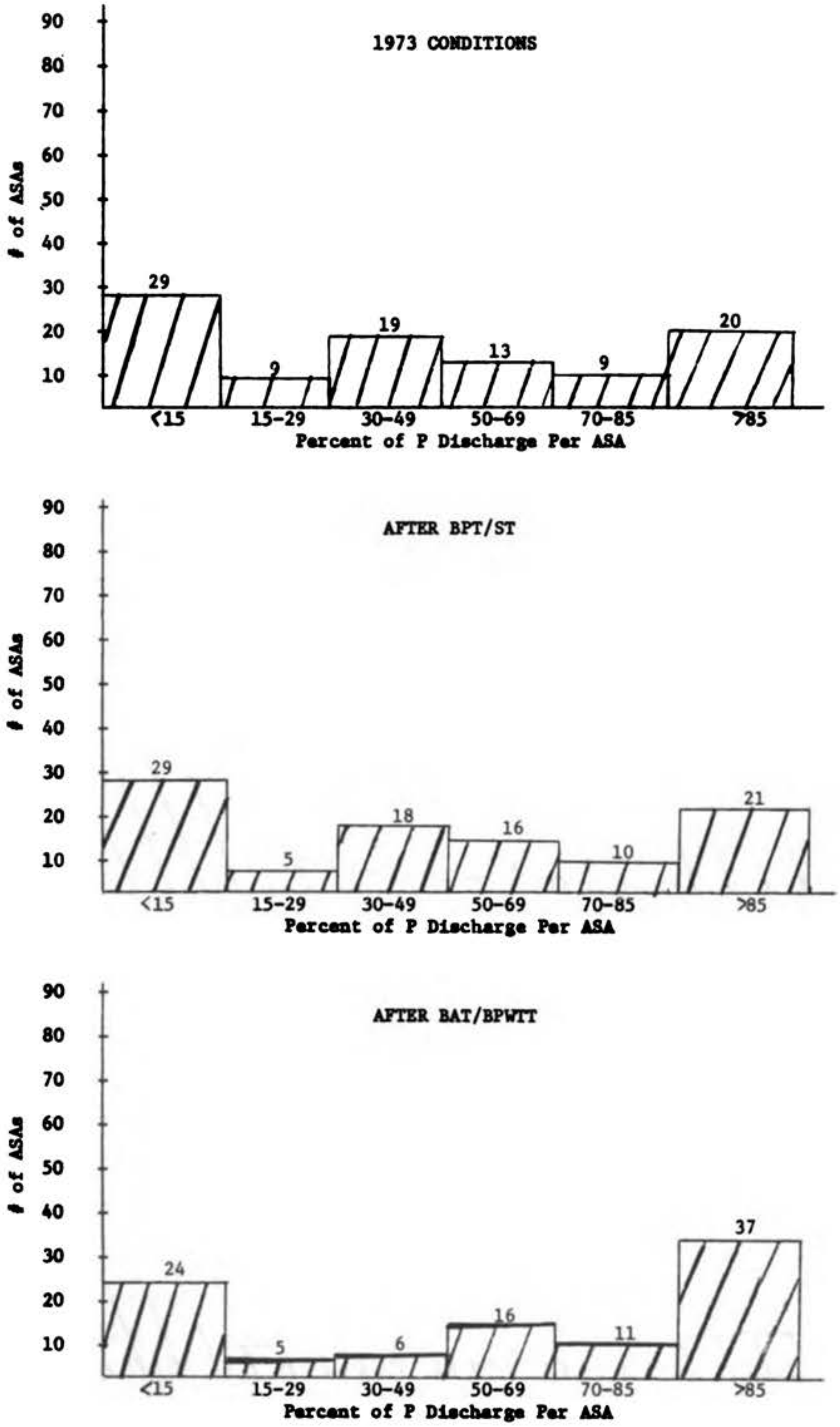
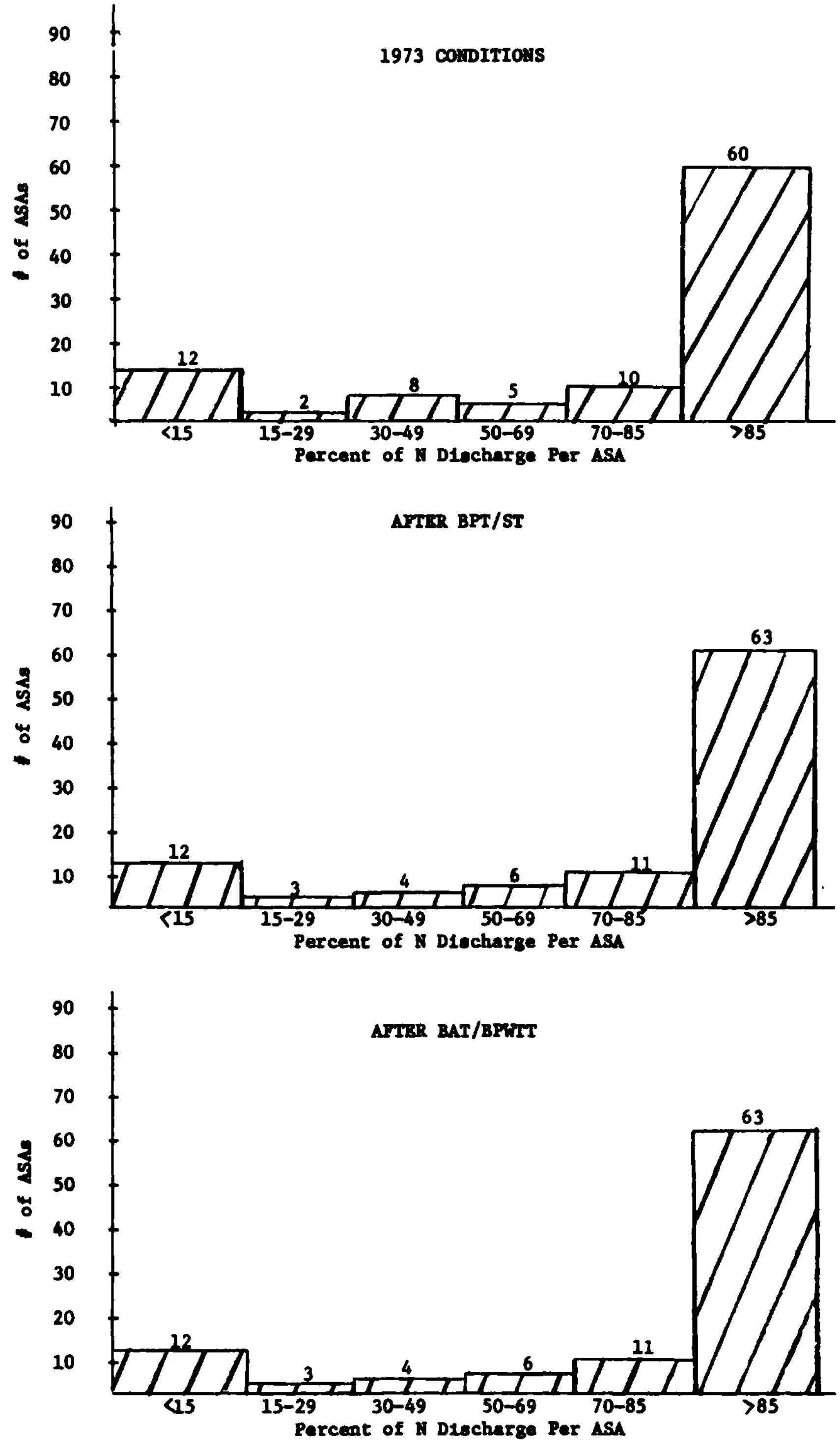


FIGURE 8-10

Histograms of Percent of Annual N Discharge per ASA, from Municipal and Non-Irrigated Agriculture, Attributed to Non-Irrigated Agriculture



Non-irrigated agriculture is estimated to account for 50 percent or more of P discharges in 64 rather than 47 ASAs after the application of BPT/ST. Municipal activities are estimated to be larger sources of P discharges in only 35 ASAs rather than in 52 ASAs after the application of BPT/ST. The geographic pattern of the relative contributions of N discharges is estimated not to change after the application of BPT/ST, as shown in Figure 8-10.

Potential Water Quality Impacts: Relative Changes in BOD Concentrations by WRR and ASA after Applying BPT/ST and BAT/BPWTT

As described in Chapter 7, a water quality index was developed as a component of NRDI to assess the relative improvements in water quality resulting from the reduction in discharges from point sources. This index estimates the concentration of BOD at the outflow point of each ASA, based on the flow for the low flow month (meaning that only point source discharges are considered), and for average flow conditions (under which both point and nonpoint sources of discharges are considered). Residuals discharges in ocean counties have been excluded, assuming that those discharges are directly to the ocean.

Under 1973 BOD discharge conditions, the water quality index suggests that water quality varied considerably among and within regions as shown in Table 8-5. Only in the Lower Mississippi, Upper Colorado, and Pacific Northwest regions were all ASAs in the least degraded class--0 to 2.9 mg/l--based on BOD concentration. Of the total 99 ASAs, 54 were in the least-degraded class. Most of the regions had at least 50 percent of their ASAs in the two classes, 0 to 2.9 and 3.0 to 5.9, indicating the least degradation of water quality, but there were several ASAs within those regions in which the water quality might be severely degraded by the 1973 level of BOD discharge.

Application of BPT/ST technology to point sources would have a noticeable impact upon water quality in most regions, as measured by the water quality index. In 13 regions, over 70 percent of the ASAs within the region would achieve water quality within the least-degraded class, and a total of 79 of the 99 ASAs would fall into the same class. In 16 regions over 70 percent of the ASAs within each region and a total of 89 of the 99 ASAs would achieve water quality within the top three classes, that is, concentration less than 8.9 mg/l. However, there would still remain several ASAs in which the water quality index remains very high; these are scattered throughout the country.

Application of BAT/BPWTT technology to point sources would have only a limited further impact upon water quality in most regions, as measured by the water quality index. Only in the same 13 regions as under BPT/ST conditions, over

TABLE 8-5

Potential Water Quality Implications By WRR Based Upon ASA BOD Dilution Ranking Index

TECHNOLOGY APPLIED	LOW FLOW CONDITIONS (point source contributions only)					AVERAGE FLOW CONDITIONS (point and nonpoint source contributions)				
	Number of ASA's in Interval					Number of ASA's in Interval				
	BOD Dilution Concentration (Mg/l)					BOD Dilution Concentration (Mg/l)				
	0-2.9	3.0-5.9	6.0-8.9	9.0-11.9	>12	0-2.9	3.0-5.9	6.0-8.9	9.0-11.9	>12
					NEW ENGLAND					
1973	3	1	1	1	0	4	1	0	1	0
BPT/ST	6	0	0	0	0	5	0	1	0	0
BAT/BPWTT	6	0	0	0	0	5	0	1	0	0
					MID ATLANTIC					
1973	1	2	1	1	1	3	3	0	0	0
BPT/ST	5	1	0	0	0	6	0	0	0	0
BAT/BPWTT	6	0	0	0	0	6	0	0	0	0
					SOUTH ATLANTIC					
1973	6	2	1	0	0	8	1	0	0	0
BPT/ST	8	1	0	0	0	9	0	0	0	0
BAT/BPWTT	9	0	0	0	0	9	0	0	0	0
					GREAT LAKES					
1973	4	1	0	1	2	4	2	1	0	1
BPT/ST	6	1	0	0	1	6	1	0	0	1
BAT/BPWTT	7	0	1	0	0	6	1	0	0	1
					OHIO					
1973	2	3	1	0	1	5	1	1	0	0
BPT/ST	6	1	0	0	0	6	1	0	0	0
BAT/BPWTT	7	0	0	0	0	6	1	0	0	0
					TENNESSEE					
1973	1	1	0	0	0	1	1	0	0	0
BPT/ST	2	0	0	0	0	2	0	0	0	0
BAT/BPWTT	2	0	0	0	0	2	0	0	0	0
					UPPER MISSISSIPPI					
1973	4	1	0	0	0	4	1	0	0	0
BPT/ST	5	0	0	0	0	4	1	0	0	0
BAT/BPWTT	5	0	0	0	0	5	0	0	0	0
					LOWER MISSISSIPPI					
1973	3	0	0	0	0	3	0	0	0	0
BPT/ST	3	0	0	0	0	3	0	0	0	0
BAT/BPWTT	3	0	0	0	0	3	0	0	0	0
					SOURIS-RED-RAINY					
1973	0	0	1	0	0	1	0	0	0	0
BPT/ST	1	0	0	0	0	1	0	0	0	0
BAT/BPWTT	1	0	0	0	0	1	0	0	0	0
					MISSOURI					
1973	8	1	0	0	2	5	1	1	2	2
BPT/ST	10	0	0	0	1	5	2	0	2	2
BAT/BPWTT	10	0	0	0	1	5	2	0	2	2
					ARKANSAS-WHITE-RED					
1973	2	3	0	1	1	3	2	1	0	1
BPT/ST	6	0	0	0	1	3	3	0	0	1
BAT/BPWTT	6	0	1	0	0	5	1	0	0	1
					TEXAS GULF					
1973	2	0	0	0	3	1	2	1	0	1
BPT/ST	2	1	2	0	0	2	3	0	0	0
BAT/BPWTT	5	0	0	0	0	4	1	0	0	0
					RIO GRANDE					
1973	3	0	1	0	1	2	1	0	2	0
BPT/ST	3	1	0	0	1	2	1	2	0	0
BAT/BPWTT	3	1	0	0	1	2	2	1	0	0

TABLE 8-5 (Continued)

TECHNOLOGY APPLIED	LOW FLOW CONDITIONS (point source contributions only)					AVERAGE FLOW CONDITIONS (point and nonpoint source contributions)				
	Number of ASA's in Interval					Number of ASA's in Interval				
	BOD Dilution Concentration (Mg/l)					BOD Dilution Concentration (Mg/l)				
	0-2.9	3.0-5.9	6.0-8.9	9.0-11.9	>12	0-2.9	3.0-5.9	6.0-8.9	9.0-11.9	>12
UPPER COLORADO										
1973	3	0	0	0	0	0	0	0	2	1
BPT/ST	3	0	0	0	0	0	0	0	2	1
BAT/BPWTT	3	0	0	0	0	0	0	0	2	1
LOWER COLORADO										
1973	3	0	0	0	0	0	0	0	2	1
BPT/ST	3	0	0	0	0	0	0	0	2	1
BAT/BPWTT	3	0	0	0	0	0	0	0	2	1
GREAT BASIN										
1973	0	1	0	0	3	0	0	0	0	4
BPT/ST	1	0	0	0	3	0	0	0	0	4
BAT/BPWTT	1	0	1	1	1	0	0	0	0	4
PACIFIC NORTHWEST										
1973	7	0	0	0	0	6	0	0	0	1
BPT/ST	7	0	0	0	0	6	0	0	0	1
BAT/BPWTT	7	0	0	0	0	6	0	0	0	1
CALIFORNIA										
1973	2	0	1	0	4	3	2	0	0	2
BPT/ST	3	0	2	0	2	4	1	0	1	1
BAT/BPWTT	3	0	2	0	2	4	1	1	0	1
NATIONAL TOTALS										
1973	54	16	7	4	18	53	18	5	9	14
BPT/ST	80	6	4	0	9	64	13	3	7	12
BAT/BPWTT	87	1	5	1	5	69	9	3	6	12

70 percent of the ASAs within each region would achieve water quality within the least-degraded class and a total of 85 of the 99 ASAs rather than 79 ASAs would fall into the same class. In the same 16 regions as under BPT/ST conditions, over 70 percent of the ASAs within each region and a total of 92 of the 99 ASAs would achieve water quality within the top three classes. A noticeable change is the reduction of the number of ASAs in the classes indicating severe degradation of water quality--9.0 to 11.9 and greater than 12. Examples of this type of change are found in the Great Lakes, Arkansas-White-Red, and Great Basin regions. However, there would remain ASAs in several regions which would still have severe water quality degradation even with the achievement of BAT/BPWTT.

Similar conclusions about 1973, BPT/ST technology, and BAT/BPWTT technology conditions emerge from the water quality index, based on average flow and including the impact of areal sources. The interesting difference is the apparent impact of areal sources of water quality in midwestern and western regions after the application of BPT/ST and BAT/BPWTT technologies. Areal sources, apparently non-irrigated agriculture, would prevent the improvement of water quality in all ASAs in these regions.

In summary, reduction in BOD discharges from point sources would have a noticeable impact upon water quality as measured by the water quality index with the application of BPT/ST technology, and only a minimal impact upon water quality with the application of BAT/BPWTT technology. However, even with the achievement of BAT/BPWTT technology there would remain several ASAs which would have severely degraded water quality during low flow conditions because of point sources. In addition, under average flow conditions, in many ASAs in the midwestern and western regions, discharges from areal sources would preclude improvement in the water quality index even with the application of BAT/BPWTT to point sources.

EFFECTS OF GROWTH

The evaluation of the impacts of application of BPT/ST and BAT/BPWTT technologies has been based on 1973 industrial production and population. However, the actual installation would obviously take place at later dates. In the interim, both population and industrial production would have increased. These increases would obviously affect the estimate of residuals discharges and RDR costs.

In order to assess the effect of growth, a separate NRDI analysis was made, as described in Chapter 6. This analysis was based on the Wharton two-digit SIC projection of industrial production and the Census Series E projection of population. The incremental growth in each industry is assumed to be discharging at the New Source Performance

Standards (NSPS) level, which is approximated by BAT. The growth in industrial production is simply the percentage increase in production over the specified time period. This type of projection assumes that industrial output would be increased by building a mix of new plants comparable to the mix of plants, products, and production processes existing in 1973. This assumption probably overestimates residuals discharges, because residuals generation in new plants is usually less than in older plants. It certainly overestimates costs because it does not allow for increased production at existing facilities, which would enable economies of scale in treating wastewater. The future population is assumed to reflect residuals generation and residuals treatment specified for the municipal facilities estimated to meet or be needed for 1990 conditions. The growth projection for any year after 1973 is produced by simply scaling down the 1990 estimate by the difference in flow in the projection year and the year 1990.

Comparisons in Table 8-6 of discharge of BOD after BPT/ST and BAT/BPWTT technologies are applied, based on 1973 production and population and estimated 1977 and 1983 industrial production and population, show only small differences in residuals discharges. Industrial discharges of BOD after application of BPT to 1973 production are estimated to be about 0.9 billion pounds annually (Column B, Table 8-6). After application of BPT to 1973 production and NSPS to 1973-1977 incremental production, industrial discharges of BOD are estimated to be about 0.9 billion pounds annually (Column C, Table 8-6). After application of BPT to 1973 production and NSPS to 1973-1983 incremental production, industrial discharges of BOD are estimated to be about 1.0 billion pounds annually (Column D, Table 8-6).

Application of BAT to 1973 industrial production is estimated to result in BOD discharges of about 0.4 billion pounds annually (Column E, Table 8-6). Application of BAT to 1973 production and NSPS to 1973-1983 incremental production is estimated to result in BOD discharges of about 0.55 billion pounds annually (Column F, Table 8-6).

Municipal discharges of BOD after application of ST to 1973 conditions are estimated to be about 1.8 billion pounds (Column B, Table 8-6); after application of ST to 1977 conditions, about 2.0 billion pounds annually (Column C, Table 8-6); after application of ST to 1983 conditions, about 2.0 billion pounds annually (Column D, Table 8-6). Application of BPWTT to 1973 conditions is estimated to result in BOD discharges from municipalities of about 0.9 billion pounds annually (Column E, Table 8-6); to 1983 conditions, about 1.4 billion pounds annually (Column F, Table 8-6). The absolute increase in BOD discharge from municipalities from 1973 to 1983 conditions reflects the assumption that the level of treatment is the same.

Table 8-7 shows capital costs for reducing BOD discharges for 1973 and estimated 1977 and 1983 conditions.

