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Part II

Environmental Protection Agency

40 CFR Parts 141 and 142

National Primary Drinking Water Regulations: Disinfectants and Disinfection Byproducts; Notice of Data Availability; Proposed Rule

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Parts 141 and 142

[WH–FRL–5915–3]

National Primary Drinking Water Regulations: Disinfectants and Disinfection Byproducts Notice of Data Availability

AGENCY: U.S. Environmental Protection Agency (USEPA).

ACTION: Notice of data availability.

SUMMARY: In 1994 USEPA proposed a Stage 1 Disinfectants/Disinfection Byproducts Rule (DBPR) to reduce the level of exposure from disinfectants and disinfection byproducts (DBPs) in drinking water (USEPA, 1994b). This Notice of Data Availability summarizes the 1994 proposal; describes new data and information that the Agency has obtained and analyses that have been developed since the proposal; provides information concerning recommendations of the Microbial-Disinfection/Disinfectants Byproducts (M–DBP) Advisory Committee (chartered in February 1997 under the Federal Advisory Committee Act) on key issues related to the proposal; and requests comment on these recommendations as well as on other regulatory implications that flow from the new data and information. USEPA solicits comment on all aspects of this Notice and the supporting record. The Agency also solicits additional data and information that may be relevant to the issues discussed in the Notice. USEPA is particularly interested in public comment on the Committee's recommendations and whether the Agency should reflect these recommendations in the final rule. USEPA also requests that any information, data or views submitted to the Agency since the close of the comment period on the 1994 proposal that members of the public would like the Agency to consider as part of the final rule development process be resubmitted during this current 90-day comment period unless already in the underlying record in the Docket for this Notice.

The Stage 1 DBPR would apply to community water systems and nontransient noncommunity water systems that treat their water with a chemical disinfectant for either primary or residual treatment. In addition, certain requirements for chlorine dioxide would apply to transient noncommunity water systems because of the short-term health effects from high levels of chlorine dioxide.

Key issues related to the Stage 1 DBPR that are addressed in this Notice include the establishment of Maximum Contaminant Levels for total trihalomethanes, five haloacetic acids, bromate and chlorite; requirements for enhanced coagulation and enhanced softening; disinfection credit; health effects information; and analytical methods.

Today's **Federal Register** also contains a related Notice of Data Availability for the Interim Enhanced Surface Water Treatment Rule (IESWTR). USEPA proposed this rule at the same time as the Stage 1 DBPR and plans to promulgate it along with the Stage 1 DBPR in November 1998.

DATES: Comments should be postmarked or delivered by hand on or before February 3, 1998. Comments must be received or post-marked by midnight February 3, 1998.

ADDRESSES: Send written comments to DBP NODA Docket Clerk, Water Docket (MC–4101); U.S. Environmental Protection Agency; 401 M Street, SW; Washington, DC 20460. Please submit an original and three copies of your comments and enclosures (including references). If you wish to hand-deliver your comments, please call the Docket between 9:00 a.m. and 4 p.m., Monday through Friday, excluding legal holidays, to obtain the room number for the Docket. Comments may be submitted electronically to ow-docket@epamail.epa.gov.

FOR FURTHER INFORMATION CONTACT: The Safe Drinking Water Hotline, Telephone (800) 426–4791. The Safe Drinking Water Hotline is open Monday through Friday, excluding Federal holidays, from 9:00 am to 5:30 pm Eastern Time. For technical inquiries, contact Thomas Grubbs or William Hamele, Office of Ground Water and Drinking Water (MC 4607), U.S. Environmental Protection Agency, 401 M Street SW, Washington DC 20460; telephone (202) 260–7270 (Grubbs) or (202) 260–2584 (Hamele).

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SUPPLEMENTARY INFORMATION:

Regulated Entities

Entities potentially regulated by the Stage 1 DBPR are public water systems that add a disinfectant or oxidant. Regulated categories and entities include:

Category	Examples of regulated entities
Public Water System.	Community water systems that add disinfectant or oxidant.
State Governments.	State government offices that regulate drinking water.

This table is not intended to be exhaustive, but rather provides a guide for readers regarding entities likely to be regulated by the Stage 1 DBPR. This table lists the types of entities that EPA is now aware could potentially be regulated by the rule. Other types of entities not listed in this table could also be regulated. To determine whether your facility may be regulated by this action, you should carefully examine the applicability criteria in § 141.130 of the proposed rule published on July 29, 1994 at 59 FR 38668 (USEPA, 1994b). If you have questions regarding the applicability of this action to a particular entity, contact one of the persons listed in the preceding **FOR FURTHER INFORMATION CONTACT** section.

Additional Information for Commenters

The Agency requests that commenters follow the following format: type or print comments in ink, and cite, where possible, the paragraph(s) in this Notice to which each comment refers. Commenters should use a separate paragraph for each method or issue discussed. Electronic comments must be submitted as a WP5.1 or WP6.1 file or as an ASCII file avoiding the use of special characters and any form of name

or title of the **Federal Register**. Comments and data will also be accepted on disks in WordPerfect in 5.1 or WP6.1 or ASCII file format. Electronic comments on this Notice may be filed online at many Federal Depository Libraries. Commenters who want EPA to acknowledge receipt of their comments should include a self-addressed, stamped envelope. No facsimiles (faxes) will be accepted.

Availability of Record

The record for this Notice, which includes supporting documentation as well as printed, paper versions of electronic comments, is available for inspection from 9 to 4 p.m., Monday through Friday, excluding legal holidays at the Water Docket, U.S. EPA Headquarters, 401 M. St., S.W. Washington, D.C. 20460. For access to docket materials, please call 202/260–3027 to schedule an appointment and obtain the room number.

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Abbreviations Used in This Notice

AOC: Assimilable organic carbon
ASDWA: Association of State Drinking Water Administrators
AWWA: American Water Works Association
AWWARF: AWWA Research Foundation
AWWSCo: American Water Works Service Company
BAC: Biologically active carbon
BAF: Biologically active filtration
BAT: Best Available Technology
BCAA: Bromochloroacetic acid
BDOC: Biodegradable organic carbon
CT: Contact time
CWS: Community Water System
DBP: Disinfection byproducts
D/DBP: Disinfectants and disinfection byproducts
DBPRAM: DBP Regulatory Analysis Model
DOC: Dissolved Organic Carbon
EPA: United States Environmental Protection Agency
ESWTR: Enhanced Surface Water Treatment Rule
FACA: Federal Advisory Committee Act
FY: Fiscal year
GAC: Granular Activated Carbon
GWDR: Ground Water Disinfection Rule
HAA5: Haloacetic acids (five)
IC: Ion chromotography
ICR: Information Collection Rule
ILSI: International Life Sciences Institute
IOC: Inorganic chemical
LOAEL: Lowest observed adverse effect level
MCL: Maximum Contaminant Level (expressed as mg/l, 1,000 micrograms (µg)=1 milligram (mg))
MCLG: Maximum Contaminant Level Goal
M–DBP: Microbial and Disinfectants/Disinfection Byproducts
MDL: Method Detection Limit
mg/dl: Milligrams per deciliter
mg/L: Milligrams per liter
MGD: Million Gallons per Day
MRDL: Maximum Residual Disinfectant Level (as mg/l)
MRDLG: Maximum Residual Disinfectant Level Goal
MWDSC: Metropolitan Water District of Southern California
NCI: National Cancer Institute
NIPDWR: National Interim Primary Drinking Water Regulation
NOAEL: No observed adverse effect level
NOM: Natural Organic Matter
NPDWR: National Primary Drinking Water Regulation
NTNCWS: Nontransient noncommunity water system
O&M: Operations and maintenance
PE: Performance evaluation
PODR: Point of Diminishing Returns
POE: Point-of-Entry Technologies
POU: Point-of-Use Technologies
ppb: Parts per billion
PQL: Practical Quantitation Level
PWS: Public Water System
RIA: Regulatory Impact Analysis
RMCL: Recommended Maximum Contaminant Level
SAB: Science Advisory board
SDWA: Safe Drinking Water Act, or the ''Act,'' as amended in 1986
SUVA: Specific ultraviolet absorbance at 254 nm
SWTR: Surface Water Treatment Rule
TOC: Total organic carbon
TTHM: Total trihalomethanes
TWG: Technical Working Group
UNC: University of North Carolina
VOC: Volatile Synthetic Organic Chemical
WIDB: Water Industry Data Base
WITAF: Water Industry Technical Action Fund

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I. Introduction and Background

A. Existing Regulations

1. Surface Water Treatment Rule

Under the Surface Water Treatment Rule (SWTR)(USEPA, 1989a), USEPA set maximum contaminant level goals of zero for *Giardia lamblia*, viruses, and *Legionella*; and promulgated national primary drinking water regulations for all public water systems (PWSs) using surface water sources or ground water sources under the direct influence of surface water. The SWTR includes treatment technique requirements for filtered and unfiltered systems that are intended to protect against the adverse health effects of exposure to *Giardia lamblia*, viruses, and *Legionella*, as well as many other pathogenic organisms. Briefly, those requirements include (1) removal or inactivation of 3 logs (99.9%) for *Giardia* and 4 logs (99.99%) for viruses (2) combined filter effluent performance of 5 NTU as a maximum and 0.5 NTU at 95th percentile monthly, based on 4-hour monitoring for treatment plants using conventional treatment or direct filtration (with separate standards for other filtration technologies); and (3) watershed protection and other requirements for unfiltered systems.