TABLE 8-6

BOD Residuals Discharge From Point Sources Based on 1973 Estimated, 1977, and 1983 Conditions of Industrial Production and Population (Millions of Pounds of BOD Discharge per Year)

	Point Source Categories	DISCHARGE CONDITIONS					
		A 1973	B 1973 BPT/ST Applied	C 1973 BPT/ST Applied 1973-1977 NSPS/ST Applied	D 1973 BPT/ST Applied 1973-1983 NSPS/ST Applied	E 1973 BAT/BPWTT Applied	F 1973 BAT/BPWTT Applied 1973-1983 NSPS/BPWTT Applied
Special Industry	Pulp and Paper	1,733	351	370	410	175	234
	Organic Chemicals	1,233	173	176	186	36	50
	Petroleum Refining	114	11	11	12	4	6
	Iron and Steel	39	6	6	7	1	2
	Inorganic Chemicals	5	4	4	5	3	4
	Plastics and Synthetics	203	30	31	32	6	8
	Textiles	120	26	26	28	8	10
General Indus.	Mining	11	6	6	6	6	6
	Other Industry	1,886	300	315	359	168	227
	Industry Subtotal (rounded)	4,300	900	950	1,000	400	550
	Municipal Subtotal (rounded)	5,800	1,800	2,000	2,000	900	1,400
	Point Source Total (rounded)	10,000	2,700	3,000	3,500	1,300	2,000

Application of BPT/ST technology to 1973 conditions is estimated to cost about $10.1 billion for industry and about $28.4 billion for municipalities (Column B, Table 8-7). Application of BPT technology to 1973 industrial production, NSPS technology to 1973-1977 incremental industrial production, and ST technology to 1977 population is estimated to cost about $11.1 billion for industry and $30.7 billion for municipalities (Column C, Table 8-7). Application of BPT technology to 1973 industrial production, NSPS technology to 1973-1983 incremental industrial production, and ST technology to 1983 population is estimated to cost about $19.2 billion for industry and $38.1 billion for municipalities (Column D, Table 8-7). Application of BAT to 1973 industrial production and BPWTT technology to 1973 population is estimated to cost about $7.0 billion for industry and $10.3 billion for municipalities (Column E, Table 8-7). Application of BAT to 1973 industrial production, NSPS to 1973-1983 incremental industrial production, and BPWTT to 1983 population is estimated to cost $14.5 billion for industry and $14.3 billion for municipalities (Column F, Table 8-7).

In summary, even with growth, through application of NSPS/ST to new sources discharges of BOD increase relatively little for 1977 conditions, and somewhat more by 1985. This indicates that the level of discharge obtained by applying BPT/ST to 1973 conditions can be maintained at about the same level and for significantly less cost without applying more stringent requirements to existing point sources. Similarly, it can be inferred that improvements in water quality obtained by applying BPT/ST to 1973 conditions can also be maintained without applying more stringent requirements to existing point sources.

Estimated BOD discharge after the application of ST to 1973 population is only 12 percent less than the estimated BOD discharge after applying ST to 1977 population, and 36 percent less than after applying ST to 1983 population. Estimated residuals discharge reduction costs for applying ST to 1973 population are 7 percent less than estimated costs for applying ST to 1977 population, and 28 percent less than for applying ST to 1983 population. Estimated BOD discharge after the application of BPT to 1973 industrial production is only 4 percent less than the estimated BOD discharge after applying BPT to 1973 industrial production and NSPS to 1973-1977 incremental industrial production, and 25 percent less than after applying BPT to 1973 production and NSPS to incremental 1973-1983 production. Estimated RDR costs for applying BPT to 1973 industrial costs are 11 percent less than estimated costs for applying BPT to 1973 industrial production and NSPS to 1973-1977 incremental production, and 50 percent less than estimated costs for applying BPT to 1973 industrial production and NSPS to 1973-1983 production.

TABLE 8-7

Capital Costs for Reduction in BOD Discharges from Point Sources Based on 1973 Estimated, 1977, and 1983 Conditions of Industrial Production and Population (10^9 1975$)

	Point Source Categories	DISCHARGE CONDITIONS					
		A 1973	B 1973 BPT/ST Applied	C 1973 BPT/ST Applied 1973-1983 NSPS/ST Applied	D 1973 BPT/ST Applied 1973-1983 NSPS/ST Applied	E 1973 BAT/BPWTT Applied	F 1973 BAT/BPWTT Applied 1973-1983 NSPS/BPWTT Applied
Special Industry	Pulp and Paper	1.9	1.8	2.1	3.1	.6	1.6
	Organic Chemicals	.3	1.3	1.6	2.4	1.3	2.1
	Petroleum Refining	.3	.7	.7	1.3	1.3	1.8
	Iron and Steel	.8	1.9	1.8	4.8	1.3	4.2
	Inorganic Chemicals	.3	.6	.6	.9	.2	.4
	Plastics and Synthetics	.4	.3	.3	.6	.2	.4
	Textiles	.2	.5	.5	1.0	.3	.7
General Indus.	Mining	.0	.3	.3	.3	.0	.0
	Other Industry	1.9	2.7	3.2	4.8	1.8	3.3
	Industry Subtotal	6.1	10.1	11.1	19.2	7.0	14.5
	Municipal Subtotal	32.5	28.4	30.7	38.1	10.3	14.3
	Point Source Total	38.6	38.5	41.8	57.3	17.3	28.3

CHAPTER 9

ANALYZING POLICIES ALTERNATIVE TO THE POLICY OF UNIFORM APPLICATION OF BAT/BPWTT TECHNOLOGY

INTRODUCTION

Chapter 8 illustrated the changes in residuals discharges, relative water quality, and RDR costs associated with the application of BPT/ST and BAT/BPWTT. It was shown that application of BPT/ST technology to all point sources could achieve significant reduction in discharges of residuals and improvement in one measure of water quality, while application of the more stringent BAT/BPWTT technology was estimated to result in relatively small additional reductions in residuals discharges and improvement in water quality. Although the additional capital investment was on the order of about half that to move from 1973 to BPT/ST, the quantities of residuals removed from point sources were substantially smaller. In light of these findings, the following threee policies alternatives to the policy of uniform application of BAT/BPWTT technology have been examined:

> Alternative Policy 1. Require that BAT/BPWTT technology be applied only in those ASAs that have relatively severe water quality problems;
> Alternative Policy 2. Consider all sources of residuals, point and nonpoint, in an ASA and select a cost-effective (i.e., minimum cost) strategy for achieving the same levels of reduction in discharges of residuals that would be achieved by the uniform application of BPT/ST and BAT/BPWTT; and
> Alternative Policy 3. Do not require point source discharges to apply BAT/BPWTT technology in all counties with a potential for ocean discharge, i.e., limit the requirements for such dischargers to application of BPT.

These alternative policies were analyzed on the basis of ASAs for RDR costs, residuals discharge, and relative water quality as measured only by BOD. The results should not be taken to reflect unique situations, that is, individual river segments. However, the results indicate the potential efficiency of non-uniform discharge reduction policies as contrasted with uniform policies.

ALTERNATIVE POLICY 1: LIMITING APPLICATION OF BAT/BPWTT TO AREAS WITH RELATIVELY POOR WATER QUALITY

ASAs with similar residuals discharges but different surface water flows will experience different resultant water qualities with the application of the same RDR technologies. Alternative Policy 1 attempts to take into account the availability of surface water to dilute the residuals discharged. This policy recognizes that water quality objectives can be achieved by various combinations of discharge reduction and dilution. The policy limits the application of BAT/BPWTT technology in ASAs, which, during low flow conditions, have a BOD dilution index equal to or greater than 3.0 mg/l (those ASAs which are not ranked in the highest water quality category as described in Chapter 7); only BPT/ST technology is applied in all other ASAs. Low flow conditions are used, because the dilution index under low flow is more sensitive to changes in point source discharges than it is under average flow conditions when large loadings from nonpoint sources tend to wash out the effects on water quality of changes in point source loadings.

Table 9-1 displays the reductions in residuals discharges and associated RDR capital costs to achieve those reductions for Alternative Policy 1. The first column indicates the policies analyzed, starting with the base condition of existing RDR technology in place as of 1973. The second and third columns indicate, respectively, the resulting BOD discharge in the water resource region and the percentage reduction in BOD discharge in relation to existing (1973) conditions, based on the sum of the results for each ASA. The fourth column shows the incremental capital costs (over and above replacement costs of present facilities) to apply BPT/ST uniformly, BAT/BPWTT uniformly, and for Alternative Policy 1. The fifth column shows these capital costs as a percentage of the incremental capital costs of applying BAT/BPWTT uniformity. The sixth column indicates the number of ASAs for which water quality as measured by the BOD index is in the highest water quality category after application of each policy. Thus, for the South Atlantic Region, six of nine ASAs in the region are in the highest category under existing RDR technology eight of nine after application of BPT/ST to all point sources; nine of nine after application of BAT to all point sources; and nine of nine after application of BAT only in those ASAs not in the highest category and BPT in the remainder. The last column shows that it was necessary to apply BAT/BPWTT in only one of the nine ASAs to achieve the highest water quality category, instead of in all nine as would be done under the uniform BAT/BPWTT policy.

On a national basis, the table shows that if uniform water quality is the objective, it can be obtained for significantly less cost--25 to 30 percent of uniform

TABLE 9-1

Reduction in Residuals Discharges and Capital Costs of Discharge Reduction by WRR with Alternative Policy 1 -- Limiting Application of BAT/BPWTT Technology to ASAs with Relatively Poor Water Quality (Based upon 1973 Low Flow Conditions+)

	BOD		Incremental Capital Cost			
Policy	Discharge 10^6 lbs/yr	% Reduction from Existing	Cost 10^6 1975$	% of Uniform BAT/BPWTT	Number of ASAs Ranked in Highest W. Q. Category After Technology Application	Number of ASAs Policy Applied to
NEW ENGLAND (I) - (6 ASAs)						
Existing Technology	495	-		-	3	6
Uniform BPT/ST	94	81	1,792	-	6	6
Uniform BAT/BPWTT	67	86	415	100	6	6
		(All ASAs ranked in highest category after BPT/ST)				
Alternative 1	94	81	0	0	6	0
			From Uniform BPT/ST			
MID-ATLANTIC (II) - (6 ASAs)						
Existing Technology	1,825	-		-	1	6
Uniform BPT/ST	440	76	6,768	-	5	6
Uniform BAT/BPWTT	250	86	1,979	100	6	6
Alternative 1	414	77	258	13	6	1
			From Uniform BPT/ST			
SOUTH ATLANTIC (III) - (9 ASAs)						
Existing Technology	1,253	-		-	6	9
Uniform BPT/ST	342	72	4,462	-	8	9
Uniform BAT/BPWTT	172	86	1,694	100	9	9
Alternative 1	336	73	72	4	9	1
			From Uniform BPT/ST			
GREAT LAKES (IV) - (8 ASAs)						
Existing Technology	1,036	-		-	4	8
Uniform BPT/ST	370	64	5,398	-	6	8
Uniform BAT/BPWTT	125	87	2,315	100	7	8
Alternative 1	201	81	1,049	45	7	2
			From Uniform BPT/ST			
OHIO (V) - (7 ASAs)						
Existing Technology	755	-		-	2	7
Uniform BPT/ST	206	73	4,925	-	6	7
Uniform BAT/BPWTT	88	88	2,778	100	7	7
Alternative 1	169	78	445	16	7	1
			From Uniform BPT/ST			
TENNESSEE (VI) - (2 ASAs)						
Existing Technology	248	-		-	1	2
Uniform BPT/ST	49	80	607	-	2	2
Uniform BAT/BPWTT	24	90	230	100	2	2
		(All ASAs ranked in highest category after BPT/ST)				
Alternative 1	49	80	0	0	2	0
			From Uniform BPT/ST			
GREAT BASIN (VII) - (4 ASAs)						
Existing Technology	27	-		-	0	4
Uniform BPT/ST	12	56	297	-	1	4
Uniform BAT/BPWTT	4	85	186	100	1	4
Alternative 1	5	81	156	84	1	3
			From Uniform BPT/ST			

TABLE 9-1 (Continued)

Policy	BOD Discharge 10^6 lbs/yr	BOD % Reduction from Existing	Incremental Capital Cost: Cost 10^6 1975$	Incremental Capital Cost: % of Uniform BAT/BPWTT	Number of ASAs Ranked in Highest W. Q. Category After Technology Application	Number of ASAs Policy Applied to
UPPER MISSISSIPPI (VIII) - (5 ASAs)						
Existing Technology	571	-		-	4	5
Uniform BPT/ST	177	70	2,926	-	5	5
Uniform BAT/BPWTT	97	83	754	100	5	5
		(All ASAs ranked in highest category after BPT/ST)				
Alternative 1	177	70	0 From Uniform BPT/ST	0	5	0
LOWER MISSISSIPPI (IX) - (3 ASAs)						
Existing Technology	394	-		-	3	3
Uniform BPT/ST	110	72	1,348	-	3	3
Uniform BAT/BPWTT	58	85	857	100	3	3
		(All ASAs ranked in highest category after BPT/ST)				
Alternative 1	110	72	0 From Uniform BPT/ST	0	3	0
SOURIS-RED-RAINY (X) - (1 ASA)						
Existing Technology	24	-		-	0	1
Uniform BPT/ST	5	80	83	-	1	1
Uniform BAT/BPWTT	4	88	9	100	1	1
		(All ASAs ranked in highest category after BPT/ST)				
Alternative 1	5	80	0 From Uniform BPT/ST	0	1	0
MISSOURI (XI) - (11 ASAs)						
Existing Technology	285	-		-	8	11
Uniform BPT/ST	110	61	1,935	-	10	11
Uniform BAT/BPWTT	94	67	248	100	10	11
Alternative 1	108	62	53 From Uniform BPT/ST	21	10	1
ARKANSAS-WHITE-RED (XII) - (7 ASAs)						
Existing Technology	250	-		-	2	7
Uniform BPT/ST	83	67	1,764	-	6	7
Uniform BAT/BPWTT	28	88	1,368	100	6	7
Alternative 1	79	68	47 From Uniform BPT/ST	3	6	1
TEXAS GULF (XIII) - (5 ASAs)						
Existing Technology	784	-		-	2	5
Uniform BPT/ST	191	76	2,701	-	2	5
Uniform BAT/BPWTT	45	94	2,659	100	5	5
Alternative 1	73	91	1,809 From Uniform BPT/ST	68	5	3
RIO GRANDE (XIV) - (5 ASAs)						
Existing Technology	29	-		-	3	5
Uniform BPT/ST	13	55	321	-	3	5
Uniform BAT/BPWTT	5	82	236	100	3	5
Alternative 1	10	65	82 From Uniform BPT/ST	35	3	2

TABLE 9-1 (Continued)

	BOD		Incremental Capital Cost		Number of ASAs Ranked in Highest W. Q. Category After Technology Application	Number of ASAs Policy Applied to
Policy	Discharge 10^6 lbs/yr	% Reduction from Existing	Cost 10^6 1975$	% of Uniform BAT/BPWTT		
UPPER COLORADO (XV) - (3 ASAs)						
Existing Technology	9	-		-	3	3
Uniform BPT/ST	2	78	106	-	3	3
Uniform BAT/BPWTT	1	89	15	100	3	3
(All ASAs ranked in highest category after BPT/ST)						
Alternative 1	2	78	0 From Uniform BPT/ST	0	3	0
LOWER COLORADO (XVI) - (3 ASAs)						
Existing Technology	77	-		-	0	3
Uniform BPT/ST	17	78	306	-	1	3
Uniform BAT/BPWTT	14	82	36	100	2	3
Alternative 1	16	79	20 From Uniform BPT/ST	55	2	2
PACIFIC NORTHWEST (XVII) - (7 ASAs)						
Existing Technology	573	-		-	7	7
Uniform BPT/ST	128	78	982	-	7	7
Uniform BAT/BPWTT	81	86	297	100	7	7
(All ASAs ranked in highest category after BPT/ST)						
Alternative 1	128	78	0 From Uniform BPT/ST	0	7	0
CALIFORNIA (XVIII) - (7 ASAs)						
Existing Technology	1,467	-		-	2	7
Uniform BPT/ST	319	78	2,934	-	3	7
Uniform BAT/BPWTT	165	89	856	100	3	7
Alternative 1	173	88	757 From Uniform BPT/ST	88	3	4
NATIONAL TOTALS - (99 ASAs)						
Existing Technology	10,100	-		-	51	99
Uniform BPT/ST	2,700	73	38,500	-	79	99
Uniform BAT/BPWTT	1,300	87	17,100	100	85	99
Alternative 1	2,100	78	4,700 From Uniform BPT/ST	28	85	21

+Low flow conditions include residuals discharges from point sources only.

application of BAT/BPWTT--by applying BAT/BPWTT to only 21 instead of all 99 ASAs. The results also suggest that in 14 ASAs, application of BAT/BPWTT technology may be inadequate to achieve desired water quality. For example, in the Great Basin, even after BAT/BPWTT, only one out of four ASAs is in the highest water quality category. On the other hand, in the remaining 78 ASAs, BAT/BPWTT may not really be necessary, because they generally may have good water quality after BPT/ST. For example, in the Upper Mississippi Basin, five out of five ASAs are in the highest water quality category after BPT/ST; in New England, six out of six.

The crucial and still unresolved question is: Does less than 3.0 mg/l of BOD represent good water quality even though BOD is only one measure of water quality? The value of 3.0 mg/l was somewhat arbitrarily chosen, to be able to illustrate the effects of policies. In this perspective, the results clearly indicate that regional diversity of available water quantity is an important factor in determining the value of uniform application of BAT/BPWTT technology to achieve desired water quality, and that a selective application of BAT/BPWTT may have the same consequences for water quality as the uniform application, but with significantly lower costs.

ALTERNATIVE POLICY 2: MINIMUM COST STRATEGIES TO ACHIEVE THE SAME REDUCTIONS IN RESIDUALS DISCHARGES AS UNIFORM APPLICATION OF BPT/ST AND BAT/BPWTT

The uniform application of BPT/ST and BAT/BPWTT to point sources will result in finite reductions in quantities of residuals discharged in each ASA. However, there are also nonpoint sources of residuals which have not been considered but for which the same reduction in residuals discharges could be achieved in an area as through the uniform application of BPT/ST and/or BAT/BPWTT, for less cost. It is also quite possible that a non-uniform policy of BPT/ST could also achieve the same discharge reduction as a uniform policy, and at less cost. For example, it may be cheaper to apply BAT in one industry than it would be to apply BPT in another.

Given the diversity of sources of residuals discharges, both point and nonpoint (urban runoff and non-irrigated agriculture), and the corresponding differences in RDR cost functions, it was hypothesized that a system of discharge reductions could be found which would result in the same amount of reduction in an ASA as uniform application of BPT/ST and BAT/BPWTT to point sources, and at a lower cost. This alternative assumes that the detrimental effects of the same residual are similar from all sources, and that the only decision criterion is cost minimization. The detrimental effect of organic material from urban runoff and non-irrigated agriculture may not be comparable to that from point sources, so the results of the analysis should be interpreted carefully.

The minimum cost strategy for an ASA was formulated using a simple method. First, the amount of BOD removed per year with the uniform application of BPT/ST and BAT/BPWTT technologies was computed for each point source category in each ASA. Similarly, the amount of BOD removed from non-irrigated agriculture and urban runoff activities when the level of reduction specified in Chapter 5 is applied, was also calculated. Next, the capital cost of each level of reduction for each source was divided by the amount of BOD removed for 1973 conditions at each RDR level in each category. These dollar-per-pound-of-removal values were then used as measures (indices) of the cost effectiveness of BOD removal for each category in an ASA (despite the fact that some of the costs are attributable to the reduction in discharge of other residuals). Finally, each ASA was manually analyzed as follows. The amounts of BOD removed annually by the uniform application of BPT/ST and BAT/BPWTT in each ASA were considered the target removal values for the ASA. A minimum cost option was created by sequentially selecting categories with the lowest cost-effective index, regardless of whether they were point or nonpoint sources, until first the BPT/ST and then the BAT/BPWTT target removal quantities were reached. Table 9-2, using ASA 506, illustrates the methodology.

Table 9-3 displays the RDR capital cost savings that can be obtained, for the nation, by substituting a minimum cost approach including all residual sources for uniform application of BPT/ST and BAT/BPWTT. It shows that if the water quality, using residuals discharge as a proxy measure, achievable by uniform BPT/ST and BAT/BPWTT is a policy objective, it can be achieved for 30 to 35 prcent less <u>total</u> cost. The results show that the amount of BOD removed throughout the nation after uniform BPT (7.5 billion pounds per day) can be accomplished with about a 60 percent reduction in cost by following a minimum cost approach.

The analysis also showed that some level of reducing BOD discharges from non-irrigated agriculture was less expensive than reducing discharges from point sources in 91 ASAs. Results related to non-irrigated agriculture and urban runoff, however, should be carefully interpreted. These results are in part a function of the method and data used, more so than are results for other activity categories. For urban runoff, the RDR technology applied (RDR level 1) had a relatively low BOD removal efficiency and consequently high unit removal costs. If additional RDR steps had been considered for urban runoff activities, resulting in lower unit removal costs, urban runoff would have proved cost effective in a greater number of ASAs. For non-irrigated agriculture, unit removal costs are extremely small because estimates of BOD generation are large and RDR technologies

TABLE 9-2

Example of Methodology for Computing Minimum Cost Using NRDI Output for ASAs

Example: ASA 506

Incremental Capital Costs (10^9 1975$)

	Uniform Policy	Minimum Cost Policy
BPT/ST	.29	.12
BAT/BPWTT	.20	.13

NRDI Output

Activity Category	BOD Removal (10^6 lbs/yr) Current	BOD Removal (10^6 lbs/yr) BPT/ST	BOD Removal (10^6 lbs/yr) BAT/BPWTT	BOD Removal (10^6 lbs/yr) Areal Sources RDR Level	Unit Capital Costs (1975$/lb) BPT/ST[1]	Unit Capital Costs (1975$/lb) BAT/BPWTT[1]	Unit Capital Costs (1975$/lb) Areal Sources
Pulp and Paper	5.23	3.64	0.49	-	2.30	4.59	-
Organic Chemicals	1.56	2.73	0.35	-	1.77	10.00	-
Petroleum Refining	2.61	0.25	0.09	-	17.20	168.00	-
Inorganic Chemicals	0.0	0.0	0.0	-	0.0	0.0	-
Plastics & Synthetics	0.22	0.38	0.05	-	1.36	8.32	-
Textiles	0.0	0.0	0.0	-	0.0	0.0	-
Mining	0.0	0.07	0.0	-	27.80	0.0	-
Other Industry	19.60	8.76	2.28	-	2.03	7.45	-
Municipal	133.00	24.00	17.70	-	9.38	8.73	-
Urban Runoff	-	-	-	5.78	-	-	60.10
Agricultural	-	-	-	36.00	-	-	3.76
TOTAL	162.0	39.80	21.00	41.80	-	-	-

Quantity Removals (Targets) -- BPT/ST = 39.80[1], BAT/BPWTT = 21.00[1]

Computing Incremental Minimum Capital Cost BPT/ST Estimate

Category Order	Activity Category	RDR Level	Unit Capital Costs 1975$/lb	BOD Removal 10^6 lbs/yr	Total Capital Costs 10^6 1975$
1	Plastics & Synthetics	BPT/ST	1.36	0.38	0.52
2	Organic Chemicals	BPT/ST	1.77	2.73	4.83
3	Other Industry	BPT/ST	2.03	8.76	17.80
4	Pulp and Paper	BPT/ST	2.30	3.64	8.37
5	Agricultural	ASL	3.76	24.30[2] (11.60)	91.40
				39.80	123.00 (rounded)

Computing Incremental Minimum Capital Cost BAT/BPWTT Estimate

Category Order	Activity Category	RDR Level	Unit Capital Costs 1975$/lb	BOD Removal 10^6 lbs/yr	Total Capital Costs 10^6 1975$
1	Agricultural	ASL	3.76	11.60	43.70
2	Pulp and Paper	BAT/BPWTT	4.59	0.49	2.25
3	Other Industry	BAT/BPWTT	7.45	2.28	17.00
4	Plastics & Synthetics	BAT/BPWTT	8.32	0.05	0.42
5	Municipal	BPT/ST	9.38	6.57[3] (17.40)	61.60
				21.00	125.00 (rounded)

1 - Incremental estimates

2 - Only 24.30 of 36.00 million pounds per day of Agricultural BOD removal is needed to meet BPT/ST.

3 - Only 6.57 of 24.00 million pounds per day of Municipal BOD removal is needed to meet BAT/BPWTT.

TABLE 9-3

Residuals Removal and Capital Cost Consequences by WRR of Implementing Minimum Cost Strategies to Achieve the Same Reductions in BOD Discharge as the Uniform Application of BPT/ST and BAT/BPWTT Technologies for ASAs

	BOD		Incremental Capital Cost		
Policy	Incremental Removal 10^6 lbs/yr	% of Additional Removal from Existing	Cost 10^6 1975$	Uniform BPT/ST	Number of ASAs Policy Applied to
NEW ENGLAND (I) - (6 ASAs)					
Existing Technology	235	-		57	6
Uniform BPT/ST	401	271	1,792	100	6
Uniform BAT/BPWTT	27	282	415	23	6
Minimum Cost BPT/ST	401	271	1,458	45	6
Minimum Cost BAT/BPWTT	27	282	302	9	6
MID-ATLANTIC (II) - (6 ASAs)					
Existing Technology	1,476	-		59	6
Uniform BPT/ST	1,385	194	6,768	100	6
Uniform BAT/BPWTT	190	207	1,979	29	6
Minimum Cost BPT/ST	1,385	194	6,190	51	6
Minimum Cost BAT/BPWTT	190	207	1,604	13	6
SOUTH ATLANTIC (III) - (9 ASAs)					
Existing Technology	1,622	-		72	9
Uniform BPT/ST	911	156	4,462	100	9
Uniform BAT/BPWTT	170	167	1,694	38	9
Minimum Cost BPT/ST	911	156	3,388	42	9
Minimum Cost BAT/BPWTT	170	167	1,849	23	9
GREAT LAKES (IV) - (8 ASAs)					
Existing Technology	1,914	-		80	8
Uniform BPT/ST	667	135	5,398	100	8
Uniform BAT/ BPWTT	244	147	2,315	43	8
Minimum Cost BPT/ST	667	135	3,303	34	8
Minimum Cost BAT/BPWTT	244	147	3,136	32	8
OHIO (V) - (7 ASAs)					
Existing Technology	950	-		61	7
Uniform BPT/ST	548	158	4,925	100	7
Uniform BAT/BPWTT	118	170	2,778	56	7
Minimum Cost BPT/ST	548	158	2,410	28	7
Minimum Cost BAT/BPWTT	118	170	1,219	14	7
TENNESSEE (VI) - (2 ASAs)					
Existing Technology	207	-		78	2
Uniform BPT/ST	199	196	607	100	2
Uniform BAT/BPWTT	25	208	230	38	2
Minimum Cost BPT/ST	199	196	333	30	2
Minimum Cost BAT/BPWTT	25	208	90	8	2
UPPER MISSISSIPPI (VII) - (5 ASAs)					
Existing Technology	862	-		77	5
Uniform BPT/ST	394	146	2,926	100	5
Uniform BAT/BPWTT	80	155	754	26	5
Minimum Cost BPT/ST	394	146	560	11	5
Minimum Cost BAT/BPWTT	80	155	328	6	5
LOWER MISSISSIPPI (VIII) - (3 ASAs)					
Existing Technology	527	-		70	3
Uniform BPT/ST	284	154	1,348	100	3
Uniform BAT/BPWTT	52	164	857	63	3
Minimum Cost BPT/ST	284	154	207	8	3
Minimum Cost BAT/BPWTT	52	164	70	3	3

TABLE 9-3 (Continued)

Policy	BOD Incremental Removal 10^6 lbs/yr	 % of Additional Removal from Existing	Incremental Capital Cost Cost 10^6 1975$	 Uniform BPT/ST	Number of ASAs Policy Applied to
SOURIS-RED-RAINY (IX) - (1 ASA)					
Existing Technology	17	-		70	1
Uniform BPT/ST	19	212	83	100	1
Uniform BAT/BPWTT	1	218	9	11	1
Minimum Cost BPT/ST	19	212	77	52	1
Minimum Cost BAT/BPWTT	1	218	9	6	1
MISSOURI (X) - (11 ASAs)					
Existing Technology	495	-		75	11
Uniform BPT/ST	176	135	1,935	100	11
Uniform BAT/BPWTT	16	139	248	13	11
Minimum Cost BPT/ST	176	135	824	8	11
Minimum Cost BAT/BPWTT	16	139	43	1	11
ARKANSAS-WHITE-RED (XI) - (7 ASAs)					
Existing Technology	382	-		64	7
Uniform BPT/ST	168	144	1,764	100	7
Uniform BAT/BPWTT	55	158	1,368	77	7
Minimum Cost BPT/ST	168	144	515	16	7
Minimum Cost BAT/BPWTT	55	158	760	24	7
TEXAS GULF (XII) - (5 ASAs)					
Existing Technology	878	-		60	5
Uniform BPT/ST	594	168	2,701	100	5
Uniform BAT/BPWTT	146	184	2,659	98	5
Minimum Cost BPT/ST	594	168	1,228	25	5
Minimum Cost BAT/BPWTT	146	184	3,587	74	5
RIO GRANDE (XIII) - (5 ASAs)					
Existing Technology	68	-		72	5
Uniform BPT/ST	17	125	321	100	5
Uniform BAT/BPWTT	7	135	236	73	5
Minimum Cost BPT/ST	17	125	94	16	5
Minimum Cost BAT/BPWTT	7	135	310	53	5
UPPER COLORADO (XIV) - (3 ASAs)					
Existing Technology	4	-		30	3
Uniform BPT/ST	7	275	106	100	3
Uniform BAT/BPWTT	1	300	15	14	3
Minimum Cost BPT/ST	7	275	2	1	3
Minimum Cost BAT/BPWTT	1	300	0	0	3
LOWER COLORADO (XV) - (3 ASAs)					
Existing Technology	47	-		46	3
Uniform BPT/ST	60	228	306	100	3
Uniform BAT/BPWTT	3	234	36	12	3
Minimum Cost BPT/ST	60	228	153	28	3
Minimum Cost BAT/BPWTT	3	234	13	2	3
GREAT BASIN (XVI) - (4 ASAs)					
Existing Technology	54	-		65	4
Uniform BPT/ST	15	128	297	100	4
Uniform BAT/BPWTT	7	141	186	63	4
Minimum Cost BPT/ST	15	128	137	25	4
Minimum Cost BAT/BPWTT	7	141	92	17	4

TABLE 9-3 (Continued)

	BOD		Incremental Capital Cost		
Policy	Incremental Removal 10^6 lbs/yr	% of Additional Removal from Existing	Cost 10^6 1975$	Uniform BPT/ST	Number of ASAs Policy Applied to
PACIFIC NORTHWEST (XVII) - (7 ASAs)					
Existing Technology	511	-		123	7
Uniform BPT/ST	446	187	982	100	7
Uniform BAT/BPWTT	48	197	297	30	7
Minimum Cost BPT/ST	446	187	402	23	7
Minimum Cost BAT/BPWTT	48	197	92	5	7
CALIFORNIA (XVIII) - (7 ASAs)					
Existing Technology	844	-		76	7
Uniform BPT/ST	1,147	236	2,934	100	7
Uniform BAT/BPWTT	155	254	857	29	7
Minimum Cost BPT/ST	1,147	236	2,500	47	7
Minimum Cost BAT/BPWTT	155	254	704	13	7
NATIONAL TOTALS - (99 ASAs)					
Existing Technology	11,000	-		69	99
Uniform BPT/ST	7,400	167	38,500	100	99
Uniform BAT/BPWTT	1,300	179	17,000	43	99
Minimum Cost BPT/ST	7,400	167	23,000	59	99
Minimum Cost BAT/BPWTT	1,300	179	14,000	36	99

considered for non-irrigated agriculture are relatively inexpensive. Because of the variability in estimating BOD discharge and RDR costs for non-irrigated agriculture, it seems unlikely that reducing BOD discharge from non-irrigated agriculture would prove cost effective in as many ASAs (91) as indicated here. The inorganic chemical and mining industries were the most expensive categories, given the assumptions used, each being selected in only 1 ASA.

Although intended only as an illustration, the analysis clearly suggests that substantial savings can be produced and the same levels of reduction in residuals discharges achieved by pursuing a least cost approach, including all residual sources, instead of applying uniform BPT/ST and BAT/BPWTT technology.

ALTERNATIVE POLICY 3: NOT REQUIRING OCEAN DISCHARGERS TO APPLY BAT/BPWTT TECHNOLOGY

As with inland ASAs where the assimilative capacity of surface receiving waters may make it possible to achieve desired water quality after applying BPT/ST, and where applying BAT/BPWTT has little or no additional effect on water quality, in certain coastal areas the assimilative capacity of the receiving waters, the oceans, is also an important consideration. The waste assimilative capacity of the oceans is great, because

> "...An enormous amount of water is moved along the United States shores by major coastal currents. Typical transport rates for the California current or Florida current, which range from 10 million to 60 million cubic meters per second, are millions of times greater than the flow of the largest wastewater dischargers. Because of this great excess of available dilution water, the dilution of discharged wastes depends only on the rate of mixing of ocean and wastewaters" (Southern Cal. Coastal Water Research Project 1975).

Consequently, it is worthwhile to investigate the alternative of not requiring the application of BAT/BPWTT technology in areas which already have or will have the potential of ocean discharge.

The diversity of U.S. coastal waters makes it extremely difficult to assess realistically the potential benefits of this alternative. Estuarine areas vary drastically from coast to coast, in the Gulf, and from north to south. In some coastal wetland areas, potential damages from ocean outfalls may necessitate applying BAT/BPWTT; while in others, coastal currents and tidal actions may dilute residuals discharges sufficiently to obviate the necessity for applying BAT/BPWTT.

To demonstrate this alternative, possible regional cost savings are illustrated by computing the cost savings resulting from not requiring application of BAT/BPWTT in coastal areas in three water resource regions--South Atlantic (III), California-South Pacific (XVIII), and Columbia-North Pacific (XVII)--in which ocean discharge is either already practiced or known to be feasible. Figure 9-1 shows the counties considered. Coastal areas in the three water resource regions are defined as those coastal counties having a treatment plant or plants determined by EPA not to require secondary (RDR) treatment. It is assumed that all point sources in a county take advantage of substituting ocean discharge for BAT/BPWTT.

Analyzing this alternative yields some interesting but not unexpected results, as shown in Table 9-4. At the national level, if only these three WRRs are considered, the possible savings in RDR cost (not savings in total cost, because costs of piping to oceans and costs of outfalls are not included) is modest: about $0.4 billion, or about 2.4 percent of total uniform BAT/BPWTT costs. At the water resource region level, however, the range of savings in particular WRRs becomes relatively greater. Of the three WRRs considered, two show significant savings: one, California-South Pacific, achieves a savings of about $0.34 billion or approximately 94 percent reduction of total uniform BAT/BPWTT costs; the other, Columbia-North Pacific, achieves a savings of about $0.07 billion, a 22 percent reduction of uniform BAT/BPWTT costs.

The savings estimate in these WRRs is believed to be reasonable, because only those counties are omitted in which EPA has indicated that municipal treatment facilities are not required to go to secondary treatment, because of ocean dilution. A tentative conclusion that may be drawn is that although the possible savings at the national level would be modest, not requiring the application of BAT/BPWTT where ocean discharge can be used will produce regionally significant savings. This discussion further illustrates the potential benefits of water quality management policies which take into consideration regional diversity.

CONCLUDING COMMENT

In this discussion of alternative WQM policies, only the capital costs of facilities have been included. O&M costs as well as administrative costs of water quality management have been excluded. One of the arguments for uniform effluent standards has been administrative ease. The strategies discussed in this chapter would require varying degrees of differential administration among regions. However, given that a large percentage of the stream segments in the U.S. are currently considered "water quality limited," achieving desired water quality standards will

Figure 9-1
Identification by WRR of Coastal Counties Assumed to Substitute Ocean Dilution for BAT/BPWTT Technology Requirements

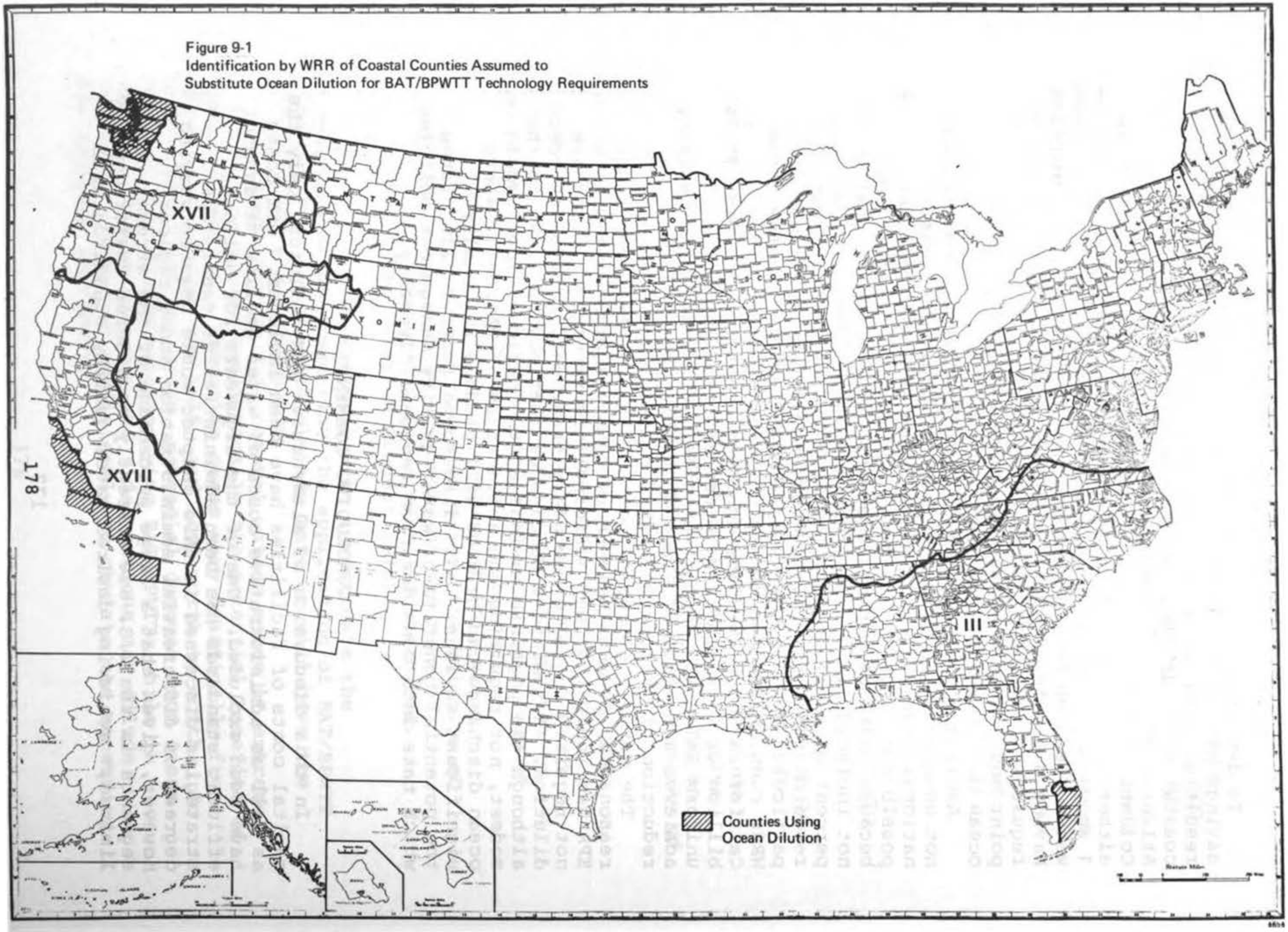


TABLE 9-4

Residuals Reduction and Capital Cost Savings by WRR of Eliminating BAT/BPWTT Technology Requirements in Counties with Potential Ocean Discharge (Based upon 1973 Low Flow Conditions+)

	BOD		Incremental Capital Cost			Number of ASAs Ranked in Highest W. Q. Category After Technology Application	
Policy	Discharge 10^6 lbs/yr	% Reduction from Existing	Cost 10^6 1975$	% of Uniform BAT/BPWTT	Number of Counties Applied to		Number of ASAs Policy Affected
SOUTH ATLANTIC (III) - (9 ASAs)							
Existing Technology	1,253	-		-	473	6	9
Uniform BPT/ST	342	72	4,462	-	473	8	9
Uniform BAT/BPWTT	172	86	1,694	100	473	9	9
Alternative 3	182	85	1,683	99	3	9	1
			From Uniform BPT/ST				
PACIFIC NORTHWEST (XVII) - (7 ASAs)							
Existing Technology	573	-		-	127	7	7
Uniform BPT/ST	128	78	982	-	127	7	7
Uniform BAT/BPWTT	81	86	297	100	127	7	7
			(All ASAs ranked in highest category after BPT/ST)				
Alternative 3	106	82	231	77	3	7	2
			From Uniform BPT/ST				
CALIFORNIA (XVIII) - (7 ASAs)							
Existing Technology	1,467	-		-	59	2	7
Uniform BPT/ST	319	78	2,934	-	59	3	7
Uniform BAT/BPWTT	165	89	857	100	59	3	7
Alternative 3	228	84	517	60	9	3	2
			From Uniform BPT/ST				
ALL OTHER WRRs - (76)							
Existing Technology	6,807	-		-	2,448	36	76
Uniform BPT/ST	1,911	71	31,622	-	2,448	61	76
Uniform BAT/BPWTT	882	85	14,252	100	2,448	66	76
Alternative 3	882	85	14,252	100	0	66	0
NATIONAL TOTALS - (99 ASAs)							
Existing Technology	10,100	-		-	3,107	51	99
Uniform BPT/ST	2,700	73	38,500	-	3,107	79	99
Uniform BAT/BPWTT	1,300	87	17,100	100	3,107	85	99
Alternative 3	1,400	86	16,700	98	16	85	5

+Includes residuals discharge from point sources only.

require detailed analysis of virtually all basins under any management strategy.