2. Total trihalomethane MCL

USEPA set an interim maximum contaminant level (MCL) for total trihalomethanes (TTHMs) of 0.10 mg/l as an annual average in November 1979 (USEPA, 1979). This standard was based on the need to balance the requirement for continued disinfection of water to reduce exposure to pathogenic microorganisms while simultaneously lowering exposure to disinfection byproducts which might be carcinogenic to humans.

The interim TTHM standard only applies to any PWSs (surface water and/or ground water) serving at least 10,000 people that add a disinfectant to the drinking water during any part of the treatment process. At their discretion, States may extend coverage to smaller PWSs. However, most States have not exercised this option. About 80 percent of the PWSs, serving populations of less than 10,000, are served by ground water that is generally low in THM precursor content (USEPA, 1979) and which would be expected to have low TTHM levels even if they disinfect.

3. Total Coliform Rule

The Total Coliform Rule (USEPA, 1989b) was revised in June 1989, and became effective on December 31, 1990. The rule, which applies to all public water systems, sets compliance with the maximum contaminant level (MCL) for total coliforms as follows. For systems that collect 40 or more samples per month, no more than 5.0% of the samples may be total coliform-positives; for those that collect fewer than 40 samples, only one sample may be total coliform-positive. If a system exceeds the MCL for a month, it must notify the public using mandatory language developed by the USEPA. The required monitoring frequency for a system ranges from 480 samples per month for the largest systems to once annually for certain of the smallest systems. All systems must have a written plan identifying where samples are to be collected. In addition, systems are required to conduct repeat sampling after a positive sample.

The Total Coliform Rule also requires each system that collects fewer than five samples per month to have the system inspected every 5 years (10 years for certain types of systems using only protected and disinfected ground water.) This on-site inspection (referred to as a sanitary survey) must be performed by the state or by an agent approved by the state.

4. Information Collection Rule

The Information Collection Rule (ICR) is a monitoring and data reporting rule that was promulgated on May 14, 1996 (USEPA, 1996b). The purpose of the ICR is to collect occurrence and treatment information to evaluate the need for possible changes to the current Surface Water Treatment Rule and existing microbial treatment practices and to evaluate the need for future regulation for disinfectants and DBPs. The ICR will provide USEPA with additional information on the national occurrence in drinking water of (1) chemical byproducts that form when disinfectants used for microbial control react with compounds already present in source water and (2) disease-causing microorganisms, including *Cryptosporidium*, *Giardia*, and viruses. The ICR will also collect engineering data on how PWSs currently control such contaminants. This information is being collected because the regulatory negotiation on disinfectants and DBPs concluded that additional information was needed to assess the potential health problem created by the presence of DBPs and pathogens in drinking water and to assess the extent and severity of risk in order to make sound regulatory and public health decisions. The ICR will also provide information to support regulatory impact analyses for various regulatory options, and to help develop monitoring strategies for cost effectively implementing regulations.

B. Public Health Concerns To Be Addressed

In 1990, USEPA's Science Advisory Board, an independent panel established by Congress, cited drinking water contamination as one of the highest ranking environmental risks. The Science Advisory board reported that microbiological contaminants (e.g. bacteria, protozoa, viruses) are likely the greatest remaining health risk management challenge for drinking water suppliers. The control of microbiological contaminants is further complicated because commonly-used disinfection processes themselves may pose health risks. Conventional practices require the addition of disinfectant chemicals to the water that, while effective in controlling many harmful microorganisms, combine with organic matter in the water and form compounds known as disinfection byproducts (DBPs). One of the most complex questions facing water supply professionals is how to minimize the risks from these DBPs and still control microbial contaminants.

Chemical disinfectants (e.g., chlorine, chloramines, chlorine dioxide) are

added to drinking water to provide continuous disinfection throughout the distribution system. There is generally little health concern over exposure to the levels of the disinfectant residuals commonly found in finished drinking water. A number of organic DBPs, including some trihalomethanes (chloroform, bromoform, and bromodichloromethane) and some haloacetic acids (e.g., dichloroacetic acid) cause cancer in laboratory animals. Other DBPs cause reproductive or developmental effects in laboratory animals (e.g., chlorite). Bromate, a byproduct of ozonation, causes cancer in laboratory animals.

Several epidemiology studies have evaluated the association of chlorination and chloramination with several adverse outcomes including cancer, cardiovascular disease, and adverse reproductive outcomes. Several studies have reported small increases in bladder, colon, and rectal cancers. In some cases, these effects appeared to be associated with the duration of exposure and volume of water consumed. Data on DBPs and cardiovascular disease are inconclusive. Animal studies in the mid 1980's indicated a potential increase in the serum lipid levels in animals exposed to chlorinated water. However, in a cross-sectional epidemiology study in humans, comparing chlorinated and unchlorinated water supplies with varying water hardness, no adverse effects on serum lipid levels were found. Recent epidemiology studies have reported increased incidence of decreased birth weight, premature births, intrauterine growth retardation, and neural tube defects with chlorinated water. As with the other reported adverse outcomes from the epidemiology studies, there is considerable debate in the scientific community on the significance of these findings (USEPA, 1994a). A discussion of new health effects information that has become available since the 1994 proposal appears in Section VI of this Notice.

In order to accurately assess risk from DBPs, it is important to have information on human exposure to DBPs, information on the toxicity of the DBPs and an understanding of the mode of action of toxicity. The preamble to the 1994 proposed DBP rule presented information on the occurrence and exposure to the Stage 1 DBPs. The information presented in that preamble was summarized from the document ''Occurrence Assessment for Disinfectants and Disinfection By-products (Phase 6a) in Drinking Water'' (USEPA, 1992a) and from information presented as a part of the 1992 and 1993 Regulatory Negotiation process that led to the 1994 Stage 1 DBP proposal (see section D below). Since the proposal, USEPA has updated the document cited above with new occurrence and exposure information. Copies of the revised document, entitled ''Occurrence Assessment for Disinfectants and Disinfection Byproducts in Public Drinking Water Supplies'' (USEPA, 1997a) can be obtained from the Docket for this Notice. The Information Collection Rule (ICR) (USEPA, 1996b) will supply additional information on the occurrence of DBPs for the Stage 2 DBP rule; however, this ICR information will not be available in time for the Stage 1 DBP rule.

C. Statutory Provisions

1. SDWA and 1986 Provisions

The Safe Drinking Water Act (SDWA or the Act), as amended in 1986, requires USEPA to publish a ''maximum contaminant level goal'' (MCLG) for each contaminant which, in the judgement of the USEPA Administrator, ''may have any adverse effect on the health of persons and which are known or anticipated to occur in public water systems'' (Section 1412(b)(3)(A)). MCLGs are to be set at a level at which ''no known or anticipated adverse effect on the health of persons occur and which allows an adequate margin of safety'' (Section 1412(b)(4)).

The Act also requires that at the same time USEPA publishes an MCLG, which is a non-enforceable health goal, it also must publish a National Primary Drinking Water Regulation (NPDWR) that specifies either a maximum contaminant level (MCL) or treatment technique (Sections 1401(1) and 1412(a)(3)). USEPA is authorized to promulgate a NPDWR ''that requires the use of a treatment technique in lieu of establishing a MCL,'' if the Agency finds that ''it is not economically or technologically feasible to ascertain the level of the contaminant''.

Section 1414(c) of the Act requires each owner or operator of a public water system to give notice to the persons served by the system of any failure to comply with an MCL or treatment technique requirement of, or testing procedure prescribed by, a NPDWR and any failure to perform monitoring required by section 1445 of the Act.

Section 1412(b)(7)(C) of the SDWA requires the USEPA Administrator to publish a NPDWR ''specifying criteria under which filtration (including coagulation and sedimentation, as appropriate) is required as a treatment technique for public water systems supplied by surface water sources''. In establishing these criteria, USEPA is required to consider ''the quality of source waters, protection afforded by watershed management, treatment practices (such as disinfection and length of water storage) and other factors relevant to protection of health''. This section of the Act also requires USEPA to promulgate a NPDWR requiring disinfection as a treatment technique for all public water systems and a rule specifying criteria by which variances to this requirement may be granted.