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CHAPTER 10

SUMMARY

The results of analyses using NRDI and the experience in constructing NRDI lead to the following general observations. The order of their listing is roughly consistent with the sequence of analysis in the previous chapters; it does not indicate any order of importance.

1. A useful inventory of sources of some important residuals, BOD (biochemical oxygen demand) and TSS (total suspended solids), can be compiled from available data by minor river basins, covering the contiguous U.S. These minor river basins are equivalent to the Water Resources Council's Aggregated Sub-Areas (ASAs). The identifiable sources include point sources--manufacturing, mining, and municipal activities--and non-point sources--agricultural and silvicultural activities, and urban runoff. This report omits certain manufacturing, feedlot, irrigated agricultural, and silvicultural activities, and omits from national coverage all residuals other than BOD and TSS.

2. This report confirms the existence of major differences in the distribution of sources of residuals and in the distribution of water quality among ASAs.

3. Applying BPT/ST (best practicable control technology currently available for point sources other than publicly owned treatment works/secondary treatment for publicly owned treatment works) to point sources is estimated to result in significant reduction in the discharge of BOD and TSS. Applying BAT/BPWTT (best available technology economically achievable for point sources other than publicly owned treatment works/best practicable wastewater treatment technology for publicly owned treatment works) is estimated to produce smaller reductions in the discharge of BOD and TSS.

4. If no residuals discharge reduction (RDR) measures are applied to reduce BOD and TSS discharges from nonpoint sources, residuals will continue to be discharged to water environments in quantities sufficient to affect water quality, after applying BPT/ST and BAT/BPWTT to point sources.

5. Two measures of water quality--BOD dilution and TSS dilution--were developed.

(a) Applying only BPT/ST to point sources is estimated to result in significant improvement in water quality under low flow conditions, as measured by this index, in a number of ASAs.

(b) Applying BAT/BPWTT to point sources is estimated to result in significant improvement in water quality, under low flow conditions, in only a few additional ASAs.

(c) If no RDR measures are applied to reduce BOD and TSS discharges from nonpoint sources, under average flow conditions, significant improvement will occur in even fewer ASAs than under the conditions represented in (a) and (b) above.

6. The estimated capital costs of applying BPT/ST to point sources are substantially larger than the estimated capital costs of applying BAT/BPWTT. However, reductions in BOD and TSS discharges, and improvements in water quality under the conditions specified in "5a" and "5b", per dollar of investment, are considerably larger for applying BPT/ST than for applying BAT/BPWTT.

7. An inventory of point and nonpoint sources of residuals, continually maintained and updated would be useful for policy decisions. It should include quantitative information on the following:

(a) location by ASA;
(b) factors affecting residuals generation, such as production process, product specifications, cropping patterns;
(c) factors affecting residuals discharge, such as extent of materials recovery and by-product production, and RDR facilities; and
(d) magnitudes of residuals discharges for such residuals as BOD, TSS, nutrients, and heavy metals.

Such an inventory would require both a consistent taxonomy and a well defined and implemented data collection system.

8. Information on the characteristics and magnitudes of residuals discharged and the costs of reducing discharges from nonpoint sources is much less accurate than for point sources.

9. Information on the locations and sources of residuals other than BOD and TSS (for example, heavy metals, pesticides, and nutrients) is severely limited.

10. A consistent methodology for estimating the costs of reducing residuals discharge must be developed for all dischargers having either a significant impact on water quality or having large estimated RDR costs. This should

include the metal finishing, machinery and mechanical products, and fruits and vegetables industries, which have been crudely estimated to have large RDR costs.

APPENDIX A

RDR UNIT PROCESS DEFINITIONS, COSTS AND REMOVALS, AND COMPENSATION FACTORS

1. INTRODUCTION

The primary purpose of this appendix is to define clearly each of the 42 RDR unit processes used in the point source analyses to compute residuals reductions and to estimate capital costs.

The use of a single set of unit processes in the municipal, in-depth industry, and in-general industry analyses provides a consistent framework for both cost and residual analyses which cut across categories.

The approach used in NRDI is quite different from that used by both EPA and NCWQ in which each industry group contractor was responsible for independently developing cost estimates. While many of these contractors used certain unit processes similar to those described here, in most cases, documentation of the derivation of the functions was inadequate to permit reconstruction of the estimates reported. Thus, although the EPA/NCWQ approach has the theoretical advantage of providing for industry-to-industry differences in certain similar RDR processes, we think this advantage is outweighed by the difficulties of relating residuals to costs and understanding derivation of those costs.

The NRDI approach was designed with the objectives of (1) providing an easily understood and consistent set of unit processes for building national and regional cost estimates, and (2) relating the performance of sequences of RDR unit processes to the specific documented residuals removal efficiencies of.the individual unit processes.

Basic information concerning the 42 functions used is presented in Table A-1. Although six different sources were used for cost function derivation, the majority of the data (27 functions) came from the Metcalf and Eddy report to NCWQ (Metcalf and Eddy Inc. 1975). The other functions were derived from other sources since they were processes not used for municipal treatment and thus not reported in the Metcalf and Eddy study.

The use of identical functions for municipal and industrial treatment is unusual since it is commonly assumed that industrial facilities are designed for a shorter service life and are thus less costly to construct. However, a review of the literature on costs of industrial

TABLE A-1

Characteristics of NRDI RDR Cost Functions

Number	Name	Source (see notes)	Costing Variables				Function Purpose
			Flow	Influent Concen.			
				BOD	TSS	COD	
1	Activated Sludge	M&E	X	X			Residuals Modification
2	Aerated Lagoon	M&E	X	X			"
3	Trickling Filter	M&E	X				"
4	Neutralization	DG1	X				"
5	Flotation	*	X				"
6	Petroleum Flotation	DG1	X				"
7	Cooling Towers	DG1	X				Thermal Disch.Red
8	Recirculation	DG1	X				Flow Reduction
9	Surface Outfall	M&E	X				Liquid Disposal
10	Ocean Outfall	M&E	X				"
11	Extended Biological Oxidation	EPA1	X				Residuals Modification
12	Chlorination	M&E	X				"
13	Earthen Basin	EPA2	X				"
14	Chemical Addition	M&E	X				"
15	Primary Sedimentation	M&E	X				"
16	Filtration (multi-media)	M&E	X				"
17	Oil Separation	AWR	X				"
18	Spray Irrigation	EPA1	X				"**
21	Equalization	M&E	X				Residuals Modification
22	Nitrification	M&E	X				"
23	Ammonia Stripping	M&E	X				"
24	Nitrification-Denitrification	M&E	X				"
25	Drying Beds	M&E	X	X	X		Sludge Handling
26	Incineration	M&E	X	X	X		"
27	Landfill	M&E	X	X	X		"
28	Vacuum Filtration	M&E	X	X	X		"
29	Gravity Thickening	M&E	X	X	X		"
30	Heat Treatment	M&E	X	X	X		"
31	Sludge Digestion	M&E	X	X	X		"
32	Chrome Reduction	DG1	X				Residuals Modification
33	Sedimentation with Chemical Addition	M&E	X				"
34	Carbon Adsorption	EPA3	X			X	"
36	Breakpoint Chlorination	M&E	X				"
37	Ion Exchange	M&E	X				"
38	Two-stage Chemical Addition	M&E	X				"
39	Evaporation	DG1	X				"**
40	Holding Pond	M&E	X				Residuals Modification
41	Cyanide Destruction	DG1	X				"
42	Screening	M&E	X				"

NOTES:

M&E - Metcalf & Eddy (1975), Assessment of Technologies & Costs for Publicly Owned Treatment Works, Appendix Part 2, NCWQ Contract, April.

DG1 - Datagraphics, Inc. (1975), Wastewater Treatment Process Cost Functions, November.

* - Used same cost function as sedimentation.

EPA1 - U.S. Environmental Protection Agency (1975a), Development Document for Final Effluent Limitations for Fruits, Vegetables and Specialties, April.

EPA2 - U.S. Environmental Protection Agency (1975b), Development Document for Interim Final and Proposed Effluent Limitation Guidelines for Ore Mining and Dressing Industries, Vol. II, October.

AWR - Associated Air and Water Resource Engineers (1973), Estimating Water Pollution Control Costs from Selected Manufacturing Industries, EPA Contract, June.

EPA3 - U.S. Environmental Protection Agency (1973), Process Design Manual for Carbon Adsorption, EPA Technology Transfer, October.

** - Includes liquid disposal also.

waste treatment functions showed that many of the sources for cost estimates were reports on muncipal costs. Thus, it was thought that the use of common functions was justified.

2. CAPITAL COST ESTIMATION

Facilities were sized and costs were estimated based on the raw influent characteristics of flow, BOD concentration, TSS concentration, and COD concentration. Flow was used in all cost analyses. BOD and TSS were used with flow in sizing sludge handling facilities, BOD was used with flow in sizing activated sludge and aerated lagoons, and COD was used with flow in sizing activated carbon adsorption processes.

Except for carbon adsorption, all functions were of the basic form

$$C = aQ^b$$

where C is construction costs (in millions of 1973 dollars), Q is adjusted flow (in millions of gallons per day) or sludge loading (in thousands of pounds per day), and a and b are constants defining the function. Since a and b are not constant over all ranges of Q, segmented continuous functional forms were used. Slightly under 100 of these continuous segments were used.

Carbon adsorption was a special case in that the unit process cost consisted of a number of separate entities. For that reason, a special cost routine was prepared which produced a special estimate for each facility.

The cost functions are presented in tabular form for a variety of plant sizes and a set of influent loading assumptions. This is done in Table A-2 for seven plant sizes and a typical municipal influent.

Construction costs were converted to capital costs by application of adjustment factors. This procedure is discussed in section 4.

3. REMOVAL EFFICIENCIES

Each RDR function (Table A-1) was characterized by residual removal rates. BOD and TSS removals were computed for all processes and P and N removal were computed for functions used in the municipal model. The results of the estimates are presented in Table A-3.

These removal rates were used exclusively in the municipal and general industry studies. In the in-depth industry studies, certain of the removal efficiencies were modified based on detailed knowledge of the discharge characteristics and how they are affected by the various processes. An example is the iron and steel industry which achieved greater than indicated TSS removals with

TABLE A-2

Construction Costs for RDR Unit Processes Based on Typical Municipal Influent* Concentrations (Millions of 1973 Dollars)

Number	Name	Plant Size (MGD)						
		.1	1.0	5.0	10.0	20.0	50.0	100.0
1	Activated Sludge	0.150	0.630	1.700	2.629	4.067	7.240	11.199
2	Aerated Lagoon	0.090	0.393	1.100	1.714	2.671	4.801	7.481
3	Trickling Filter	0.051	0.220	0.984	1.876	3.576	8.391	15.996
4	Neutralization	0.022	0.088	0.231	0.350	0.532	0.924	1.402
5	Flotation	0.120	0.200	0.420	0.699	1.163	2.282	3.799
6	Petroleum Flotation	0.020	0.111	0.361	0.601	1.000	1.961	3.265
7	Cooling Towers	0.010	0.042	0.110	0.166	0.252	0.436	0.661
8	Recirculation	0.106	0.421	1.106	1.676	2.540	4.402	6.672
9	Surface Outfall	0.010	0.046	0.136	0.215	0.342	0.630	1.000
10	Ocean Outfall	0.100	0.531	1.708	2.823	4.668	9.073	15.002
11	Extended Biological Oxidation	0.053	0.190	0.490	0.737	1.108	1.900	2.857
12	Chlorination	0.020	0.076	0.194	0.289	0.433	0.736	1.100
13	Earthen Basin	0.002	0.011	0.033	0.063	0.123	0.227	0.361
14	Chemical Addition	0.009	0.025	0.044	0.080	0.147	0.328	0.600
15	Primary Sedimentation	0.120	0.200	0.420	0.699	1.163	2.282	3.799
16	Filtration (multi-media)	0.100	0.200	0.570	0.894	1.404	2.548	4.000
17	Oil Separation	0.013	0.087	0.335	0.601	1.075	2.321	4.155
18	Spray Irrigation	0.062	0.210	0.680	1.128	1.871	3.653	6.059
21	Equalization	0.100	0.150	0.313	0.430	0.683	1.260	2.001
22	Nitrification	0.230	0.400	1.313	2.191	3.656	7.193	12.002
23	Ammonia Stripping	0.243	0.310	0.966	1.575	2.569	4.905	8.001
24	Nitrification-Denitrification	0.510	0.800	2.527	4.148	6.807	13.102	21.503
25	Drying Beds	0.010	0.042	0.153	0.301	0.592	1.447	2.844
26	Incineration	0.144	0.719	2.212	2.500	2.640	4.119	5.768
27	Landfill	0.013	0.063	0.192	0.310	0.500	0.941	1.519
28	Vacuum Filtration	0.099	0.313	0.697	0.864	0.896	0.941	1.557
29	Gravity Thickening	0.014	0.046	0.106	0.159	0.254	0.473	0.758
30	Heat Treatment	0.128	0.323	0.620	0.820	1.085	1.887	3.696
31	Sludge Digestion	0.075	0.298	0.787	1.231	2.008	3.833	6.253
32	Chrome Reduction	0.515	1.638	3.663	5.180	7.325	11.582	16.380
33	Sedimentation with Chemical Addition	0.129	0.225	0.464	0.781	1.314	2.615	4.401
34	Carbon Adsorption	0.357	0.965	2.030	3.230	5.392	11.157	20.016
36	Breakpoint Chlorination	0.055	0.185	0.433	0.624	0.899	1.457	2.100
37	Ion Exchange	0.232	0.450	1.366	2.205	3.557	6.694	10.800
38	Two-stage Chemical Addition	0.160	0.450	1.246	1.932	2.997	5.352	8.299
39	Evaporation	0.412	2.028	6.180	9.985	16.135	30.427	49.166
40	Holding Pond	0.250	0.480	1.200	1.990	3.300	6.440	10.679
41	Cyanide Destruction	0.515	1.638	3.663	5.180	7.325	11.582	16.380
42	Screening	0.015	0.028	0.076	0.116	0.178	0.313	0.480

*Assuming that BOD = 200 mg/l; TSS = 200 mg/l; and COD = 500 mg/l.

TABLE A-3

Efficiencies For RDR Unit Processes

No.	Name	Removal Efficiencies (%)*			
		BOD**	TSS	P	N
1	Activated Sludge	85	77	20	20
2	Aerated Lagoon	75	65	10	20
3	Trickling Filter	79	68	10	20
4	Neutralization	0	0		
5	Flotation	40	80		
6	Petroleum Flotation	40	80		
11	Extended Biological Oxidation	75	65		
12	Chlorination	0	0		
13	Earthen Basin	0***	80		
14	Chemical Addition	52	71		
15	Primary Sedimentation	33	52	9	10
16	Filtration (multi-media)	50	72	50	0
17	Oil Separation	0	0		
18	Spray Irrigation	100	100		
21	Equalization	0	0		
22+	Nitrification	70	57	0	0
23	Ammonia Stripping	0	0		
24	Nitrification-Denitrification	0	0	0	90
32	Chrome Reduction	0	0		
33	Sedimentation with Chemical Control	52	71	94	0
34	Carbon Adsorption	60	60	20	0
36	Breakpoint Chlorination	0	0		
37	Ion Exchange	0	0		
38	Two-stage Chemical Addition	60	68		
39	Evaporation	100	100		
40	Holding Pond	79	68	10	0
41	Cyanide Destruction	0	0		
42	Screening	0	0		

SOURCE: Bechtel Inc. (1975)

NOTES:
* P and N removals shown only for Municipal Functions
** For Municipal, BOD removals for primary and secondary combined are limited to 85%
*** Earthen basins used only for discharges with zero BOD loadings
\+ Municipal only

sedimentation due to the heavy particles in discharge from this industry.

4. ADJUSTMENTS OF CAPITAL COST ESTIMATES

Total capital costs for industrial and municipal activities, based on the capital cost RDR functions described in Section 2, were adjusted to take into account two factors. One adjustment was necessary to approximate the total capital investment required to build an operational facility. The other adjustment was to convert capital cost estimates from 1973 dollars to 1975 dollars in order to be comparable to NCWQ.

In order to approximate the total capital investment required to build municipal sewage treatment systems, the costs of building interceptor sewers were included as well as RDR costs. EPA and professional engineers have viewed interceptor sewers as an integral part of a treatment system because of the necessity to transport liquid residuals in collector sewers to sewage treatment plants. In the MFI, interceptor sewer costs (Category IVB) were estimated to be about 40 percent of the RDR costs (Categories I and II). Consequently, the estimated capital costs of RDR technology for municipal activities was increased by 40 percent.

In order to approximate the total capital investment required to build industrial end-of-pipe RDR technology, adjustments for essential components not included in the cost estimates were included. The essential components not included in the industrial capital estimate were pumping, outfalls, and miscellaneous structures and site works (Engineeering Science Inc. 1975). These components add, on average, about an additional 30 percent to the costs of RDR and sludge disposal facilities (Table A-4). An adjustment for contingency was assumed to be 5 percent and for all other factors was assumed to be another 5 percent. Consequently, the estimated capital costs of RDR technology for all industrial activities was increased by 40 percent in order to compensate for components not considered, and for contingency and other factor costs.

The other major adjustment was to convert capital cost estimates from 1973 to 1975 dollars. Since NCWQ converted their technology capital cost estimates in 1973 dollars to 1975 dollars by a factor of 1.3, the same factor was used.

In summary, total capital cost estimates were adjusted in order to compensate for components not included in the RDR costs, to correct for underestimates of contingency and other factors, and to convert to 1975 dollars. This adjustment factor of 1.82 (100 x 1.4 x 1.3) was applied to all BPT/ST and BAT/BPWTT capital cost estimates.

TABLE A-4

Comparison of Unit Process RDR Technology Costs and Costs of Components Not Included In RDR Cost Functions (Millions of 1973$)

Sequence of Unit Process RDR Technologies	Flow (MGD)			
	.1	1.0	5.0	10.0
Primary Sedimentation	.117	.220	.420	.707
Activated Sludge	.149	.630	1.700	2.640
Gravity Thickening	.012	.061	.184	.298
Vacuum Filtration	.099	.312	.695	.864
Landfill	.015	.049	.112	.146
TOTAL	.392	1.252	3.111	4.655

Components Not Included In RDR Cost Functions	Flow (MGD)			
	.1	1.0	5.0	10.0
Miscellaneous Structures and Sitework	.030	.080	.110	.120
Outfalls	.010	.040	.105	.113
Pumping	.200	.350	.700	1.000
TOTAL	.240	.470	.915	1.233
% of RDR Costs	61%	37%	30%	26%

Source: Metcalf and Eddy Inc. (1975) Appendix Part 2.

5. COLLECTOR AND INTERCEPTOR SEWER COSTS

Tables A-5 and A-6 show the capital cost factors by population size group used to compute collector and interceptor sewer capital costs.

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TABLE A-5

Collector Sewer Capital Costs per Capita by Population Size Group
(June, 1973 dollars)

Population Size	Capital Cost
0 - 500	$580
500 - 1,000	479
1,000 - 2,500	406
2,500 - 5,000	348
5,000 - 10,000	319
10,000 - 25,000	274
25,000 - 50,000	244
50,000 - 100,000	210
100,000 - 250,000	178
250,000 - 500,000	129
500,000 - 1,000,000	129
>1,000,000	129

TABLE A-6

Interceptor Sewer Cost Factors by Population Group

Population Size	f_i (Multiplied by Treatment Plant Cost)
0 - 500	.373
500 - 1,000	.384
1,000 - 2,500	.498
2,500 - 5,000	.722
5,000 - 10,000	.790
10,000 - 25,000	1.060
25,000 - 50,000	1.487
50,000 - 100,000	1.533
100,000 - 250,000	1.763
250,000 - 500,000	2.473
500,000 - 1,000,000	2.473
>1,000,000	2.473

APPENDIX B

Compilation of Data by WRR

TABLE B-1

BOD and TSS Discharge and RDR Costs For 1973 Conditions and Applying BPT/ST and BAT/BPTWTT

Water Resource Region	Technology Applied	Total Point Source Residuals Discharge								
		BOD (lbs. 10^6)			TSS (lbs. 10^6)			Capital Costs (10^6 1975$)		
		Ind.	Munic.	Total	Ind.	Munic.	Total	Ind.	Munic.	Total
I. New England (6 ASAs)	1973	150	340	490	1,900	330	2,230	220	810	1,030
	BPT/ST	30	70	100	160	60	220	660	1,150	1,810
	BAT/BPWTT	10	60	70	90	50	140	220	200	220
II. Mid Atlantic (6 ASAs)	1973	570	1,260	1,830	9,770	1,280	11,050	790	3,230	4,020
	BPT/ST	110	330	440	700	330	1,040	1,560	5,280	6,840
	BAT/BPWTT	50	200	250	450	180	630	820	1,180	2,000
III. South Atlantic (9 ASAs)	1973	640	610	1,250	3,170	670	3,840	1,130	2,110	3,240
	BPT/ST	180	170	350	460	150	610	1,350	3,160	4,510
	BAT/BPWTT	80	90	170	230	80	310	760	950	1,710
IV. Great Lakes (8 ASAs)	1973	420	610	1,030	27,600	690	28,300	890	3,500	4,390
	BPT/ST	80	290	370	2,540	310	2,850	1,900	3,560	5,460
	BAT/BPWTT	40	90	130	2,110	80	2,190	980	1,360	2,340
V. Ohio (7 ASAs)	1973	310	450	750	4,740	490	5,230	760	2,280	3,040
	BPT/ST	70	140	210	620	140	750	1,600	3,380	4,980
	BAT/BPWTT	30	60	90	220	50	280	940	1,870	2,810
VI. Tennessee (2 ASAs)	1973	160	90	250	9,530	100	9,630	170	300	470
	BPT/ST	30	20	50	200	20	220	260	360	620
	BAT/BPWTT	10	10	20	170	10	180	150	80	230
VII. Upper Mississippi (5 ASAs)	1973	270	300	570	7,100	300	7,400	300	1,970	2,270
	BPT/ST	60	120	180	1,080	120	1,200	620	2,340	2,960
	BAT/BPWTT	30	70	100	990	70	1,060	280	480	760
VIII. Lower Mississippi (3 ASAs)	1973	310	80	390	1,500	110	1,610	380	580	960
	BPT/ST	60	40	100	190	40	230	610	750	1,360
	BAT/BPWTT	30	30	60	120	30	150	530	340	870
IX. Souris-Red-Rainy (1 ASA)	1973	10	10	20	120	10	130	20	40	60
	BPT/ST	0	0	0	10	0	10	20	70	90
	BAT/BPWTT	0	0	0	0	0	0	10	0	10
X. Missouri (11 ASAs)	1973	40	250	290	392,000	250	392,000	160	1,320	1,480
	BPT/ST	20	90	110	3,250	90	3,340	280	1,670	1,950
	BAT/BPWTT	10	80	90	3,220	80	3,300	190	100	290
XI. Ark-White-Red (7 ASAs)	1973	130	120	250	5,610	120	5,730	230	910	1,140
	BPT/ST	30	50	80	150	50	200	420	1,370	1,790
	BAT/BPWTT	20	10	30	110	10	120	280	1,100	1,380
XII. Texas Gulf (5 ASAs)	1973	620	160	780	2,570	190	2,760	470	1,180	1,650
	BPT/ST	100	90	190	170	90	260	1,070	1,660	2,730
	BAT/BPWTT	30	10	40	90	10	100	870	1,820	2,690

TABLE B-1 (Continued)

Water Resource Region	Technology Applied	Total Point Source Residuals Discharge						Capital Costs (10^6 1975$)		
		BOD (lbs. 10^6)			TSS (lbs. 10^6)					
		Ind.	Munic.	Total	Ind.	Munic.	Total	Ind.	Munic.	Total
XIII. Rio Grande (5 ASAs)	1973	20	10	30	16,490	10	16,500	20	220	240
	BPT/ST	0	10	10	330	10	340	110	220	330
	BAT/BPWTT	0	0	0	230	0	230	40	200	240
XIV. Upper Colorado (3 ASAs)	1973	0	10	10	3,790	10	3,800	0	30	30
	BPT/ST	0	0	0	170	0	170	50	50	100
	BAT/BPWTT	0	0	0	110	0	110	10	10	20
XV. Lower Colorado (3 ASAs)	1973	10	60	70	94,620	80	94,700	30	120	150
	BPT/ST	0	10	10	770	10	780	70	240	310
	BAT/BPWTT	0	10	10	770	10	780	20	10	30
XVI. Great Basin (4 ASAs)	1973	10	20	30	86,800	30	86,900	40	160	200
	BPT/ST	0	10	10	880	10	890	90	210	300
	BAT/BPWTT	0	0	0	810	0	810	60	110	170
XVII. Pacific Northwest (7 ASAs)	1973	470	100	570	39,600	100	39,700	470	740	1,210
	BPT/ST	80	40	120	480	40	520	320	680	1,000
	BAT/BPWTT	40	40	80	420	40	460	220	80	300
XVIII. California (7 ASAs)	1973	210	1,260	1,470	15,500	1,290	16,800	340	1,920	2,260
	BPT/ST	50	270	320	440	260	700	670	2,300	2,970
	BAT/BPWTT	20	140	160	350	110	460	460	410	870
NATIONAL TOTALS (rounded)	1973	4,350	5,750	10,100	723,000	6,050	727,000	6,100	32,500	38,600
	BPT/ST	900	1,760	2,660	12,400	1,720	14,300	10,100	28,400	38,500
	BAT/BPWTT	400	900	1,300	12,300	820	13,300	6,800	10,300	17,100

TABLE B-2

Comparison of BOD and TSS Discharges From Point and Areal Sources For 1973 Conditions and Applying BPT/ST and BAT/BPWTT to Point Sources

Water Resource Region	Technology Applied	BOD (lbs. 10^6)							TSS (lbs. 10^6)						
		Total Point	% of Regional Total	Urban Runoff	% of Regional Total	Agric.	% of Regional Total	Total All Sources	Total Point	% of Regional Total	Urban Runoff	% of Regional Total	Agric.	% of Regional Total	Total All Sources
I. New England	1973	500	57	330	37	50	6	880	2,220	16	6,400	47	4,930	37	13,600
(6 ASAs)	BPT/ST	90	19	330	69	50	12	470	220	2	6,400	55	4,930	43	11,600
	BAT/BPWTT	70	15	330	73	50	12	450	140	1	6,400	56	4,930	43	11,500
II. Mid Atlantic	1973	1,830	71	690	27	80	2	2,600	11,050	32	11,720	33	11,810	35	34,600
(6 ASAs)	BPT/ST	440	37	690	57	80	6	1,210	1,010	4	11,720	48	11,810	48	24,500
	BAT/BPWTT	250	25	690	68	80	7	1,020	620	2	11,720	48	11,810	50	24,200
III. South Atlantic	1973	1,250	65	570	30	100	5	1,920	3,850	9	11,130	27	26,270	64	41,300
(9 ASAs)	BPT/ST	340	34	570	57	100	9	1,010	610	2	11,130	29	26,270	69	38,000
	BAT/BPWTT	170	20	570	68	100	12	840	310	1	11,130	29	26,270	70	37,700
IV. Great Lakes	1973	1,040	58	620	35	140	7	1,800	28,280	50	9,810	17	18,720	33	56,800
(8 ASAs)	BPT/ST	370	33	620	55	140	12	1,130	2,850	9	9,810	31	18,720	60	31,400
	BAT/BPWTT	130	15	620	70	140	15	890	2,190	7	9,810	32	18,720	61	30,700
V. Ohio	1973	750	42	310	17	750	41	1,810	5,230	3	5,260	3	151,930	94	162,000
(7 ASAs)	BPT/ST	210	17	310	25	750	58	1,270	750	1	5,260	3	151,930	96	158,000
	BAT/BPWTT	90	8	310	27	750	65	1,150	280	1	5,260	3	151,930	96	157,000
VI. Tennessee	1973	250	48	50	10	220	42	520	9,630	19	1,000	2	40,980	79	51,600
(2 ASAs)	BPT/ST	50	16	50	16	220	68	320	220	1	1,000	2	40,980	97	42,200
	BAT/BPWTT	20	7	50	17	220	76	290	180	1	1,000	2	40,980	97	42,200
VII. Upper Miss.	1973	570	34	110	7	970	59	1,650	7,400	4	2,160	1	175,360	95	185,000
(5 ASAs)	BPT/ST	180	14	110	9	970	77	1,260	1,190	1	2,160	1	175,360	98	179,000
	BAT/BPWTT	100	8	110	9	970	83	1,180	1,060	1	2,160	1	175,360	98	179,000
VIII. Lower Miss.	1973	390	37	110	10	550	53	1,050	1,610	1	2,230	1	182,940	98	187,000
(3 ASAs)	BPT/ST	110	14	110	14	550	72	770	240	1	2,230	1	182,940	98	185,000
	BAT/BPWTT	60	8	110	15	550	77	720	150	1	2,230	1	182,940	98	185,000
IX. Souris-Red-Rainy	1973	20	40	-	-	30	60	50	130	3	-	-	3,550	97	3,680
(1 ASA)	BPT/ST	0	0	-	-	30	100	30	10	1	-	-	3,550	99	3,560
	BAT/BPWTT	0	0	-	-	30	100	30	10	1	-	-	3,550	99	3,560

TABLE B-2 (Continued)

Water Resource Region	Technology Applied	BOD (lbs. 10^6)							TSS (lbs. 10^6)						
		Total Point	% of Regional Total	Urban Runoff	% of Regional Total	Agric.	% of Regional Total	Total All Sources	Total Point	% of Regional Total	Urban Runoff	% of Regional Total	Agric.	% of Regional Total	Total All Sources
X. Missouri (11 ASAs)	1973	290	14	50	2	1,650	84	1,990	392,420	55	970	1	325,060	45	718,000
	BPT/ST	110	6	50	3	1,650	91	1,810	3,340	1	970	1	325,060	98	329,000
	BAT/BPWTT	90	5	50	3	1,650	92	1,790	3,300	1	970	1	325,060	98	329,000
XI. Ark-White-Red (7 ASAs)	1973	250	46	50	10	250	45	550	5,740	7	890	1	78,980	92	85,600
	BPT/ST	80	21	50	13	250	66	380	200	1	890	1	78,980	98	80,000
	BAT/BPWTT	30	9	50	16	250	75	330	120	1	890	1	78,980	98	80,000
XII. Texas Gulf (5 ASAs)	1973	780	77	180	18	50	5	1,010	2,760	9	3,480	11	25,520	80	31,800
	BPT/ST	190	45	180	43	50	12	420	260	1	3,480	12	25,520	87	29,300
	BAT/BPWTT	50	17	180	66	50	17	280	100	1	3,480	12	25,520	87	29,100
XIII. Rio Grande (5 ASAs)	1973	30	75	-	-	10	25	40	16,500	75	-	-	5,470	25	22,000
	BPT/ST	10	50	-	-	10	50	20	340	6	-	-	5,470	94	5,810
	BAT/BPWTT	0	0	-	-	10	100	10	230	4	-	-	5,470	96	5,700
XIV. Upper Colorado (3 ASAs)	1973	10	1	-	-	720	99	730	3,800	3	-	-	127,530	97	131,000
	BPT/ST	0	0	-	-	720	100	720	180	1	-	-	127,530	99	128,000
	BAT/BPWTT	0	0	-	-	720	100	720	110	1	-	-	127,530	99	128,000
XV. Lower Colorado (3 ASAs)	1973	80	57	-	-	60	43	140	94,690	79	-	-	25,010	21	120,000
	BPT/ST	20	25	-	-	60	75	80	790	3	-	-	25,010	97	25,800
	BAT/BPWTT	10	14	-	-	60	86	70	780	3	-	-	25,010	97	25,800
XVI. Great Basin (4 ASAs)	1973	30	50	10	17	20	33	60	86,850	93	210	1	5,840	6	92,900
	BPT/ST	10	25	10	25	20	50	40	890	13	210	3	5,840	84	6,940
	BAT/BPWTT	0	0	10	33	20	67	30	810	12	210	3	5,840	85	6,860
XVII. Pacific N.W. (7 ASAs)	1973	570	54	110	10	380	36	1,060	39,650	34	1,880	2	75,910	64	117,000
	BPT/ST	130	21	110	18	380	61	620	520	1	1,880	2	75,910	97	78,300
	BAT/BPWTT	80	14	110	20	380	66	570	460	1	1,880	2	75,910	97	78,300
XVIII. California (7 ASAs)	1973	1,470	69	140	6	530	25	2,140	16,820	16	2,750	2	87,990	82	108,000
	BPT/ST	320	32	140	14	530	54	990	700	1	2,750	3	87,990	96	91,400
	BAT/BPWTT	160	19	140	17	530	64	830	460	1	2,750	3	87,990	96	91,200
NATIONAL TOTALS (rounded)	1973	10,100	51	3,320	17	6,530	32	20,000	728,000	34	59,900	3	1,370,000	63	2,160,000
	BPT/ST	2,700	22	3,320	26	6,530	52	12,600	14,300	1	59,900	4	1,370,000	95	1,450,000
	BAT/BPWTT	1,300	12	3,320	30	6,530	58	11,200	13,400	1	59,900	4	1,370,000	95	1,440,000

TABLE B-3

Comparison Of N&P Discharge From Municipal and Non-Irrigated Agricultural For 1973 Conditions and Applying BPT/ST and BAT/BPWTT

Water Resource Region	Technology Applied	Phosphorus (lbs. 10^6)					Nitrogen (lbs. 10^6)				
		Municipal	% of Regional Total	Non-Irr. Agric.	% of Regional Total	Regional Total	Municipal	% of Regional Total	Non-Irr. Agric.	% of Regional Total	Regional Total
I. New England (6 ASAs)	1973	90	100	0	0	90	30	60	20	40	50
	BPT/ST	80	100	0	0	80	20	50	20	50	40
	BAT/BPWTT	60	100	0	0	60	20	50	20	50	40
II. Mid Atlantic (6 ASAs)	1973	380	97	10	3	390	100	71	40	29	140
	BPT/ST	330	97	10	3	340	90	69	40	31	130
	BAT/BPWTT	240	96	10	4	250	80	67	40	33	120
III. South Atlantic (9 ASAs)	1973	200	95	10	5	210	50	50	50	50	100
	BPT/ST	170	94	10	6	180	40	44	50	56	90
	BAT/BPWTT	100	91	10	9	110	40	44	50	56	90
IV. Great Lakes (8 ASAs)	1973	270	93	20	7	290	90	56	70	44	160
	BPT/ST	270	93	20	7	290	90	56	70	44	160
	BAT/BPWTT	130	87	20	13	150	90	56	70	44	160
V. Ohio (7 ASAs)	1973	170	51	160	49	330	50	12	370	88	420
	BPT/ST	160	50	160	50	320	40	10	370	90	410
	BAT/BPWTT	70	30	160	70	230	40	10	370	90	410
VI. Tennessee (2 ASAs)	1973	20	40	30	60	50	10	8	110	92	120
	BPT/ST	20	40	30	60	50	10	8	110	92	120
	BAT/BPWTT	10	25	30	75	40	10	8	110	92	120
VII. Upper Miss. (5 ASAs)	1973	110	41	160	59	270	30	6	480	94	510
	BPT/ST	100	38	160	62	260	30	6	480	94	510
	BAT/BPWTT	80	33	160	67	240	30	6	480	94	510
VIII. Lower Miss. (3 ASAs)	1973	60	28	150	72	210	10	3	280	97	290
	BPT/ST	50	33	150	67	200	10	3	280	97	290
	BAT/BPWTT	40	21	150	79	190	10	3	280	97	290
IX. Souris-Red-Rainy (1 ASA)	1973	0	-	0	-	0	0	-	20	100	20
	BPT/ST	0	-	0	-	0	0	-	20	100	20
	BAT/BPWTT	0	-	0	-	0	0	-	20	100	20
X. Missouri (11 ASAs)	1973	80	20	320	80	400	20	2	820	98	840
	BPT/ST	70	18	320	82	390	20	2	820	98	840
	BAT/BPWTT	70	18	320	82	390	20	2	820	98	840

TABLE B-3 (Continued)

Water Resource Region	Technology Applied	Phosphorus (lbs. 10^6)					Nitrogen (lbs. 10^6)				
		Municipal	% of Regional Total	Non-Irr. Agric.	% of Regional Total	Regional Total	Municipal	% of Regional Total	Non-Irr. Agric.	% of Regional Total	Regional Total
XI. Ark-White-Red	1973	50	50	50	50	100	10	7	130	93	140
(7 ASAs)	BPT/ST	50	50	50	50	100	10	7	130	93	140
	BAT/BPWTT	10	17	50	83	60	10	7	130	93	140
XII. Texas Gulf	1973	80	89	10	11	90	20	40	30	60	50
(5 ASAs)	BPT/ST	80	89	10	11	90	20	40	30	60	50
	BAT/BPWTT	10	50	10	20	20	20	40	30	60	50
XIII. Rio Grande	1973	10	100	0	0	10	0	-	0	-	0
(5 ASAs)	BPT/ST	10	100	0	0	10	0	-	0	-	0
	BAT/BPWTT	0	-	0	-	0	0	-	0	-	0
XIV. Upper Colorado	1973	0	0	160	100	160	0	0	360	100	360
(3 ASAs)	BPT/ST	0	0	160	100	160	0	0	360	100	360
	BAT/BPWTT	0	0	160	100	160	0	0	360	100	360
XV. Lower Colorado	1973	20	40	30	60	50	10	25	30	75	40
(3 ASAs)	BPT/ST	20	40	30	60	50	0	0	30	100	30
	BAT/BPWTT	10	25	30	75	40	0	0	30	100	30
XVI. Great Basin	1973	10	50	10	50	20	0	0	10	100	10
(4 ASAs)	BPT/ST	10	50	10	50	20	0	0	10	100	10
	BAT/BPWTT	10	50	10	50	20	0	0	10	100	10
XVII. Pacific N.W.	1973	60	33	120	67	180	10	5	190	95	200
(7 ASAs)	BPT/ST	50	29	120	71	170	10	5	190	95	200
	BAT/BPWTT	50	29	120	71	170	10	5	190	95	200
XVIII. California	1973	240	70	100	30	340	60	18	270	82	330
(7 ASAs)	BPT/ST	200	67	100	33	300	50	16	270	84	320
	BAT/BPWTT	100	50	100	50	200	50	16	270	84	320
NATIONAL TOTALS	1973	1,800	58	1,300	42	3,100	500	13	3,300	87	3,800
	BPT/ST	1,600	55	1,300	45	2,900	400	11	3,300	89	3,700
	BAT/BPWTT	1,000	38	1,300	62	2,300	400	11	3,300	89	3,700