2. Changes to Initial Provisions and New Mandates

In 1996, Congress reauthorized the Safe Drinking Water Act. Several of the 1986 provisions discussed above were renumbered and augmented with additional language, while other sections mandate new drinking water requirements. These modifications, as well as new provisions, are detailed below.

As part of the 1996 amendments to the Safe Drinking Water Act (the Amendments), USEPA's general authority to set a MCLG and NPDWR was modified to apply to contaminants that may ''have an adverse effect on the health of persons'', that are ''known to occur or there is a substantial likelihood that the contaminant will occur in public water systems with a frequency and at levels of public health concern'', and for which ''in the sole judgement of the Administrator, regulation of such contaminant presents a meaningful opportunity for health risk reduction for persons served by public water systems' (1986 SDWA Section 1412 (b)(3)(A) stricken and amended with 1412(b)(1)(A)).

The Amendments also require that USEPA, when proposing a NPDWR that includes an MCL or treatment technique, publish and seek public comment on health risk reduction and cost analyses. The Amendments also require USEPA to take into consideration the effects of contaminants upon sensitive subpopulations (i.e. infants, children, pregnant women, the elderly, and individuals with a history of serious illness), and other relevant factors. (Section 1412 (b)(3)(C)).

The 1996 Amendments also newly require USEPA to promulgate an Interim Enhanced SWTR and a Stage I Disinfectants and Disinfection Byproducts Rule by November 1998. In addition, the 1996 Amendments require USEPA to promulgate a Final Enhanced SWTR and a Stage 2 Disinfection Byproducts Rule by November 2000 and May 2002, respectively (Section 1412(b)(2)(C)).

Under the Amendments of 1996, recordkeeping requirements were modified to apply to ''every person who is subject to a requirement of this title or who is a grantee'' (Section 1445 (a)(1)(A)). Such persons are required to ''establish and maintain such records, make such reports, conduct such monitoring, and provide such information as the Administrator may reasonably require by regulation * * *''.

D. Regulatory Negotiation Process

In 1992 USEPA initiated a negotiated rulemaking to develop a disinfectants/disinfection byproducts rule. The negotiators included representatives of State and local health and regulatory agencies, public water systems, elected officials, consumer groups and environmental groups. The Committee met from November 1992 through June 1993.

Early in the process, the negotiators agreed that large amounts of information necessary to understand how to optimize the use of disinfectants to concurrently minimize microbial and DBP risk on a plant-specific basis were unavailable. Nevertheless, the Committee agreed that USEPA propose a Disinfectant/Disinfection Byproducts rule to extend coverage to all community and nontransient noncommunity water systems that use disinfectants. This rule proposed to reduce the current TTHM MCL, regulate additional disinfection byproducts, set limits for the use of disinfectants, and reduce the level of organic compounds in the source water that may react with disinfectants to form byproducts.

One of the major goals addressed by the Committee was to develop an approach that would reduce the level of exposure from disinfectants and DBPs without undermining the control of microbial pathogens. The intention was to ensure that drinking water is microbiologically safe at the limits set for disinfectants and DBPs and that these chemicals do not pose an unacceptable risk at these limits.

Following months of intensive discussions and technical analysis, the Committee recommended the development of three sets of rules: a two-staged Disinfectants/Disinfection Byproduct Rule (proposal: 59 FR 38668, July 29, 1994), an ''interim'' ESWTR (proposal: 59 FR 38832, July 29, 1994), and an Information Collection rule (proposal: 59 FR 6332, February 10, 1994). The IESWTR would only apply to systems serving 10,000 people or more. The Committee agreed that a ''long-term'' ESWTR (LTESWTR) would be needed for systems serving fewer than 10,000 people when the results of more research and water quality monitoring became available. The LTESWTR could also include additional refinements for larger systems.

The approach in developing these proposals considered the constraints of simultaneously treating water to control for both microbial contaminants and DBPs. As part of this effort, the Negotiating Committee concluded that the SWTR may need to be revised to address health risk from high densities of pathogens in poorer quality source waters and from the protozoan, *Cryptosporidium*. The Committee also agreed that the schedules for IESWTR and LTESWTR should be ''linked'' to the schedule for the Stage 1 DBP Rule to assure simultaneous compliance and a balanced risk-risk based implementation. The Committee agreed that additional information on health risk, occurrence, treatment technologies, and analytical methods needed to be developed in order to better understand the risk-risk tradeoff, and how to accomplish an overall reduction in risk.

Finally the Negotiating Committee agreed that to develop a reasonable set of rules and to understand more fully the limitations of the current SWTR, additional field data were critical. Thus, a key component of the regulation negotiation agreement was the promulgation of the Information Collection Rule (ICR) noted above and described in more detail below.

E. Information Collection Rule

As stated above, the ICR established monitoring and data reporting requirements for large public water systems serving populations over 100,000. About 350 PWSs operating 500 treatment plants are involved in the data collection effort. Under the ICR, these PWSs monitor their source water for bacteria, viruses, and protozoa (surface water sources only); water quality factors affecting DBP formation; and DBPs within the treatment plant and in the distribution system. In addition, PWSs must provide operating data and a description of their treatment plan design. Finally, a subset of PWSs perform treatment studies, using either granular activated carbon or membrane processes, to evaluate DBP precursor removal. Monitoring for treatment study applicability began in September 1996. The remaining occurrence monitoring began in July 1997.

The initial intent of the ICR was to collect monitoring data and other information for use in developing the Stage 2 DBPR and IESWTR and to estimate national costs for various treatment options. However, because of delays in promulgating the ICR and technical difficulties associated with laboratory approval and review of facility sampling plans, most ICR monitoring did not begin until July 1, 1997. As a result of this delay and the new Stage 1 DBPR and IESWTR deadlines specified in the 1996 SDWA amendments, ICR data will not be available for analysis in connection with these rules. In place of the ICR data, the Agency has worked with stakeholders to identify additional data developed since 1994 that can be used in components of these rules. USEPA intends to continue to work with stakeholders in analyzing and using the comprehensive ICR data and research for developing subsequent revisions to the SWTR and the Stage 2 DBP Rule.

F. Formation of 1997 Federal Advisory Committee

In May 1996, the Agency initiated a series of public informational meetings to exchange information on issues related to microbial and disinfectants/disinfection byproducts regulations. To help meet the deadlines for the IESWTR and Stage 1 DBPR established by Congress in the 1996 SDWA Amendments and to maximize stakeholder participation, the Agency established the Microbial and Disinfectants/Disinfection Byproducts (M–DBP) Advisory Committee under the Federal Advisory Committee Act (FACA) on February 12, 1997, to collect, share, and analyze new information and data, as well as to build consensus on the regulatory implications of this new information. The Committee consists of 17 members representing USEPA, State and local public health and regulatory agencies, local elected officials, drinking water suppliers, chemical and equipment manufacturers, and public interest groups.

The Committee met five times, in March through July 1997, to discuss issues related to the IESWTR and Stage 1 DBPR. Technical support for these discussions was provided by a Technical Work Group (TWG) established by the Committee at its first meeting in March 1997. The Committee's activities resulted in the collection, development, evaluation, and presentation of substantial new data and information related to key elements of both proposed rules. The Committee reached agreement on the following major issues discussed in this Notice and the Notice for the IESWTR published elsewhere in today's **Federal Register**: (1) MCLs for TTHMs, HAA5 and bromate; (2) requirements for enhanced coagulation and enhanced softening (as part of DBP control); (3) microbial benchmarking/profiling to

provide a methodology and process by which a PWS and the State, working together, assure that there will be no significant reduction in microbial protection as the result of modifying disinfection practices in order to meet MCLs for TTHM and HAA5; (4) disinfection credit; (5) turbidity; (6) *Cryptosporidium* MCLG; (7) removal of *Cryptosporidium;* (8) role of *Cryptosporidium* inactivation as part of a multiple barrier concept and (9) sanitary surveys. The Committee's recommendations to USEPA on these issues were set forth in an Agreement In Principle document dated July 15, 1997. This document is included with this Notice as Appendix 1.

G. Overview of 1994 DBP Proposal

The proposed Disinfectants and Disinfection Byproducts Stage I Rule (DBPI) addressed a number of complex and interrelated drinking water issues. The proposal attempted to balance the control of health risks from compounds formed during drinking water disinfection against the risks from microbial organisms (such as *Giardia lamblia, Cryptosporidium,* bacteria, and viruses) to be controlled by the IESWTR.