APPENDIX C

Percent of Establishments in Industries Studied In-General Discharging Exclusively into Public Sewers

Industry Name	1972 SIC Category	Percent of Establishments* Discharging Exclusively into Public Sewers
Ore Mining and Dressing	1011	NA
	1021	NA
	1031	NA
	1041	NA
	1044	NA
	1051	NA
	1061	NA
	1092	NA
	1094	NA
	1099	NA
Coal Mining	1111	NA
	1211	NA
Petroleum and Gas Extraction	13	NA
Minerals Mining and Processing	1411	NA
	1442	NA
	1446	NA
	1454	NA
	1455	NA
	1459	NA
	1472	NA
	1473	NA
	1475	NA
	1476	NA
	1477	NA
	1492	NA
	1496	NA
	1499	NA
Meat Products and Rendering	2011	55
	2013	64
	2016	64
	2017[1]	54
	2017[2]	42
Miscellaneous Food and Beverages	2017[1]	58
	2051	93
	2052	68
	2065	68
	2066	50
	2067	100
	2074	8
	2075	21
	2076	62
	2077[2]	42
	2079	63
	2082	61
	2083	54
	2085	30
	2086	69
	2087	84

APPENDIX C

Industry Name	1972 SIC Category	Percent of Establishments* Discharging Exclusively into Public Sewers
Dairy Products	2021 2022 2023 2024 2026	38 25 37 76 67
Fruits and Vegetables	2032 2033 2034 2035 2037 2038 2099	44 29 47 52 26 67 66
Grain Mill Products	2043 2046 2047	54 33 50
Cane Sugar Refining	2062	4
Seafood	2077[2] 2091 2092	47 9 37
Builders Paper	2661[3]	36
Paving and Roofing	2951 2952 3996	6 27 40
Rubber	2822 3021 3031	9 27 0
Leather Tanning	3111	61
Glass	3211 3221 3229	15 32 19
Concrete, Gypsum	3275 3297	24 40
Pottery	3264	10
Asbestos	2661[3] 3292	36 35
Non-Ferrous Metals	3333	0
Ferroalloy	3313	5
Electroplating	3471 3479	78 83

APPENDIX C

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*All establishments using 20 million gallons/year or more.

[1] 2017 is classified under two NCWQ industry categories: Meat Products and Rendering and Miscellaneous Food and Beverages.

[2] 2077 is classified under three NCWQ industry categories: Meat Products and Rendering, Seafoods, and Miscellaneous Food and Beverages.

[3] 2661 is classified under two NCWQ industry categories: Builders Paper and Asbestos.

APPENDIX D

COMPARISON OF NRDI INDUSTRY EFFLUENTS AND EPA EFFLUENT GUIDELINES

P.L. 92-500 calls upon EPA to define effluent limitations and levels of residuals discharge reduction (mg/l or unit/unit product output) for point sources based on applying best practicable technology currently available (BPT) and best available technology economically achievable (BAT) for an industry. The effluent guidelines documents suggest specific RDR processes to provide adequate levels of residuals reduction to meet the defined effluent guidelines for an industry.

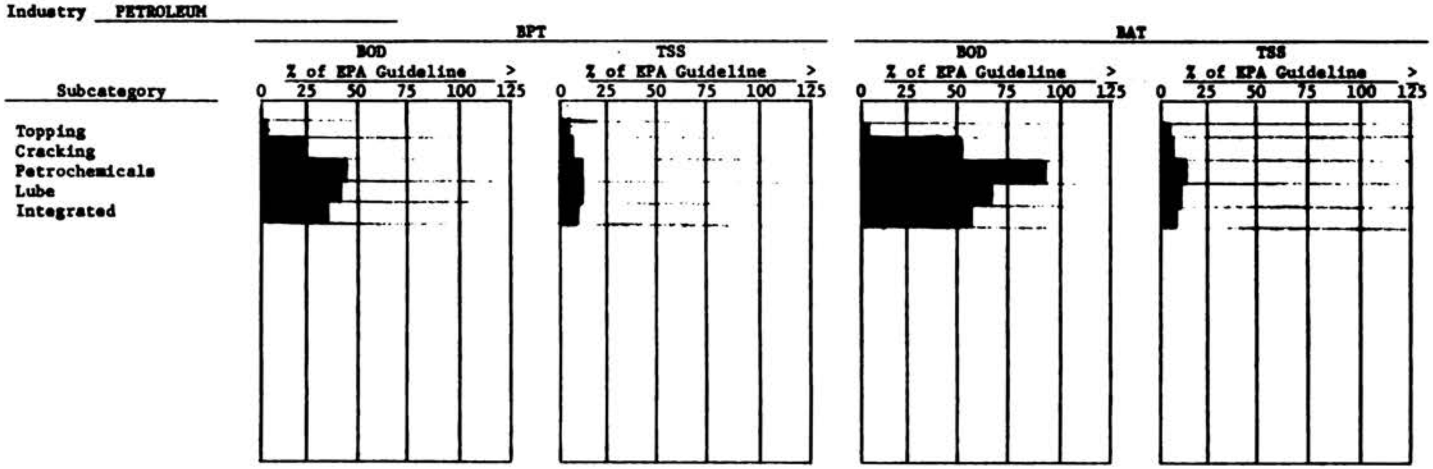
NRDI applies the RDR unit processes suggested by EPA to the average residuals loads defined by either EPA or NCWQ industry contractors for an industry subcategory. The resultant effluent levels are calculated based upon the representative removal efficiencies (Eckenfelder; U.S. EPA 1975) for a given RDR unit process. In many cases, however, the final effluents obtained from the recommended RDR technology sequences do not correspond to the effluent levels set by EPA.[1] These differences are documented in Table D-1, by subcategory, for the industries studied in depth by NRDI.

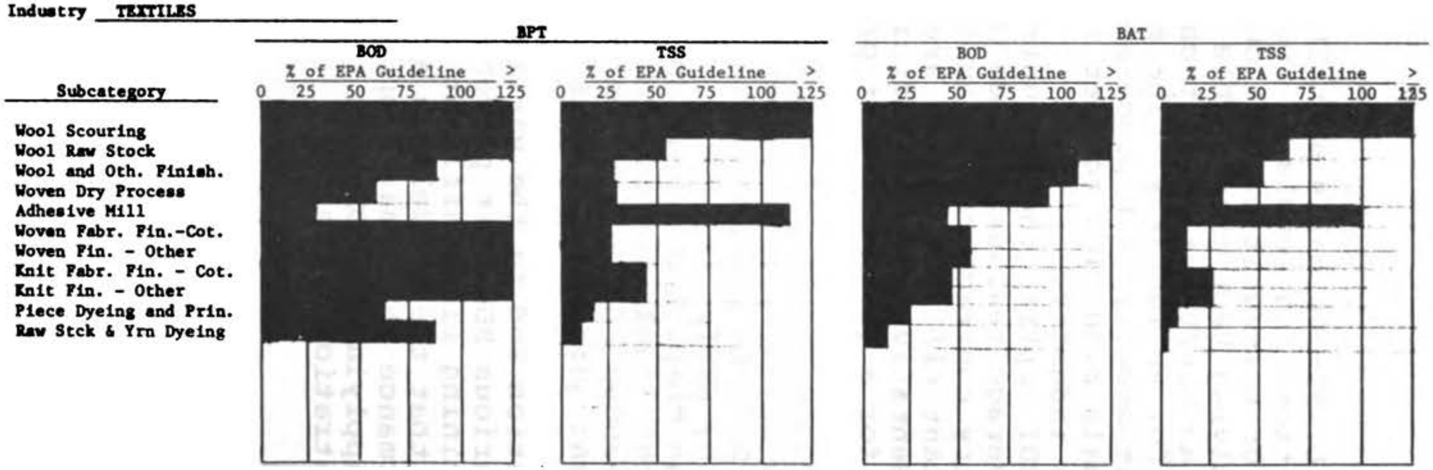
The comparisons help to illustrate the fact that the effluent levels for BOD and TSS obtained by applying recommended RDR unit processes do not always meet the effluent guidelines. This can be partially explained by the difficulties in obtaining accurate estimates of residuals generation and in the variability in operating efficiencies for various RDR unit processes; both are key variables in determining final effluent levels. It should further be noted that the guidelines are based on exemplary plant performance which may represent the industry differently from applying an RDR unit process to an average residual concentration value.

TABLE D-1

Comparison of NRDI Industry Effluents After Applying BPT and BAT and the EPA Effluent Guidelines for Industries Studied In-Depth

$$\left(\text{\% of EPA Guideline} = \frac{\text{NRDI Effluent}}{\text{EPA Guideline}} \times 100\right)$$



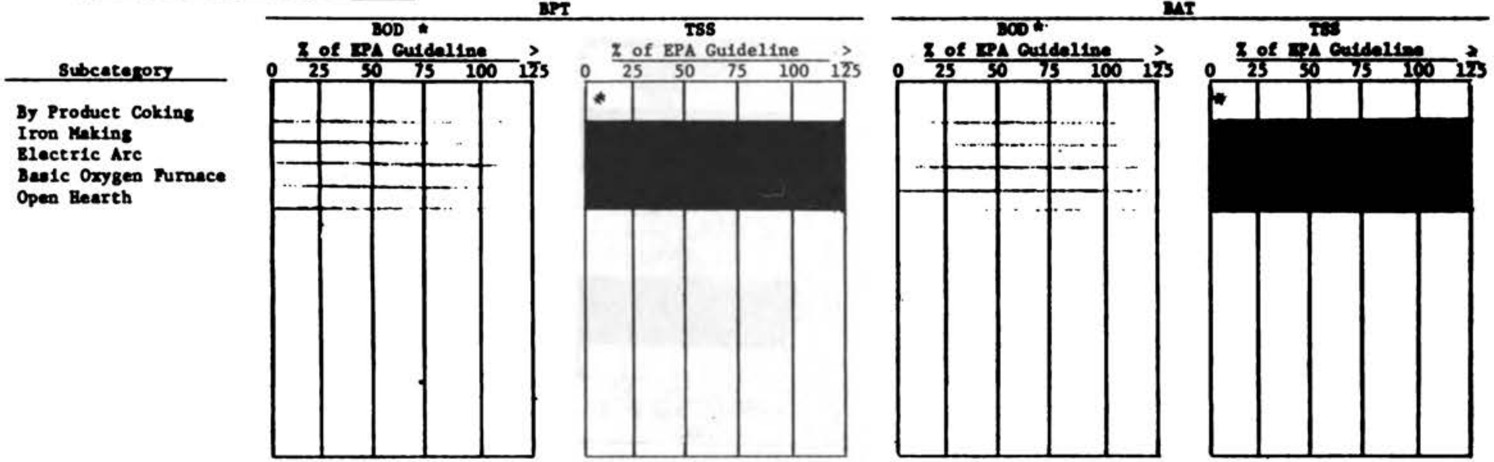


NOTE: Less than 100% indicates that estimated NRDI effluent is less than EPA guideline; greater than 100% indicates that estimated NRDI effluent exceeds EPA guideline.

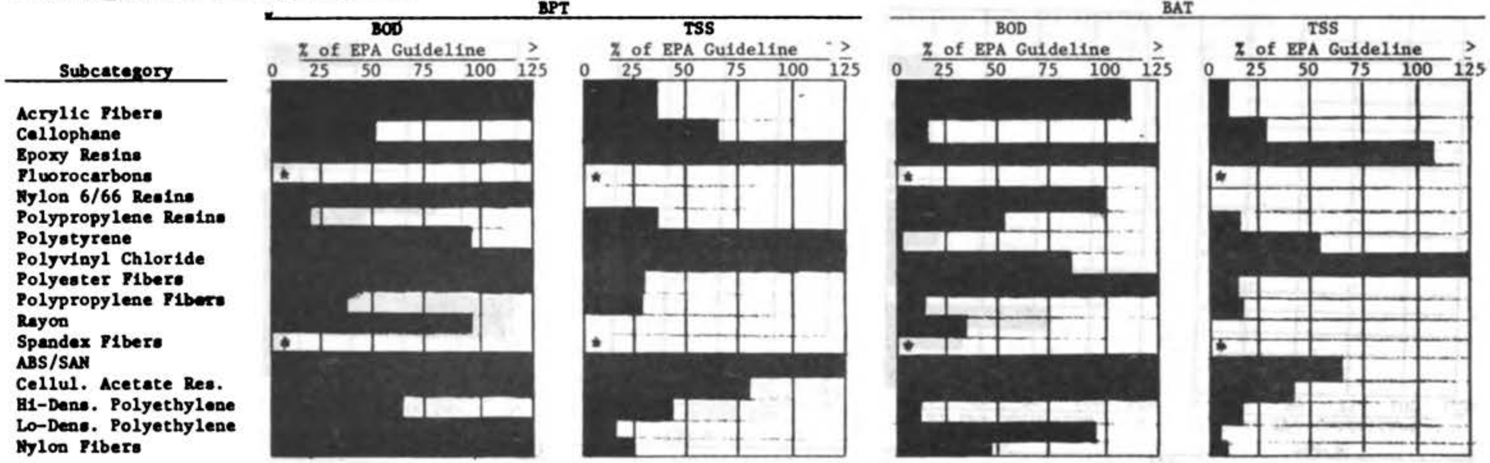
TABLE D-1 (Continued)

(% of EPA Guideline = $\frac{\text{NRDI Effluent}}{\text{EPA Guideline}}$ x 100)

Industry IRON AND STEEL



Industry PLASTICS AND SYNTHETICS



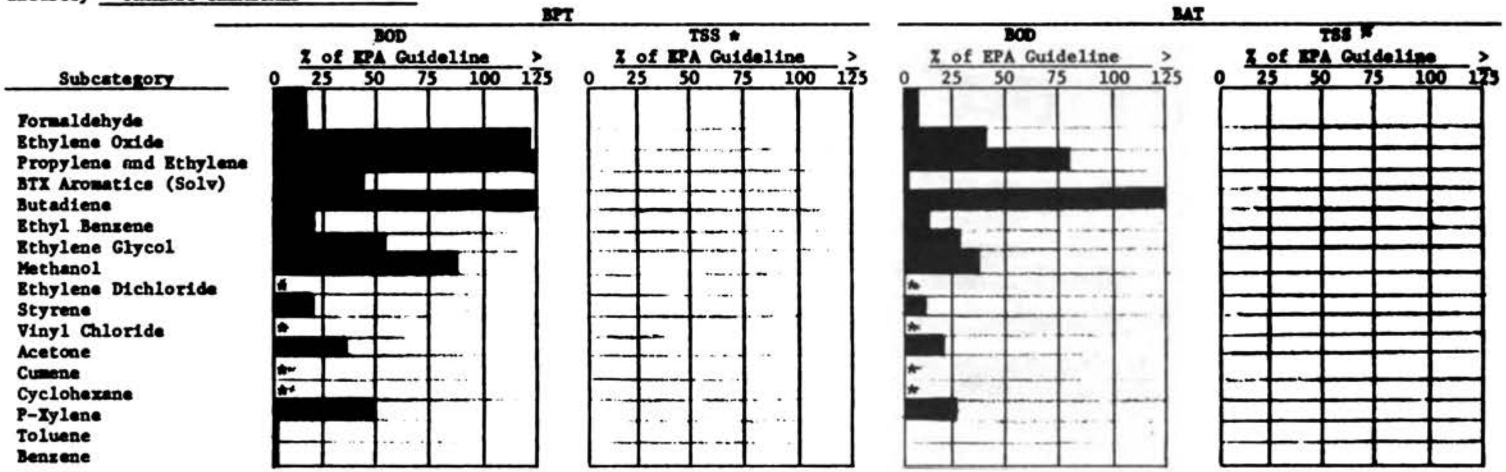
* Unable to make calculations due to lack of residuals generation data, although EPA guidelines are promulgated.

NOTE: Less than 100% indicates that estimated NRDI effluent is less than EPA guideline; greater than 100% indicates that estimated NRDI effluent exceeds ERA guideline.

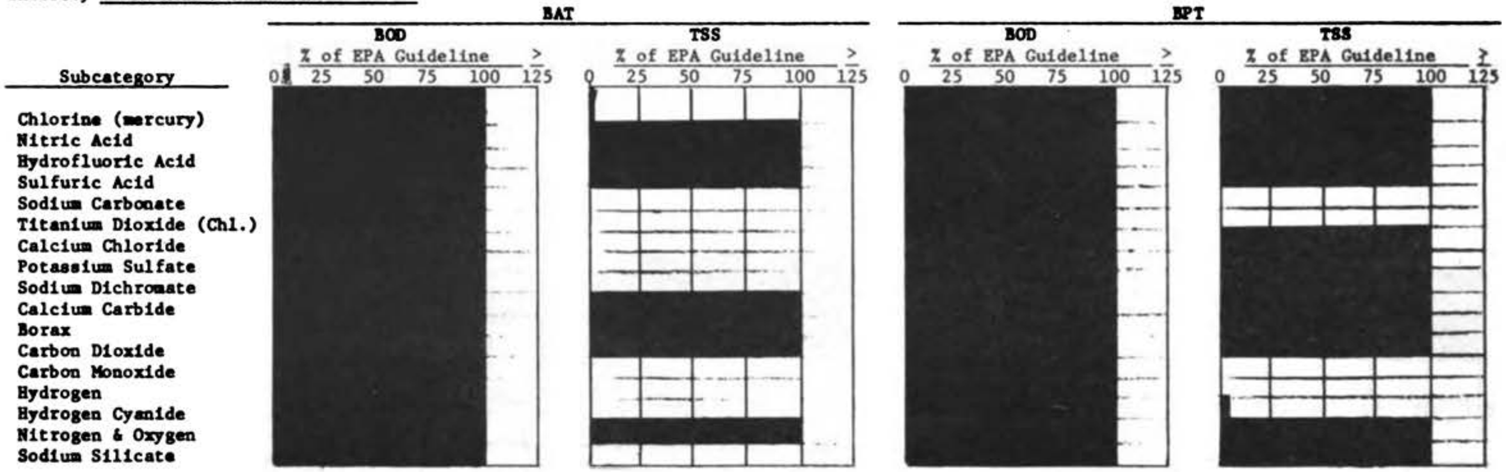
TABLE D-1 (Continued)

$(\% \text{ of EPA Guideline} = \frac{\text{NRDI Effluent}}{\text{EPA Guideline}} \times 100)$

Industry ORGANIC CHEMICALS[1]



Industry INORGANIC CHEMICALS[2,3]



1. Top 17 subcategories in industry represent 79% of total production in 1973.
2. Top 17 subcategories in industry represent 98% of total production in 1973.
3. EPA guideline is zero discharge for all subcategories shown as being 100% of EPA guideline; estimated NRDI effluents for these subcategories is also zero.