The proposed Stage 1 DBP rule applied to all community water systems (CWSs) and nontransient noncommunity water systems (NTNCWSs) that treat their water with a chemical disinfectant for either primary or residual treatment. In addition, certain requirements for chlorine dioxide would apply to transient noncommunity water systems because of the short-term health effects from high levels of chlorine dioxide. Following is a summary of key components of the 1994 Stage 1 DBPR proposal.

1. MCLGs/MCLs/MRDLGs/MRDLs

EPA proposed MCLGs of zero for chloroform, bromodichloromethane, bromoform, bromate, and dichloroacetic acid and MCLGs of 0.06 mg/L for dibromochloromethane, 0.3 mg/L for trichloroacetic acid, 0.04 mg/L for chloral hydrate, and 0.08 mg/L for chlorite. In addition, EPA proposed to lower the MCL for TTHMs from 0.10 to 0.080 mg/L and added an MCL for five haloacetic acids (i.e., the sum of the concentrations of mono-, di-, and trichloroacetic acids and mono-and dibromoacetic acids) of 0.060 mg/L. EPA also, for the first time, proposed MCLs for two inorganic DBPs: 0.010 mg/L for bromate and 1.0 mg/L for chlorite.

In addition to proposing MCLGs and MCLs for several DBPs, EPA proposed maximum residual disinfectant level goals (MRDLGs) of 4 mg/L for chlorine and chloramines and 0.3 mg/L for chlorine dioxide. The Agency also proposed maximum residual disinfectant levels (MRDLs) for chlorine and chloramines of 4.0 mg/L, and 0.8 mg/L for chlorine dioxide. MRDLs protect public health by setting limits on the level of residual disinfectants in the distribution system. MRDLs are similar in concept to MCLs—MCLs set limits on contaminants and MRDLs set limits on residual disinfectants in the distribution system. MRDLs, like MCLs, are enforceable, while MRDLGs, like MCLGs, are not enforceable.

2. Best Available Technologies

EPA identified the best available (BAT) technology for achieving compliance with the MCLs for both TTHMs and HAA5 as enhanced coagulation or treatment with granular activated carbon with a ten minute empty bed contact time and 180 day reactivation frequency (GAC10), with chlorine as the primary and residual disinfectant. The BAT for achieving compliance with the MCL for bromate was control of ozone treatment process to reduce formation of bromate. The BAT for achieving compliance with the chlorite MCL was control of precursor removal treatment processes to reduce disinfectant demand, and control of chlorine dioxide treatment processes to reduce disinfectant levels. EPA identified BAT for achieving compliance with the MRDL for chlorine, chloramine, and chlorine dioxide as control of precursor removal treatment processes to reduce disinfectant demand, and control of disinfection treatment processes to reduce disinfectant levels.

3. Treatment Technique

EPA proposed a treatment technique that would require surface water systems and groundwater systems under the direct influence of surface water that use conventional treatment or precipitative softening to remove DBP precursors by enhanced coagulation or enhanced softening. A system would have been required to remove a certain percentage of TOC (based on raw water quality) prior to the point of continuous disinfection. EPA also proposed a procedure to be used by a PWS not able to meet the percent reduction, to allow them to comply with an alternative minimum TOC removal level. Compliance for systems required to operate with enhanced coagulation or enhanced softening was based on a running annual average, computed quarterly, of normalized monthly TOC percent reductions. A complete discussion of the proposed requirements is in Section III.A.

4. Preoxidation (Predisinfection) Credit

The proposed rule did not allow PWSs required to use enhanced coagulation or enhanced softening to take credit for compliance with disinfection requirements in the SWTR/IESWTR prior to removing required levels of precursors unless they met specified criteria. These criteria are explained in Section IV.A.

5. Analytical Methods

EPA proposed nine analytical methods (some of which can be used for multiple analytes) to ensure compliance with proposed MRDLs for chlorine, chloramines, and chlorine dioxide. The three disinfectant residuals were measured and reported as: chlorine as free chlorine (four methods) or total chlorine (five methods); chloramines as combined chlorine (three methods) or total chlorine (five methods); and chlorine dioxide as chlorine dioxide (3 methods). EPA proposed methods for the analysis of two classes of organic DBPs: TTHMs (three methods) and HAA5 (2 methods). In addition, EPA proposed one method for measuring both inorganic DBPs (chlorite and bromate) and two methods for total organic carbon (TOC).

6. New Information

Since July, 1994, new information has become available in several key areas related to issues put forth in the DBP Stage 1 proposal. The key issues where new information has become available since the proposal include the following: (1) MCLs; (2) Enhanced Coagulation and Enhanced Softening; (3) Predisinfection Credit; (4) Health Effects Information; (5) Analytical Methods; and (6) the Regulatory Impact Analysis (DBP and TOC occurrence, compliance decision tree). This information and its implications are discussed in more detail below.

II. Health Effects

The preamble to the 1994 proposed rule provided a summary of the health criteria documents for bromate; chloramines; haloacetic acids and chloral hydrate; chlorine; chlorine dioxide, chlorite, and chlorate; and trihalomethanes. The information presented in the proposal was used to establish MCLGs and MRDLGs for the disinfectants and DBPs listed above. Since the 1994 proposal, several epidemiology and toxicology studies have been completed. The study results need to be considered for the final Stage 1 DBPR. The following section briefly

discusses the new epidemiological and laboratory toxicology studies. In addition, USEPA has developed summaries of this new information and included these documents in the Docket for this action as ''Summaries of New Health Effects Data'' (USEPA, 1997b).

A. Cancer Epidemiology Studies

The preamble to the proposed rule discussed several cancer epidemiology studies that had been conducted over the past 20 years on chlorinated drinking water (see USEPA, 1994b). At the time of the proposed rule, there was disagreement among the members of the Negotiating Committee on the conclusions to be drawn from the cancer epidemiology studies. Some members of the Committee felt that the cancer epidemiology data, taken in conjunction with the results from toxicological studies, provide an ample and sufficient weight of evidence to conclude that exposure to DBPs in drinking water could result in an increased cancer risk at levels encountered in some public water supplies. Other members of the Committee concluded that the degree of resolution in cancer epidemiology studies on the consumption of chlorinated drinking water to date was insufficient to provide definitive information for the regulation. USEPA, therefore, agreed to pursue additional research to reduce the uncertainties associated with these epidemiology data and to better characterize and project the potential human cancer risks associated with the consumption of chlorinated drinking water. To implement this commitment, USEPA sponsored two expert panel reviews on the state of cancer epidemiology. Each of these panels recommended short and long-term research for improving the assessment of risks using cancer epidemiology.

1. Expert Panels Recommendations on Cancer Epidemiology

USEPA conducted an expert panel workshop in July 1994 on the scientific considerations for conducting cancer epidemiologic studies for DBPs (USEPA, 1994a). The expert panel presented the following conclusions.

(A)lthough ecological and analytic epidemiologic studies have reported associations between chlorinated water and cancer at various sites, many of the studies have methodologic problems or systematic biases that limit the interpretation of results. Moreover, the studies vary according to the amount of information available on exposure to chlorinated water or DBPs. The panel agrees that existing epidemiologic data are insufficient to conclude that the reported associations are causal or provide an accurate estimate of the magnitude of risk.

This cancer workshop panel also provided several recommendations for conducting additional research. These included: (1) improving exposure assessments; (2) conducting a reanalysis of previously conducted interview-based case control studies using improved exposure estimates and analytical methods to determine the validity of these risks and to address confounding factors and bias not adequately excluded in previous reports such as the meta-analysis completed by Morris, et al. (1992) discussed in the 1994 proposed rule (USEPA, 1994b, page 38689); (3) conducting feasibility studies to identify geographic locations with adequate exposure data and appropriate cohorts for study (including the possibility of using existing cohorts that are being studied for other potential exposures); and (4) consideration of several possible designs for full scale studies (i.e., cohort, case-control, and case-control nested within a cohort).

In October 1995, the International Life Sciences Institute (ILSI) sponsored a workshop on ''Disinfection by-products in Drinking Water: Critical Issues in Health Effects Research'' (ILSI, 1995). One of the panels at the workshop provided a brief summary of the findings from cancer epidemiology studies and made recommendations for further research in this area. The panel concluded that the epidemiological studies of bladder and colorectal cancer have generally shown an increased risk associated with the consumption of chlorinated surface water, although a causal association has not been conclusively established. The panel made several recommendations for future research including the need to conduct hypothesis driven cancer epidemiological studies to examine the risk of classes of DBPs other than THMs and to support these studies with improved exposure assessments.