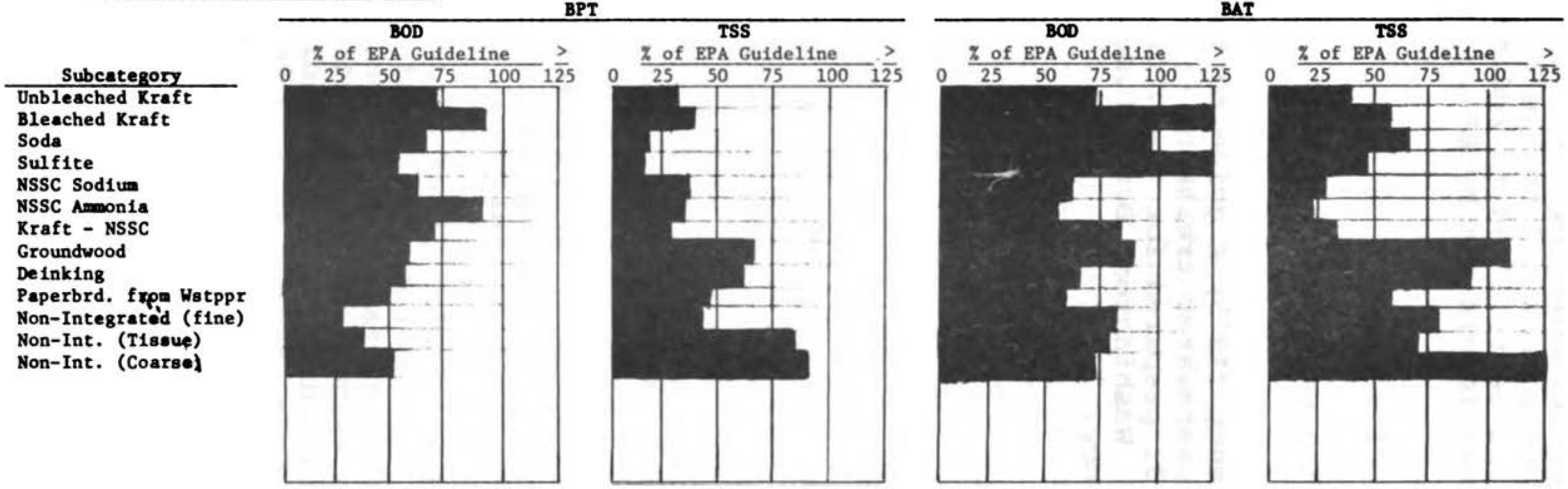
* Unable to make calculations due to lack of residuals generation data, although EPA guidelines are promulgated.

NOTE: Less than 100% indicates that estimated NRDI effluent is less than EPA guideline; greater than 100% indicates that estimated NRDI effluent exceeds EPA guideline.

TABLE D-1 (Continued)

$$(\% \text{ of EPA Guideline} = \frac{\text{NRDI Effluent}}{\text{EPA Guideline}} \times 100)$$

Industry PULP AND PAPER



NOTE: Less than 100% indicates that estimated NRDI effluent is less than EPA guideline; greater than 100% indicates that estimated NRDI effluent exceeds EPA guideline.

NOTE

1 In other words, the removal efficiencies of the recommended technologies do not correspond to the removal efficiencies that would be required to reduce raw waste loads to the effluent levels set by EPA.

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APPENDIX E

INVENTORIES OF INDUSTRIES STUDIED IN DEPTH

1. PULP AND PAPER INDUSTRY

The pulp and paper industry comprises some 600 mills[1] producing, as of January 1, 1973, approximately 168,000 tons of pulp per day in integrated mills[2] and 26,000 tons of paper per day in non-integrated mills. The industry is approximately defined by SIC categories 2611, 2621, and 2631. The 1967 Census of Manufactures (U.S. COM 1971) reports that these categories represent about 34 percent of total industrial process water use, which illustrates the importance of studying the industry in depth.

The inventory[3] used in NRDI consists of 556 mills, including roughly 97 percent of total production and 92 percent of all mills in the industry. The mills are classified into 13 production process categories based upon whichever process accounts for the greatest percentage of output. The inventory (Table E-1) contains estimated product, residuals generation coefficients, county location, and in-place RDR unit processes for each mill.

2. PETROLEUM REFINING INDUSTRY

The petroleum refining industry comprises 250 refineries with a rated crude throughput capacity of 14,216,580 barrels per stream day (Engineering Science Inc. 1975). The industry is defined by SIC category 2911. The 1967 Census of Manufactures reports that this category represents about 2 percent of total industrial process water use.

The inventory used in NRDI includes all 250 refineries. The refineries are classified (U.S. EPA 1974) into five production process categories based upon the predominant production process at each refinery. The inventory includes estimated product output, residuals generation coefficients, county location, and in-place RDR unit processes for each refinery (Table E-2).

3. TEXTILE INDUSTRY

The textile industry comprises approximately 6,000[4] plants, of which 1,926[4] have been defined as wet plants (using production processes which require water). NAS has

TABLE 8-1

Pulp and Paper Industry

PLANT INVENTORY			
Subcategory	# of Plants	Total MGD	Capacity T/D
Unbleached Kraft	28	493	24,634
Bleached Kraft	72	2,548	63,689
Soda	3	33	1,085
Sulfite	24	301	7,529
NSSC Sodium	16	72	4,805
NSSC Ammonia	2	7	670
Kraft - NSSC	10	147	9,781
Groundwood	37	377	18,862
Drinking	16	55	2,758
Paperbrd. from Wastepaper	152	251	25,097
Non-Integrated (Fine)	80	240	9,612
Non-Integrated (Tissue)	48	112	4,467
Non-Integrated (Coarse)	68	71	7,057
TOTAL	556	4,707	180,046

RESIDUALS GENERATION COEFFICIENT				
WW *	BOD	TSS	COD	TDS
	lbs/2000 lbs			
.020	40.0	45.0		
.040	80.0	100.0		
.030	95.0	150.0		
.040	200.0	90.0		
.015	55.0	25.0		
.010	70.0	40.0		
.015	55.0	45.0		
.020	50.0	120.0		
.020	65.0	200.0		
.010	15.0	30.0		
.025	20.0	50.0		
.025	30.0	75.0		
.010	35.0	90.0		
MG/ton				

ESTIMATES OF RESIDUAL DISCHARGE

	WW**	BOD	TSS	COD	TDS
	Million lbs. 1973				
Residuals Generation (Uncontrolled Discharge)	1717.4	3872.8	5082.1		
Present Residuals Discharge (1973) Estimated Value of Capital in Place* = $2,030	1717.4	2023.6	2391.8		
Discharge After BPT	1717.4	387.3	406.6		
Discharge After BAT	1717.4	193.6	152.5		

Discharge After BPT			
Unit Process	Removal Eff.		
	BOD	TSS	COD
•Primary Clarification	33%	52%	
•Activated Sludge including secondary clarification	85%	77%	
•Gravity Thickening			
•Vacuum Filtration			
•Landfill			
Total	90%	92%	

Estimated Cost($1975 x 10^6)	
Capital	O & M
$1,830	N/A

Discharge After BAT			
	Removal Eff.		
	BOD	TSS	COD
•BPT	90%	92%	
•Multi-media Filtration	50%	72%	
Total	95%	98%	

Estimated Cost($1975 x 10^6)	
Capital	O & M
$643	N/A

*$1975 x 10^6

**Billion gallons in 1973

TABLE E-2

Petroleum Industry

PLANT INVENTORY			
Subcategory	# of Plants	Total MGD	Capacity T/D
Topping	74	18	753
Cracking	113	209	6,443
Petrochem.	18	87	2,284
Lube	36	119	2,903
Integrated	9	124	1,514
TOTALS	250	557	13,897

RESIDUALS GENERATION COEFFICIENT				
WW *	BOD	TSS	COD	TDS
	lbs/1000 bbls			
.0233	1.2	4.1	13.0	
.0325	25.5	6.35	76.0	
.0380	60.0	17.0	162.0	
.041	76.0	25.0	190.0	
.082	69.0	20.3	115.0	

* MG/ton

ESTIMATES OF RESIDUAL DISCHARGE

	WW**	BOD	TSS	COD	TDS
		Million lbs. 1973			
Residuals Generation (Uncontrolled Discharge)	193.8	218.3	64.8	555.1	
Present Residuals Discharge (1973) Estimated Value of Capital in Place = $327	193.8	115.9	29.8	555.1	
Discharge After BPT	193.8	10.9	1.5	555.1	
Discharge After BAT	193.8	4.4	0.5	555.1	

Discharge After BPT			
Unit Process	Removal Eff.		
	BOD	TSS	COD
Recirculation	-	-	
Equalization/Oil Separation	-	-	
Flotation	40%	80%	
Activated Sludge/Second.Clar	85%	77%	
Multi-media Filtration	50%	72%	
Gravity Thickening	-	-	
Vacuum Filtration	-	-	
Landfill	-	-	
Total	95.0	97.7	

Estimated Cost ($1975 x 10⁶)	
Capital	O & M
$673	N/A

Discharge After BAT			
	Removal Eff.		
	BOD	TSS	COD
BPT	96%	97.7%	
Carbon Adsorption	60%	60%	
Regeneration			
Cooling Towers			
Total	98.0	99.2	

Estimated Cost ($1975 x 10⁶)	
Capital	O & M
$1,290	N/A

*$1975 x 10^6

**Billion gallons in 1973.

estimated that the 1,926 wet plants represent a production capacity of 334,064 tons per day. The industry is approximately defined by the two-digit SIC category 22. The 1967 Census of Manufactures reports that this category represents about 2 percent of total industrial process use, which illustrates the importance of studying the industry in depth.

The inventory used in NRDI consists of 1,926 wet plants, classified into 11 production process categories. The inventory includes estimated product output, residuals generation coefficients, county location for each plant and base level treatment, and RDR unit processes in place, for each production process category (Table E-3).

Product output per plant was estimated for 1,544 plants based upon reported data from the remaining 382 plants which responded to a Lockwood Greene questionnaire. Regressions were run, using the surveyed plants, between product output and the number of employees in each plant for the 11 production process categories. Using the number of employees in each plant, product output was then estimated for each of the remaining 1,544 plants. Base level RDR (in place) was approximated for each of the 11 categories by assuming that the RDR unit processes shown to be generally in place, per category, for the surveyed plants are generally in place for all plants in a category.

4. IRON AND STEEL INDUSTRY

The iron and steel industry comprises some 434 plants distributed among the following subcategories:

	Plants	Production (T/day)
By-Product Coke	50	186,000
Iron Making	11	29,000
Steel Production	48	304,000
Steel Scrap	112	74,000
Non-Integrated	213	41,000

These plants are estimated to have produced 378,000 tons of steel per day in 1973, which holds the record for peak steel production in the U.S. The industry is approximately defined by SIC category 3312. The 1967 Census of Manufactures reports that this category alone accounts for 24 percent of total industrial process water intake.

The inventory used in NRDI consists of 221 plants. NRDI disaggregated steel production into three types of process, which combined the NCWQ steel production and steel scrap categories, and took plant production data from the NCWQ report. A plant is classified by whichever process accounts for the greatest percentage of the plant output. NRDI does not account for non-integrated production because there are no plant level production data. NRDI includes the NCWQ

TABLE E-3

Textiles Industry

PLANT INVENTORY			
Subcategory	# of Plants	Total MGD	Capacity T/D
Wool Scouring	41	16	1,877
Wool Raw Stock	64	40	498
Wool & Other Finishing	158	46	573
Woven Dry Process	329	13	4,339
Adhesive Mill	145	9	2,923
Woven Fabric Fnshng.-Ctt.	476	161	5,947
Woven Fbrc. Fnshng.-Otr.	119	39	1,462
Knit Fbrc. Fnshng.-Cotton	243	43	1,208
Knit Fbrc. Fnshng.-Other	133	50	1,376
Piece Dyng. & Printing	83	41	2,468
Raw Stock & Yarn Dyeing	129	57	1,587
TOTAL	1,920	515	24,258

RESIDUALS GENERATION COEFFICIENT				
WW *	BOD	TSS	COD	TDS
lbs/2000 lbs				
.0086	390	538		
.08	200	86		
.08	200	86		
.003	7.4	3.8		
.003	3.6	13.8		
.027	124	42		
.027	124	42		
.036	75	90		
.036	75	90		
.0166	47	16.6		
.036	60	14.7		
*MG/ton				

ESTIMATES OF RESIDUAL DISCHARGE

	WW **	BOD	TSS	COD	TDS
	Million gallons in 1973				
Residuals Generation (Uncontrolled Discharge)	1,131.8	693.8	529.8		
Present Residuals Discharge (1973) Estimated Value of Capital in Place = $255	1,131.8	382.7	387.2		
Discharge After BPT	1,131.8	69.4	58.3		
Discharge After BAT	1,131.8	22.8	12.3		

Discharge After BPT			
Unit Process	Removal Eff.		
	BOD	TSS	COD
Subcategory specific,			
see Chapter 3 for EDR			
technology sequences			

Estimated Cost ($1975 x 10⁶)	
Capital	O & M
$428	N/A

Discharge After BAT			
	Removal Eff.		
	BOD	TSS	COD
Subcategory specific,			
see Chapter 3 for EDR			
technology sequences			

Estimated Cost ($1975 x 10⁶)	
Capital	O & M
$320	N/A

*$1975 x 10^6

**Billion gallons in 1973.

reported production level, residuals generation coefficients, and county location for each plant in each subcategory (Table E-4). The in-place RDR technology is the average level of technology installed in 1972 for each subcategory as estimated in the EPA development document.

5. PLASTICS AND SYNTHETICS INDUSTRY

The plastics and synthetics industry produced approximately 47,814 tons per day in 1972. The industry is defined by SIC categories 2821, 2823, 2824, and 2869. The 1967 Census of Manufactures reports that these categories represent about 1 percent of total industrial process water use, which illustrates the importance of studying the industry in depth.

The total number of plants in the industry producing the approximately 30 products considered under effluent guidelines is not clearly defined. EPA identified 250 plants as producers of plastics and synthetics.

The NCWQ contractor, Procon, Inc., estimated 757 plants as producers of plastics and synthetics. The NRDI inventory comes from the International Research and Technology work for the NCWQ and is based on the Procon inventory which identifies 246 plants with production information covering 17 products. It is important to note that the plants producing organic chemicals also produce plastics and synthetics. This introduces potential double counting of costs for a plant producing both organics and plastics because of economies of scale in constructing RDR facilities. Furthermore, because of the multi-product/process nature of the industry, a plant may be classified in more than one product/process category based upon its array of major products. The inventory includes estimated product output, residuals generation coefficients per product category, county location, and company name for each mill (Table E-5).

6. ORGANIC CHEMICALS INDUSTRY

The organic chemicals industry produced 244,399.4 tons per day of organic chemical products in 1972. The industry is approximately defined by SIC categories 2865 and 2869. According to the 1967 Census of Manufactures, this industry represents about 9.2 percent of total industrial process water use, which illustrates the importance of studying the industry in depth.

The total number of plants in the industry producing the approximately 80 products falling under effluent guidelines is not clearly defined. EPA identifies 238 plants as Phase I while Phase II inventory information is not available at this time. The NCWQ contractor, Catalytic Inc., studied 69

TABLE E-4

Iron and Steel Industry

PLANT INVENTORY			
Subcategory	# of Plants	Total MGD	Capacity T/D
By Product Coking	51	47.4	187199.6
Iron Making	11	114.7	29400.0
Electric Arc	114	1188.9	84555.9
BOF	31	4598.0	318199.6
Open Hearth	15	1419.1	96999.8
TOTAL	222	7368.1	716354.7

RESIDUALS GENERATION COEFFICIENT				
WW*	BOD	TSS	COD	TDS
lbs/2000 lbs				
.0003	1.2	0.8		
.0039	0.0	52.3		
.014	0.0	30.9		
.0145	0.0	72.3		
.0146	0.0	76.9		

*MG/ton

ESTIMATES OF RESIDUAL DISCHARGE

	WW+	BOD	TSS	COD	TDS
	Million Gallons in 1973				
Residuals Generation (Uncontrolled Discharge)	2579.5	78.6	12167.9		
Present Residuals Discharge (1973) Estimated Value of Capital in Place = $853	2579.5	39.3	2568.0		
Discharge After BPT	2579.5	5.9	820.3		
Discharge After BAT	2579.5	1.2	68.1		

Discharge After BPT			
Unit Process	Removal Eff.		
	BOD	TSS	COD
Subcategory specific,			
see Chapter 3 for EDR			
technology sequences			

Estimated Cost ($1975 x 10^6)	
Capital	O & M
$1,890	N/A

Discharge After BAT			
	Removal Eff.		
Subcategory specific,	BOD	TSS	COD
see Chapter 3 for EDR			
technology sequences			

Estimated Cost ($1975 x 10^6)	
Capital	O & M
$1,310	N/A

*$1975 x 10^6

+Billion gallons in 1973.

TABLE E-5

Plastics and Synthetics Industry

PLANT INVENTORY			
Subcategory	# of Plants	Total MGD	Capacity T/D
Acrylic Fibers	7	7.1	1050
Cellophane	7	30.9	525
Epoxy Resins	8	3.0	513
Fluorcarbons	5	10.7	523
Nylon 6/66 Resins	31	6.9	419
Polypropylene Resins	10	6.8	3144
Polystyrene	35	13.3	6061
Polyvinyl Chloride	38	28.5	7902
Polyester Fibers	29	4.8	4453
Polypropylene Fibers	9	1.1	372
Rayon	8	51.9	1574
Spandex Fibers	3	0.1	22
ABS/SAN	12	9.1	2216
Cellulose Acetate Resins	12	20.8	2078
Hi-density Polyethylene	14	28.3	4040
Lo-density Polyethylene	23	42.1	9890
Nylon Fibers	31	50.2	3032
TOTAL	282	315.6	47,814

RESIDUALS GENERATION COEFFICIENT				
WW *	BOD	TSS	COD	TDS
lbs/2000 lbs				
.0068	52.0	3.4	90.0	
.0588	44.0	96.0	170.0	
.0058	138.0	28.0	130.0	
.0205	6.6	8.8	48.0	
.0166	30.0	0.04	28.0	
.0022	8.5	3.7	15.6	
.0022	2.0	8.4	6.0	
.0036	11.4	60.0	58.0	
.0011	40.0	1.4	52.0	
.0030	1.5	2.8	4.4	
.033	44.0	0.0	110.0	
.0027	40.0	0.0	80.0	
.0041	41.4	16.0	67.0	
.01	110.0	22.0	112.0	
.007	2.0	3.4	2.4	
.0043	8.8	0.8	24.0	
.0166	14.0	0.4	16.0	
*MG/ton				

ESTIMATES OF RESIDUAL DISCHARGE

	WW **	BOD	TSS	COD	TDS
	Million lbs. 1973				
Residuals Generation (Uncontrolled Discharge)	105.9	335.0	241.5		
Present Residuals Discharge (1973) Estimated Value* of Capital in Place - $454	105.9	224.5	115.9		
Discharge After BPT	105.9	33.5	26.6		
Discharge After BAT	105.9	6.7	2.4		

Discharge After BPT			
Unit Process	Removal Eff.		
	BOD	TSS	COD
Equalization	-	-	-
~~Neutralization~~	-	-	-
Primary Clarification	33%	52%	-
Activated Sludge, including secondary clarification	85%	77%	-
Gravity Thickening	-	-	-
Vacuum Filtration	-	-	-
Landfill	-	-	-
Total	90.6%	90%	

Estimated Cost($1975 x 10^6)	
Capital	O & M
$298	N/A

Discharge After BAT			
	Removal Eff.		
	BOD	TSS	COD
BPT	90.6%	90%	
Two Stage Chemical Addition			
Total	98.0	99.0	

Estimated Cost ($1975 x 10^6)	
Capital	O & M
$195	N/A

*$1975 x 10^6

**Billion gallons in 1973.

products and identified 345 plants as producers of Phase I and Phase II organic chemicals. The NRDI inventory comes from the International Research and Technology Corporation work for the NCWQ and is based on the Catalytic inventory. It identifies 522 plants, gives production information for 320 plants and studies 64 Phase I and II Organic chemical products. Due to the multi-product/process nature of the industry, a plant may be classified in more than one product/process category based upon its array of major products. The inventory includes estimated product output, residuals generation coefficients per product category, county location, and company name for each mill (Table E-6).