2. Implementation of Expert Panel Recommendations

a. *Improve Exposure Assessments/ Geographic Identification Studies/ Classes of DBPs Other Than THMs.* USEPA, in conjunction with other parties, has begun research to provide the tools needed to improve exposure assessments for epidemiology studies. USEPA is supporting studies in Colorado, North Carolina, and New Jersey that will provide improved tools for conducting exposure assessments for epidemiology studies. While the results from these studies will not be available for the final Stage 1 DBP rule, they will be very useful in designing future epidemiology studies.

In addition to USEPA's research, the Microbial/DBP Research Council (M/DBP Council) is funding a study on ''Identification of Geographic Areas for Possible Epidemiological Studies'' and is evaluating several proposals for a project on ''Development of Methods for Predicting THM and HAA Concentrations in Exposure Assessment Studies.'' The M/DBP Council was formed as a joint USEPA and American Water Works Association Research Foundation (AWWARF) project to identify and fund critical research. This research, in conjunction with the USEPA research discussed above, will improve the understanding of risks associated with the consumption of chlorinated surface water. However, as with USEPA's work, this research will not be completed in time to impact the Stage 1 DBPR.

b. Meta-analysis of Existing Cancer Epidemiology Data. The 1994 proposal includes results of a meta-analysis that pooled the relative risks from 10 cancer epidemiology studies in which there was a presumed exposure to chlorinated water and its byproducts (Morris et al., 1992). This meta-analysis estimated that approximately 10,000 cancer cases each year could be attributed to the consumption of chlorinated drinking water and its byproducts. As discussed in the preamble to the proposed rule, this study generated considerable debate among the members of the Negotiation Committee. An evaluation of the Morris et al. meta-analysis has been recently completed for USEPA. USEPA is currently evaluating this report and will provide an opportunity to comment on EPA's assessment and implications for the regulatory provisions for the final Stage 1 DBPR.

In addition to the meta-analysis, USEPA has summarized several new cancer epidemiology studies and included them as part of the ''Summaries of New Health Effects Data'' (USEPA, 1997b) that is included in the Docket for this Notice. USEPA will be evaluating the data from the new epidemiology studies and will provide an opportunity to comment on the potential implications of these new studies for the regulatory provisions for the final Stage 1 DBPR.

B. Reproductive and Developmental Epidemiology Studies

The preamble to the 1994 proposal discussed several reproductive epidemiology studies that had been conducted (see USEPA, 1994b, page 38690). It also included a discussion of an USEPA and ILSI expert panel that reviewed the published epidemiologic and experimental data on reproductive

and developmental effects and a strategy developed by the panel for related short-term and long-term research (USEPA, 1993b). The panel concluded that the currently available data on the effects of chlorination byproducts provide an inadequate basis for identifying DBPs as a reproductive or developmental hazard. Recommendations were made for refining studies using existing data bases, strengthening studies designed to collect new data, improving exposure assessments, investigating selected health endpoints, and developing a stronger link between animal research and epidemiology studies.

The results from the ILSI expert panel, and additional information provided since the 1994 proposal, are summarized in Reif et al. (1996). This paper reviewed the available epidemiological data on the reported association between the consumption of chlorinated drinking water and reproductive and developmental effects. The panel reached the following conclusions. ''The currently available human studies on effects of chlorination by-products provide an inadequate basis for identifying DBPs as a reproductive or developmental hazard. Nevertheless, additional laboratory animal and epidemiological research should be conducted, employing a coordinated multi disciplinary approach.'' They also provided recommendations for short- and longer-term research.

1. Improving Exposure Assessments

Many of the exposure assessment projects identified above for cancer epidemiology are also relevant to improving exposure assessments for evaluating reproductive and developmental effects. As discussed in the cancer epidemiology section, while the results from these studies will not be available for the final Stage 1 DBPR, they will be very useful in designing future reproductive epidemiology studies.

2. New Studies Since Proposal

Since the proposal, several new reproductive and developmental epidemiology studies have been published. Additionally, studies in California and Colorado are nearing completion, but results will not be available for this NODA. Savitz et al. (1995) used data from a population-based case-control study to evaluate the potential risk of miscarriage, preterm delivery and low birth weight in North Carolina based on water source, amount of water consumed, and TTHM concentration in water. The authors concluded, ''These data do not indicate a strong association between chlorinated byproducts and adverse pregnancy outcome, but given the limited quality of the exposure assessment and the increased miscarriage risk in the higher exposure group, more refined evaluation is warranted.''

Kanitz et al. (1996) conducted an epidemiology study in Italy on the association between somatic parameters (e.g., birthweight, body length, cranial circumference, and neonatal jaundice) and drinking water disinfection with chlorine dioxide and/or sodium hypochlorite. The authors concluded, ''The study provides some new information on the possible association between some drinking water disinfection treatments and somatic parameters of infants at birth. Further investigations will be needed to verify the results of the present study by rigorous exposure assessments.''

The 1994 proposed rule reported the results of a New Jersey Department of Health report on the results of a cross-sectional study evaluating the association between drinking water contaminants with low birth weight and selected birth defects (Bove et al., 1992a, 1992b). Since the proposal, an article summarizing the cross-sectional study has been published by Bove et al. (1995). The results are consistent with those reported in the proposed Stage 1 DBPR. The authors concluded, ''By itself, this study cannot resolve whether the drinking water contaminants caused the adverse birth outcomes; therefore, these findings should be followed up utilizing available drinking water contamination databases.''

While the new epidemiology studies add to the database on the potential reproductive and developmental effects from DBPs, USEPA believes that the results are inconclusive. A more complete discussion of the new reproductive and development epidemiology studies can be found in the ''Summaries of New Health Effects Data'' (USEPA, 1997b).

C. Significant New Toxicological Information for the Stage 1 Disinfectants and Disinfection Byproducts

Since the proposal, new toxicological information has become available for several of the disinfectants and DBPs. The information presented below is a summary of the significant new information for several disinfectants and DBPs. For a more complete discussion of the new information see the ''Summaries of New Health Effects Data'' (USEPA, 1997b) in the Docket (a summary of the new information for chlorine and chloramines is not included below, but is included in the document cited above.)

1. Chlorite

The 1994 proposal included an MCLG of 0.08 mg/L and an MCL of 1.0 mg/L for chlorite. In order to fill an important data gap, the Chemical Manufacturers Association (CMA) agreed to conduct a two-generation reproductive effects study of chlorite. The Negotiating Committee agreed that if the studies indicated that a level of 1.0 mg/L of chlorite is safe, the MCL would remain at 1.0 mg/L. If the studies indicate that a level of 1.0 mg/L of chlorite is not safe or, if such a study is not conducted, the MCL would be re-evaluated.

After the Negotiating Committee agreed to support a proposed MCL of 1.0 mg/L, USEPA selected developmental neurotoxicity hazard as the critical effect for chlorite (Mobley et al., 1990). Based on this 1990 rat developmental study, an MCLG of 0.08 mg/L was derived for chlorite. USEPA believed that the MCL of 1.0 mg/L agreed to by the Committee was not adequate to protect the public from the acute developmental health effects of chlorite. USEPA decided to propose an MCL of 1.0 mg/L to honor the agreement of the Committee and requested comment on several possible approaches for promulgating the final rule.

Since the proposal, a study on the subchronic toxicity of sodium chlorite in rats (Harrington et al., 1995a) and a developmental toxicity study in rabbits (Harrington, et al., 1995b) have been published. Both of these studies reported no adverse toxicological effects. Other than the two-generation reproductive study cited above, which USEPA recently received, relevant new literature has not been found that would alter the assessment for chlorite from the 1994 proposal. USEPA is conducting an external peer review of the CMA two-generation reproductive study. These peer review comments will be included in the Docket for this NODA when they become available. USEPA will evaluate the data from the CMA study, including the peer review, and will provide an opportunity to comment on the potential implications for the regulatory provisions for chlorite prior to the final Stage 1 DBP rule. The CMA study is included in the Docket for this action (CMA, 1997).

2. Chlorine Dioxide

The proposed Stage 1 DBPR included a MRDLG of 0.3 mg/L and a MRDL of 0.8 mg/L for chlorine dioxide. The proposed MRDLG for chlorine dioxide was based on developmental neurotoxicity as the critical effect (Orme et al., 1985). The Negotiating Committee agreed to the MRDL of 0.8 mg/L for

chlorine dioxide with certain qualifications and reservations. As cited above, the Committee agreed that a two-generation reproductive study on chlorite would be completed for consideration in the final Stage 1 DBPR. Toxicity information on chlorite is considered relevant for characterizing the toxicity of chlorine dioxide. If the chlorite study indicated no concern from reproductive effects at 0.8 mg/L, then the proposed MRDL for chlorine dioxide would remain the same as proposed. If these new data indicate reproductive or developmental effects, then the MRDL will need to be re-examined comparing the tradeoffs and regulatory impacts of a lower chlorine dioxide MRDL and the positive aspects of using chlorine dioxide as a disinfectant.