7. INORGANIC CHEMICALS INDUSTRY

The inorganic chemicals industry produced 419,206 tons per day of inorganic chemical products in 1972. The industry is approximately defined by SIC categories 2812, 2813, 2816, and 2819. According to the 1967 Census of Manufactures, this industry represents about 1.3 percent of total industrial process water use, which illustrates the importance of studying the industry in depth.

The total number of plants in the industry producing the approximately 60 products considered under effluent guidelines is not clearly defined. Many of the products studied do not have guidelines promulgated at this time. EPA does not present inventory information in the Phase I and II development documents. The NCWQ contractor, Catalytic, Inc., identified 994 plants, 95 products of inorganic chemicals; however, this inventory is in the process of being consolidated to omit divisions within the same plant. The NRDI inventory comes from International Research and Technology Corporation work for NCWQ and is based on the Catalytic inventory which identifies 926 plants; however, production information is available for only 688 plants covering 35 products. Because of the multi-product/process nature of the industry, a plant may be classified in more than one product/process category based upon its array of major products. The inventory includes estimated product output, residuals generation per product category, county location, and company name for each mill (Table E-7).

TABLE E-6

Organic Chemicals

PLANT INVENTORY			
Subcategory	# of Plants	Total MGD	Capacity T/D
Acetaldehyde	7	6.1	1916
Acrylonitrile	4	NA	NA
Citric Acid	1	13.7	120
Dimethyl Terephthalate	8	1.8	3493
Maleic Anhydride	6	.5	406
Pentaerythritol	3	.4	172
Phenol and Acetone	8	2.0	3245
Plasticizers	10	3.0	1341
Propylene Oxide	5	28.9	1903
Tetraethyl Lead	2	15.7	656
Formaldehyde	47	3.2	10812
Ethylene Oxide	14	1.2	5833
Phthalic Anhydride	10	3.2	1400
Propylene and Ethylene	39	28.8	41067
BTX Aromatics (Solv)	22	1.5	14580
Isopropanol	4	11.5	2337
Acrylates	4	6.3	1105
Acetylene	14	1.4	1279
Acrylic Acid	4	1.1	1105
Aniline	4	.3	731
Bisphenol A	5	.1	644
Butadiene	17	14.2	6177
Paracresol	1	.1	37
Ethyl Benzene	15	.8	7927
Ethylene Glycol	14	7.2	5965
Methanol	12	1.3	12484
Ethylene Dichloride	20	4.4	22114
Methyl Amines	6	.4	416
Methyl Methacrylates	5	.5	1167
Styrene	13	35.6	10158
Terephthalic Acid	4	1.0	2447
Totals			

RESIDUALS GENERATION COEFFICIENT				
WW*	BOD	TSS	COD	TDS
lbs/2000 lbs				
.0032				
.001	2.24			
.114	77.4			
.0005	656.8			
.0011	48.8			
.0024	216			
.0006	780			
.0002	11.2			
.015	107.8			
.024	63.0			
.0003	8.0			
.0002	.2			
.0023	1.4			
.0007	.256			
.0001	-			
.0049	1.9			
.0057	94.0			
.0011	3.8			
.001	1.49			
.0004	-			
.0001	10.2			
.0023	5.9			
.0026	246.0			
.0001	.26			
.0012	.68			
.0001	.98			
.0002	-			
.0009	.96			
.0004	90.0			
.0035	2			
.0004	1.6			

*MG/ton

TABLE E-6 (Continued)

INDUSTRY DISCHARGE INVENTORY

PLANT INVENTORY				RESIDUALS GENERATION COEFFICIENT				
Subcategory	# of Plants	Total MGD	Capacity T/D	WW*	BOD	TSS	COD	TDS
				lbs/2000 lbs				
Methyl Ethyl Ketone	6	.3	896	.0003	75.0			
Cresol	1	0	8	.0005	95.4			
Hexamethylene Tetramine	5	.2	126	.0014	18.4			
Sec Butyl Alcohol	1	.7	85	.0079	28.4			
Monosodium Glutamate	3	1.1	70	.016	122			
Caprolactum	3	3.0	1135	.0026	3.2			
Vinyl Chloride	22	55.5	13885	.004	–			
Vinyl Acetate	8	.2	2446	.0001	.08			
Acetic Acid	10	3.7	3707	.001	.7			
Oxo Chemicals	12	2.2	2723	.0008	6.4			
Acetone	17	1.3	3360	.0004	.52			
Cumene	13	.1	4155	–	–			
Cyclohexane	9	0	3635	NA	NA			
-Xylene	28	.1	9131	NA	NA			
Naphthenic Acid	4	4.6	47	.098	282.0			
Nitro anilene	1	.2	3	.065	33.8			
Saccharin	1	.2	3	.064	706.0			
Perchloroethylene	8	1.8	1389	.0013	.88			
Chlorinated Methanes	12	1.5	2068	.0007	.44			
Toluene	36	.8	7730	.0001	.0002			
Benzene	51	1.5	15199	.0001	.0002			
M-Xylene	1	0	52	.0001	.0002			
O-Xylene	12	.2	2320	.0001	.0002			
Chlorobenzene	4	.2	275	.0006	.3			
Chlorotoluene	6	5.7	197	.029	.49			
Methyl Chloride	15	3.1	1052	.0028	35.4			
Acetic Esters	12	.5	1657	.0003	.098			
Tricresyl Phosphate	3	1.0	145	.0067	2.2			
Formic Acid	4	3.5	109	.032	7.9			
Propylene Glycol	6	.8	645	.0013	.032			
Pentachlorophenol	2	1.3	28	.045	1.88			
Totals								

* MG/ton

TABLE E-6 (Continued)

PLANT INVENTORY			
Subcategory	# of Plants	Total MGD	Capacity T/D
BTX Aromatics	1	-	1
Phenol	11	1.9	3080
Totals	657	293.4	244399

RESIDUALS GENERATION COEFFICIENT				
WW*	BOD	TSS	COD	TDS
	lbs/2000 lbs			
-	.2			
.0006	11.2			

*MG /ton

TABLE E-6 (Continued)

ESTIMATES OF RESIDUAL DISCHARGE

	WW +	BOD	TSS	COD	TDS
	Million lbs. 1973				
Residuals Generation (Uncontrolled Discharge)	97.2	1,980.2			
Present Residuals Discharge (1973) Estimated Value* of Capital in Place = $364	97.2	1,326.7			
Discharge After BPT	97.2	186.1			
Discharge After BAT	97.2	39.6			

Discharge After BPT

Unit Process	Removal Eff.		
	BOD	TSS	COD
Equalization Neutralization			
Primary Clarification	33%	52%	
Activated Sludge including			
Secondary Clarification	85%	77%	
Gravity Thickening	-	-	
Vacuum Filtration	-	-	
Landfill	-	-	
TOTAL	90.6%	90%	

Estimated Cost ($1975 x 10^6)

Capital	O & M
$1,425	N/A

Discharge After BAT

	Removal Eff.		
	BOD	TSS	COD
BPT	90.6%	90%	
Multimedia Filtration	50%	72%	
Carbon Adsorption	60%	60%	
TOTAL	98%	98.5%	

Estimated Cost ($1975 x 10^6)

Capital	O & M
$1,409	N/A

*$1975 x 10^6

+Billion gallons in 1973

TABLE E-7

Inorganic Chemicals

PLANT INVENTORY			
Subcategory	# of Plants	Total MGD	Capacity T/D
Chlorine (mercury)	67	1430.9	32476
Nitric Acid	78	8.8	29663
Hydrofluoric Acid	14	26.3	1217
Sulfuric Acid	159	5.4	121493
Sodium Carbonate	11	0	25894
Titanium Dioxide (Chl.)	8	41.1	1590
Titanium Dioxide (Sulf)	5	34.0	1214
Calcium Chloride	9	3.1	3382
Hydrogen Peroxide (Alkyl H)	5	20.4	290
Hydrogen Peroxide (Elect.)	2	--	33
Potassium Sulfate	7	5.4	4478
Sodium Dichromate	28	9.6	4543
Aluminum Chloride	11	0	260
Calcium Carbide	5	6.0	1428
Sodium Bicarbonate	4	1.0	705
Sodium Sulfite	7	.1	798
Ammonium Chloride-Solvay	1	0	6
Barium Carbonate	3	1.1	219
Borax	4	1.4	2069
Bromine	10	1.4	488
Carbon Dioxide	94	1.8	39014
Carbon Monoxide	1	28.8	29123
Chromic Acid	4	.2	106
Ferric Chloride	9	.5	516
Ferrous Sulfate	-	-	-
Hydrogen	45	19.0	19209
Hydrogen Cyanide	11	11.7	1585
Manganese Sulfate	4	1.3	228
Nitrogen & Oxygen	108	.8	92874
Potassium Chloride	-	-	-
Sodium Hydrosulfide	14	.5	314
Totals			

RESIDUALS GENERATION COEFFICIENT				
WW*	BOD	TSS	COD	TDS
lbs/2000 lbs				
.044	-	15.5		
.0003	.002	.040		
.022	NA	NA		
.000044	NA	.050		
.000001	NA	NA		
.0259	NA	.67		
.028	.18	533		
.0009	NA	.26		
.07	.77	1.07		
.0001	NA	NA		
.0012	NA	1300.0		
.002	NA	.04		
.00003	NA	NA		
.004	NA	1.0		
.001	NA	.5		
.00015	.2	NA		
.0023	NA	NA		
.0048	NA	.21		
.0007	.091	NA		
.0029	NA	1.0		
.00005	NA	.09		
.0009	.12	.12		
.0021	NA	.04		
.0009	NA	1.0		
NA	NA	NA		
.0009	NA	1.0		
.007	13.5	2.0		
.0057	NA	554.0		
.000009	NA	.009		
NA	NA	NA		
.0017	NA	40.9		

*MG/ton

TABLE E-7 (Continued)

PLANT INVENTORY			
Subcategory	# of Plants	Total MGD	Capacity T/D
Sodium Thiosulfate	4	0	81
Sulfur Dioxide	9	7.2	657
Sodium Metal	5	1.2	563
Sodium Silicate	31	1.9	2690
Totals	777	1670.9	419206

RESIDUALS GENERATION COEFFICIENT				
WW*	BOD	TSS	COD	TDS
lbs/2000 lbs				
.0003	NA	NA		
.011	10.9	22.2		
.0022	NA	.092		
.00071	NA	NA		

*MG/ton

TABLE E-7 (Continued)

ESTIMATES OF RESIDUAL DISCHARGE

	WW +	BOD	TSS	COD	TDS
	Million lbs. 1973				
Residuals Generation (Uncontrolled Discharge)	559.8	11.7	2395.9		
Present Residuals Discharge (1973)	559.8	7.9	1150.0		
Discharge After BPT	559.8	5.6	693.9		
Discharge After BAT	593.8	4.1	347.1		

Present Residuals Discharge (1973)

Estimated Value*of Capital in Place = $366

Discharge After **BPT**

Unit Process	Removal Eff.		
	BOD	TSS	COD
Subcategory specific,			
see Chapter 3 for RDR			
technology sequences			

Estimated Cost ($1975 x 10^6)

Capital	O & M
$564	N/A

Discharge After **BAT**

	Removal Eff.		
	BOD	TSS	COD
Subcategory specific,			
see Chapter 3 for RDR			
technology sequences			

Estimated Cost ($1975 x 10^6)

Capital	O & M
$147	N/A

*$1975 x 10^6

+Billion gallons in 1973

NOTES

1 EPA, the NCWQ contractor, Hazen and Sawyer, and industry sources generally agree that there are approximately 600 pulp and paper mills in the United States.

2 Integrated mills produce both pulp and paper and account for over 80 percent of total plant capacity and 65 percent of the total number of mills in the industry.

3 The NRDI inventory is based upon the Phase I and II inventories developed by EPA and the 1974 Post's Pulp and Paper Directory.

4 Estimated by NCWQ contractor, Lockwood Greene.

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APPENDIX F

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE
SOUTHERN REGION
P. O. Box 400
Chickasha, Oklahoma 73018

December 5, 1975

Dr. Ralph Luken
Environmental Studies Board
National Research Council
2101 Constitution Avenue
Washington, D. C. 20418

Dear Dr. Luken:

I've examined the material you sent me in regard to pollutant loadings from nonirrigated cropland. The equations proposed by MRI for nitrogen, phosphorus, pesticides and BOD using suspended sediment, an enrichment ratio, and the content in the watershed is a logical approach. One difficulty comes in estimating those parameters. Also, it should be noted that not all of the nitrogen and phosphorus and pesticide associated with the sediment is available for biological use. Therefore, estimates of total nitrogen, total phosphorus, and total pesticide are not necessarily the best estimate in terms of water quality. Unfortunately, biologists have not provided us with better estimators. In addition, some of the sediment settles to the bottom of the impoundments and is covered by subsequent sediment inputs.

Their methods of estimating the nitrogen, phosphorus, pesticide and BOD content of the watershed soil are crude at best as indicated in your analysis. A better estimate of the total N and total P in soils could be obtained from the Soil Conservation Service or the soil testing laboratories at the State Experiment Stations. There is very limited data for estimating the enrichment ratios and this data is principally from small plot studies. I think that the errors involved in estimating these parameters are probably not more than a factor of 2 for each parameter.

The method used to predict suspended sediment appears to have the greatest potential for error. From suspended sediment data for some Texas streams and some tributaries of the Delaware River, I calculated the average measured values shown in the enclosed table. The "measured" values are a little lower than the Iowa State University values you calculated, but a great deal lower than the MRI values. Slightly lower values might be anticipated because the "measured" values include pasture, range, and forested land which has low sediment yields except when gullies are present.

While the Iowa State sediment delivery ratio appears to give more realistic estimates of suspended sediment, it must be recognized that the Universal Soil Loss equation was developed from small plot data. Extending the use of the equation to watersheds or counties involves assuming some average value for each of the parameters, especially the degree and length-of-slope parameter. Because the slope-length factor can vary so much, we decided in our Guidelines Report that estimates of soil loss for large areas could only be grouped into four classes: low, medium, large, and very large. Thus, both methods may be subject to considerable error in the estimation of gross erosion.

In my opinion, an adequate comparison of point versus nonpoint sources may still be possible for suspended sediment, pesticides, and BOD. Limiting sediment yield from sources such as construction and mining sites will certainly leave rural lands as the source of most of the total suspended sediment. Secondary treatment of municipal and industrial waste should probably leave rural lands as the major source of BOD. Agricultural lands are already the major source of pesticides provided all pesticide manufacturing plants are controlled. The estimates of nitrogen and phosphorus appear to be inadequate for accurate comparison. Municipal wastes will require tertiary treatment for a significant reduction in nitrogen and phosphorus. With tertiary treatment, the contribution of soluble nitrogen and phosphorus will probably approach that from nonpoint contributions in many watersheds. In terms of total nitrogen and total phosphorus, the contribution from nonpoint sources will probably exceed the contribution from point sources in most watersheds.

I have asked a colleague of mine in Washington to send you a copy of our Guidelines Report when it is printed this week. Enclosed is a draft of Chapter 4 in the second volume of that report that may be of some help to you.

Sincerely,

Maurice H. Frere

Maurice H. Frere
Soil Scientist

Enclosures

cc: B. A. Stewart

Predicted and Average Measured Sediment Yields for Six Aggregated Subareas

				Average	
	Area	MRI	ISU	Measurements	Area
ASA	mi^2	tons/mi^2			
1201	849	3,535	616	120	4,200
1202	4,268	4,313	328	190	12,700
1203	12,424	2,948	1,116	560	24,600
1204	7,909	2,041	265	190	18,200
1205	5,447	2,776	157	140	2,600
203	3,112	4,392	321	120	10,100

APPENDIX G

Comparison of NCWQ and Iowa State Estimates Of Sediment Delivery Ratios from Non-Irrigated Cropland

ASA Number	Computed NCWQ Sediment Delivery Ratio Sdn	Iowa State Sediment Delivery Ratio SdI	Ratio $\frac{SdI}{Sdn}$
0101	0.02	.016	1.25
0102	0.02	.016	1.25
0103	0.01	.041	0.24
0104	0.04	.041	0.98
0105	0.03	.041	0.73
0106	0.05	.04*	1.25
0201	0.08	.025	3.20
0202	0.04	.025	1.60
0203	0.17	.012	14.1
0204	0.20	.016	12.5
0205	0.19	.01	19.0
0206	0.14	.008	17.5
0301	0.11	.006	18.3
0302	0.09	.005	18.0
0303	0.07	.004	17.5
0304	0.04	.003	13.3
0305	0.003	.003	0
0306	0,07	.002	35.0
0307	0.09	.016	5.62
0308	0.11	.019	0.58
0309	0.09	.012	7.50
0401	0.02	.03*	0.67
0402	0.15	.03*	5.00
0403	0.21	.03*	7.00
0404	0.14	.03*	4.66
0405	0.14	.03*	4.66
0406	0.21	.03*	7.00
0407	0.08	.03*	2.66
0408	0.12	.03*	4.00
0501	0.08	.03*	2.66
0502	0.12	.064*	1.87
0503	0.20	.03*	6.66
0504	0.06	.03*	2.00
0505	0.19	.185*	1.02
0506	0.30	.03*	10.0
0507	0.15	.01*	15.0
0601	0.14	.01*	14.0
0602	0.20	.134*	1.49

APPENDIX G
(Continued)

ASA Number	Computed NCWQ Sediment Delivery Ratio Sdn	Iowa State Sediment Delivery Ratio SdI	Ratio $\frac{\text{SdI}}{\text{Sdn}}$
0701	0.27	.001	270.
0702	0.23	.028	8.21
0703	0.34	.049	6.93
0704	0.32	N/A	-
0705	0.27	N/A	-
0801	0.31	.043*	7.20
0802	0.17	.035	4.85
0803	0.06	.258	0.23
0901	0.14	.014	10.0
1001	0.23	.079	2.91
1002	0,14	,074	1.89
1003	0.07	.161	0.43
1004	0.04	.372	0.11
1005	0.08	.003	26.6
1006	0.18	.007	25.7
1007	0.08	.032	2.50
1008	0.11	.032	3.43
1009	0.35	.112	3.12
1010	0.16	.037	4.32
1011	0.20	.111	1.80
1101	0.05	.074	0.68
1102	0.06	.03*	2.00
1103	0.12	.024*	5.00
1104	0,10	.032	3.12
1105	0.07	.013*	5.38
1106	0.13	.0145*	8.96
1107	0.07	.053	1.32
1201	0.04	.006	6.66
1202	0.16	.012	13.3
1203	0.18	.044	4.09
1204	0.12	.0095*	12.6
1205	0.15	.008	18.7
1301	-	-	-
1302	0.001	.001*	1.00
1303	0.001	.059	0.02
1304	0.0002	.022	0.01
1305	0.03	.001	30.0
1401	0.001	.064	0.02
1402	0.001	.058	0.02
1403	0.003	.213	0.01
1501	0.001	.077	0.01
1502	0.001	.023	0.04
1503	0.001	.001	1.00

APPENDIX G
(Continued)

ASA Number	Computed NCWQ Sediment Delivery Ratio Sdn	Iowa State Sediment Delivery Ratio SdI	Ratio SdI/Sdn
1601	0.006	.01*	0.60
1602	0.0004	.01*	0.04
1603	-	-	-
1604	0.00003	.01*	0000
1701	0.002	.01*	0.20
1702	0.09	.043	2.09
1703	0.01	.01*	1.00
1704	0.07	.057	1.22
1705	0.01	.068	0.15
1706	-	.01*	-
1707	0.00008	.01*	0.01
1801	0.003	.378	0.01
1802	0.01	.021	0.48
1803	0.004	.003	1.33
1804	0.03	.018	1.66
1805	0.10	.107	0.93
1806	0.004	.005	0.80
1807	0.000	.01*	0

*Indicates an assumption was made in computing the ratio. In some cases several regions were computed as one. In other cases a region's delivery ratio was computed based upon assumed ratios somewhere else in the system.