Other than the two-generation reproductive study conducted by CMA for chlorite, there is no new literature that would alter the assessment for chlorine dioxide from the 1994 proposal. As stated above, USEPA believes that the results from the chlorite study are applicable for addressing the toxicity data gaps for chlorine dioxide. USEPA will evaluate the data from the CMA study, including the peer review, and will provide an opportunity to comment on the potential implications for the regulatory provisions for chlorine dioxide prior to the final Stage 1 DBP rule.

3. Trihalomethanes

The proposed rule includes an MCL for total trihalomethanes (TTHM) of 0.080 mg/L. MCLGs of zero for chloroform, bromodichloromethane (BDCM), and bromoform were based on sufficient evidence of carcinogenicity in animals. The MCLG of 0.060 mg/L for dibromochloromethane (DBCM) was based on observed liver toxicity from a subchronic study and possible carcinogenicity. Since the 1994 proposal, several new studies have been published on the metabolism for BDCM and chloroform (Testai et al., 1995; Gemma et al., 1996a, 1996b; Gao et al., 1996; Nakajima et al., 1995). In addition, several new studies were found concerning the genotoxicity of chloroform, BDCM, and bromoform (Roldan-Arjona and Pueyo, 1993; LeCurieux et al., 1995; Pegram et al., 1997; Larson et al., 1994c; Fujie et al., 1993; Shelby and Witt, 1995; Hayashi et al., 1992; Sofuni et al., 1996; Matsuoka et al., 1996; Miyagawa et al., 1995; Banerji and Fernandes, 1996; and Potter et al., 1996). There are considerable new data on cytotoxicity and regenerative cell proliferation in the liver and kidney of rats and mice under various conditions (Larson et al., 1993, 1994a, 1994b, 1994c, 1995a, 1995b, 1996; Templin et al., 1996a, 1996b). Many other studies also examined the mechanism of chloroform carcinogenicity, including studying the effects on methylation and expression of growth control genes (Fox et al., 1990, Vorce and Goodman, 1991, Dees and Travis, 1994, Testai et al., 1995, Sprankle et al., 1996, Chiu et al., 1996, Gemma et al., 1996a, 1996b). Short-term toxicity studies (Thorton-Manning et al., 1994; Lilly et al., 1994 and 1996) and chronic toxicity studies which included reproductive evaluations (Klinefelter et al., 1995) were found for BDCM.

The new studies on THMs contribute to the weight-of-evidence conclusions reached in the 1994 proposal. Based on the available new studies noted above, the proposed MCLGs for BDCM, DBCM, and bromoform are not anticipated to change.

The International Life Science Institute (ILSI) convened an expert panel in 1996 to explore the application of the USEPA's 1996 Proposed Guidelines for Carcinogen Risk Assessment (USEPA, 1996a) to the available data on the potential carcinogenicity of chloroform and dichloroacetic acid (DCA); these data include chronic bioassay data and information on mutagenicity, metabolism, toxicokinetics and mode of carcinogenic action. USEPA will be evaluating the data from the ILSI expert panel for chloroform and will provide an opportunity to comment on the potential implications for the regulatory provisions for chloroform and the trihalomethanes prior to the final Stage 1 DBP rule.

4. Haloacetic Acids

The proposed rule included an MCL of 0.060 mg/L for the haloacetic acids (five HAAs-monobromoacetic acid, dibromoacetic acid, monochloroacetic acid, dichloroacetic acid, and trichloroacetic acid) with an MCLG of zero for dichloroacetic acid (DCA) based on sufficient evidence of carcinogenicity in animals, and a MCLG of 0.3 mg/L for trichloroacetic acid (TCA) based on developmental toxicity and possible carcinogenicity.

There has been cancer research completed for other HAAs since the 1994 proposal. The 1994 proposal did not include an MCLG for monochloroacetic acid (MCA) because there were inadequate occurrence data for MCA. Since the proposal, a few toxicological studies on MCA have been identified. A recent 2-year carcinogenicity study on MCA and trichloroacetic acid (TCA) (DeAngelo et al., 1997) demonstrated that MCA and TCA were not carcinogenic in male rats. This confirms the results of the NTP (1990) cancer rodent bioassays of MCA. There have been several recent studies examining the mode of carcinogenic action for both DCA and TCA (Pereira and Phelps 1996; and Pereira 1996) including mutagenicity studies (Austin et al., 1996; Mackay et al., 1995; Fox et al., 1996; Fuscoe et al., 1996; Tao et al., 1996; and Parrish et al., 1996). As discussed above USEPA will evaluate the significance of the ILSI panel's report on the risk assessment for DCA and provide an opportunity to comment on the potential implications for the regulatory provisions for DCA and the other haloacetic acids prior to the final Stage 1 DBP rule.

Screening studies have shown the potential of different haloacetic acids, including DCA and brominated haloacetic acids, to produce reproductive and developmental effects (Linder et al., 1997c; Hunter et al., 1996; Richard and Hunter, 1996; Linder et al. 1994, 1995, 1997a, 1997b). At this time, these new studies are not expected to alter the MCLGs for DCA or TCA in the proposed rule. USEPA continues to believe that there are inadequate occurrence data to establish MCLGs for MCA, monobromoacetic acid and dibromoacetic acid.

5. Chloral Hydrate

The proposed rule included an MCLG of 0.04 mg/L for chloral hydrate. USEPA did not set an MCL for chloral hydrate because it believed the MCLs for TTHM and HAA5, and the treatment technique requirements would provide adequate control for chloral hydrate. In the 1994 proposal, chloral hydrate was considered a group C, possible human carcinogen. Since the 1994 proposal, several new studies have been published which contribute to the weight of evidence conclusion for the potential carcinogenicity of chloral hydrate. These include *in vitro* cell transformation and genotoxicity studies (Gibson et al., 1995; Adler, 1996; Allen et al., 1994; Parry et al., 1996; and Ni et al., 1996). Some screening studies were found concerning the potential of chloral hydrate to cause reproductive and developmental toxicity (Klinefelter et al., 1995 and Saillenfait et al., 1995). The available new studies mentioned above do not indicate a change in the MCLG for chloral hydrate.

6. Bromate

The proposed rule included an MCL of 0.010 mg/L and an MCLG of zero for bromate. A major issue in the proposal was that setting an MCL at 0.010 mg/L

would exceed the theoretical 1×10^{-4} lifetime excess cancer risk level for bromate of 5 ug/L. Since the proposal, several toxicology studies have been completed on bromate, including assays for reproductive and developmental effects (Wolfe and Kaiser, 1996).

USEPA has recently completed a chronic cancer study in male rats and male mice for bromate. USEPA is evaluating this data and will provide an opportunity for public comment on the potential implications for the regulatory provisions for bromate prior to the final rule.

D. Summary of Key Observations

Since the proposal, several epidemiology and toxicology studies have been completed on the potential health effects associated with exposure to DBPs. USEPA currently believes the new published data will not impact the MCLGs for BDCM, CDBM, bromoform, chloral hydrate, or trichloroacetic acid. However, USEPA is currently evaluating the results from new toxicology studies for chlorite and bromate and will evaluate the report from the ILSI expert panel on chloroform and DCA when it becomes available. USEPA will provide an opportunity to comment on the potential implications for the regulatory provisions for these DBPs prior to the final rule.

E. Request for Public Comments

USEPA requests comment on all the new information outlined above and its potential impacts on the regulatory provisions for the final Stage 1 DBPR and any additional data on the health effects from DBPs that need to be considered for the final Stage 1 DBPR.

III. Enhanced Coagulation and Enhanced Softening

A. 1994 Enhanced Coagulation and Enhanced Softening Proposal

As discussed above, the 1994 proposed rule for D/DBPs included enhanced coagulation/enhanced softening requirements in addition to maximum contaminant levels (MCLs) for total trihalomethanes (TTHMs) and the sum of five haloacetic acids (HAA5) (USEPA, 1994b). In that proposal, Subpart H systems (utilities treating either surface water or groundwater under the direct influence of surface water) that use conventional treatment (i.e., coagulation, sedimentation, and filtration) or precipitative softening would be required to remove DBP precursors by enhanced coagulation or enhanced softening. The removal of total organic carbon (TOC) would be used as a performance indicator for DBP precursor control. The 1994 proposed rule (in ''Step 1'' of the treatment technique) provided for 20–50 percent TOC removal, depending on influent water quality (Table III–1).

TABLE III–1.—1994 PROPOSED REQUIRED REMOVAL OF TOC BY ENHANCED COAGULATION/ENHANCED SOFTENING FOR SURFACE-WATER SYSTEMS [a] USING CONVENTIONAL TREATMENT [b]

Source-water TOC, mg/L	Source-water alkalinity, mg/L as $CaCO_3$		
	0–60 (percent)	>60–120 (percent)	>120 [c] (percent)
>2.0–4.0	40.0	30.0	20.0
>4.0–8.0	45.0	35.0	25.0
>8.0	50.0	40.0	30.0

[a] Also applies to utilities that treat groundwater under the influence of surface water.
[b] Systems meeting at least one of the conditions in Section 141.135(a)(1)(i)–(iv) of the proposed rule are not required to operate with enhanced coagulation.
[c] Systems practicing precipitative softening must meet the TOC removal requirements in this column.

The 1994 Stage I **Federal Register** notice proposed that systems achieve a percent TOC removal based on their influent TOC concentration and alkalinity. The proposed rule provided for a number of exceptions to the enhanced coagulation and enhanced softening requirements, namely: (a) When the system's treated water TOC concentration, prior to the point of continuous disinfection, is ≤2.0 mg/L (b) when the PWS's source water TOC level, prior to any treatment, is <4.0 mg/L; the alkalinity is >60 mg/L; and these systems are achieving TTHMs <0.040 mg/L and HAA5 <0.030 mg/L, or have made irrevocable financial commitments to technologies that will meet these levels; (c) the PWS's TTHM annual average is no more than 0.040 mg/L and the HAA5 annual average is no more than 0.030 mg/L and the system uses only chlorine for disinfection; and (d) PWSs practicing softening and removing at least 10 mg/L of magnesium hardness (as $CaCO_3$), except those that use ion exchange, are not subject to performance criteria for the removal of TOC.

As part of the enhanced coagulation requirements, the proposed rule indicated that if a PWS could not meet the prescribed TOC removal criteria, it must perform a series of jar or pilot-scale tests (''Step 2'') to determine how much TOC removal they can reasonably and practically achieve. This Step 2 requirement was created to handle the 10 percent of the waters that were not expected to meet the Step 1 criteria, and considerations as to what was practical to achieve involved a consensus-based balancing of policy and scientific perspectives.

The proposed jar-testing protocol involves adding regular-grade alum in 10 mg/L increments (or an equivalent amount of iron coagulant) until specific depressed pH goals are achieved (this was referred to as ''maximum pH'' in the proposal), which depends on influent alkalinity and what is practical to achieve. For the alkalinity ranges 0–60, >60–120, >120–240, and >240 mg/L as calcium carbonate ($CaCO_3$), the maximum pH values are 5.5, 6.3, 7.0, and 7.5, respectively. The maximum pH is a target pH goal for step 2 testing. The maximum pH is the pH value the tested water must be at or below before incremental coagulant addition is discontinued. The protocol was based on alum, as more data were available on the use of this coagulant in a wide variety of waters. However, the proposed rule allows for the use of iron coagulants in the step 2 jar testing.

The TOC of each jar-treated water is measured, and then the residual TOC is plotted versus alum dosage. The ''point of diminishing returns'' (PODR) is determined to be when 10 mg/L of additional alum (or an equivalent amount of iron coagulant) does not decrease residual TOC by 0.3 mg/L (i.e., slope of TOC versus alum dosage curve ≤[0.3 mg/L TOC]/[10 mg/L alum]). These data would be used by a utility

to request alternative TOC removal performance criteria from the primacy agency. However, one of the intents in setting the step 1 TOC removal percentages at the values chosen was to provide that 90 percent of the systems would not need to do step 2 testing. This would minimize transactional costs for the primacy agencies.

If the TOC removal curve never met the slope criterion at any coagulant dose, such a water would be considered unamenable to enhanced coagulation and no TOC removal would be required for such a water. Waters with low TOC and moderate-to-high alkalinity were expected to be some of the more difficult to treat with enhanced coagulation, so systems treating such waters were encouraged to explore alternative technologies (e.g., ozone/chloramines) that could reduce DBP levels significantly below the proposed Stage 1 MCLs (i.e., <50 percent of the proposed Stage 1 MCLs).

EPA solicited comments on all aspects of enhanced coagulation's step 2 protocol in the preamble to the rule, as well as on the step 1 TOC removal percentages including:

(1) Whether the TOC removal levels shown in Table III–1 are representative of what 90 percent of systems required to use enhanced coagulation could be expected to achieve with elevated, but not unreasonable, coagulant addition?

(2) Whether filtration should be required as part of the bench-pilot-scale procedure for determination of Step 2 enhanced coagulation? If so, what type of filter should be specified for bench-scale studies?

(3) Whether a slope of 0.3 mg/L of TOC removed per 10 mg/L of alum should be considered representative of the point of diminishing returns for coagulant addition under Step 2? Comments were also solicited on how the slope should be determined (e.g., point-to-point, curve-fitting); and if the slope varies above and below 0.3/10, where should the Step 2 alternate TOC removal requirement be set—at the first point below 0.3/10?, at some other point?

(4) How often bench- or pilot-scale studies should be performed to determine compliance under step 2? Should such frequency and duration of testing be included in the rule or left to guidance (i.e., allow the State to define what testing would be needed on a case by case basis for each system)? Is quarterly monitoring appropriate for all systems. What is the best method to present the testing data to the primacy agency that reflects changing influent water quality conditions and also keeps transactional costs to a minimum? How should compliance be determined if the system is not initially meeting the percent TOC reduction requirements because of a difficult to treat waters and a desire to demonstrate alternative performance criteria?

EPA also solicited comments on several issues related to the enhanced softening requirements including:

(1) 3×3 matrix: For softening plants, is enhanced softening properly defined by the percent removals in Table III–1 in this Notice, or by 10 mg/L removal of magnesium hardness reported as $CaCO_3$?

(2) Use of ferrous salts: Can ferrous salts be used at softening pH levels to further enhance TOC removals?

(3) Step 2: Whether data are available on the use of ferrous salts in the softening process which can help define a step 2 for softening? What is the definition of Step 2?

B. New Information on Enhanced Coagulation and Enhanced Softening since 1994 Proposal

Since the 1994 proposal, there has been considerable research on a number of enhanced coagulation and enhanced softening issues highlighted above in a wide variety of waters nationwide. A summary of the results of some of the studies and surveys are included below. Studies of enhanced coagulation are covered first, followed by discussion of enhanced softening studies. Note that a number of the softening studies looked at TOC removal in essentially the same framework as is used for enhanced coagulation, with emphasis on the coagulant and lime dose and geared toward finding a similar format for step 2 enhanced softening as was defined for enhanced coagulation. A number of these studies focused on the benefits of increased lime or coagulant doses in removing TOC in softening systems. Results of these studies generally showed that percent TOC removal is dependent on the raw water.

1. New Data on Enhanced Coagulation

a. UNC Enhanced Coagulation Study. To address many of the aforementioned issues, the University of North Carolina (UNC) at Chapel Hill, with funding from the Water Industry Technical Action Fund (WITAF), performed an enhanced coagulation study (Singer et al., 1995). The UNC research team evaluated a wide range of waters nationwide, which included at least three waters in each box of the 3×3 matrix in Table III–1. Each water was jartested in order to determine the feasibility of achieving the proposed step 1 TOC percent removal requirement for each water, as well as to assess the PODR criteria.

In addition, recognizing that coagulation primarily removes the humic fraction of the natural organic matter (NOM) in water (Owen et al., 1993), a determination of the percent humic content was made for each of the waters studied in order to better characterize the treatability of each water. NOM fractionation was performed on samples of each raw water and on select coagulated waters using an XAD–8 resin adsorption procedure (Thurman & Malcolm, 1981). In this procedure, the hydrophobic fraction of the water, which includes humic substances, was determined.

Furthermore, Edzwald and Van Benschoten (1990) have found the specific ultraviolet absorbance (SUVA) of a water to be a good indicator of the humic content of that water, so SUVA was also determined in the UNC study. SUVA is defined as the UV (measured in m^{-1}) divided by the dissolved organic carbon (DOC) concentration (measured as mg/L). Typically, SUVA values <3 L/mg-m are representative of largely nonhumic material, whereas SUVA values in the range of 4–5 L/m-mg represent mainly humic material (Edzwald & Van Benschoten, 1990).

Figures III–1 and III–2 represent a typical set of jar test results from the UNC study. In these tests, water from Raleigh, NC, with a TOC of 7.5 mg/L and alkalinity of 17 mg/L was evaluated (White et al., 1997). At low alum doses (<20 mg/L), an initial TOC (and turbidity) plateau was observed for which no removal of TOC (or turbidity) occurred with the coagulant addition. Following the addition of a ''threshold'' alum dose (20 mg/L), a steep drop in the concentration of TOC (and turbidity) was observed with increases in alum dose. As the alum dose increased further, the drop in TOC (and turbidity) decreased to a final plateau at which little to no additional removal of TOC (or turbidity) was seen with further increases in alum dose (>40 mg/L).

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FIGURE III-1: pH and turbidity profiles of alum jar tests for Raleigh, N.C.

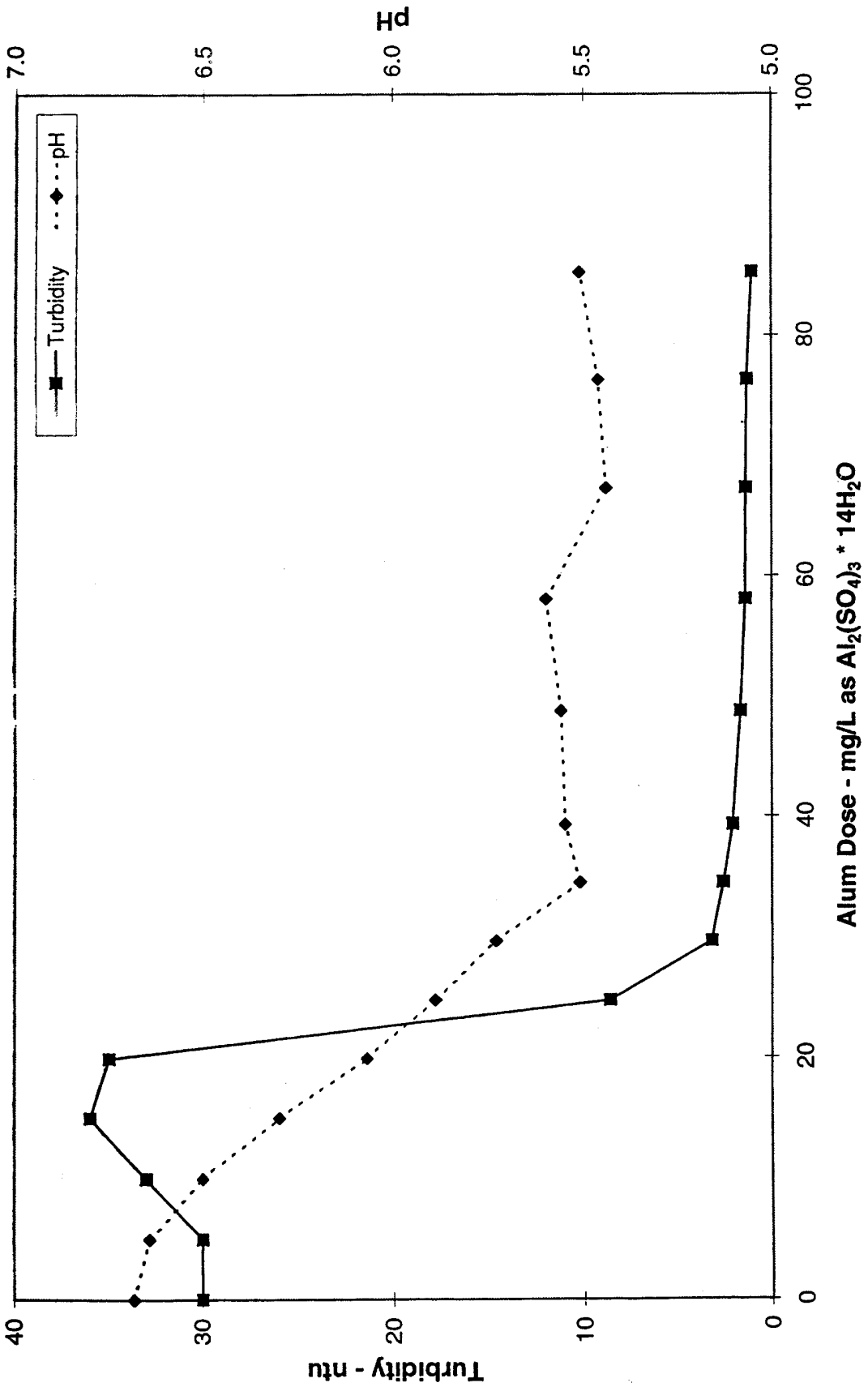

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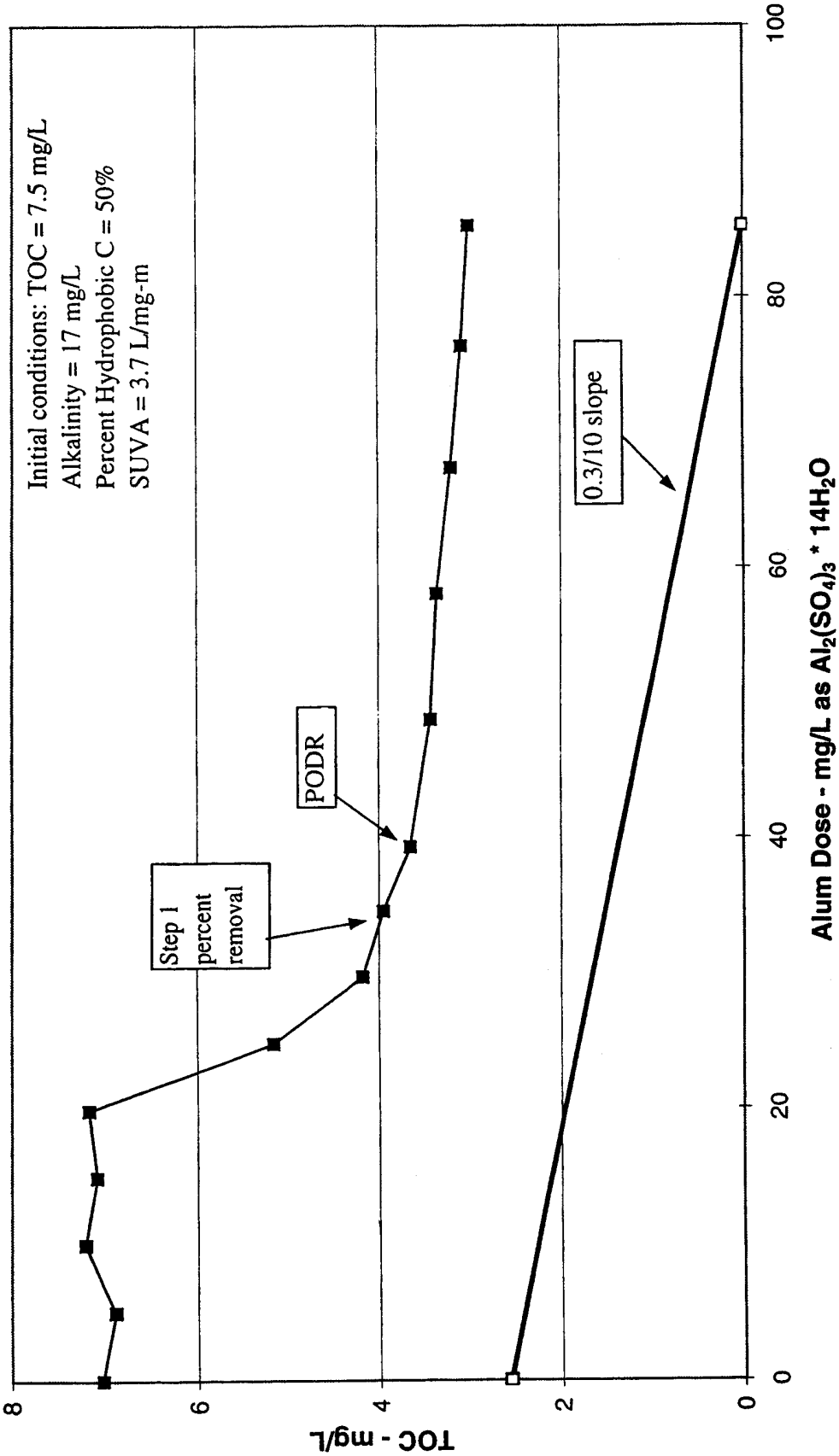
FIGURE III-2: Alum jar-test profile for Raleigh, N.C., showing dosages required to meet Step 1 removal and PODR



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In the jar tests of the Raleigh water, an alum dose of ~35 mg/L resulted in the removal of ~47 percent of the TOC, where the proposed step 1 TOC removal for this water was predicted to be 45 percent. The PODR, based on the slope criterion of 0.3 mg/L TOC/10 mg/L of alum, was realized at a jar-test alum dose of 39 mg/L, in which 51 percent of the TOC was removed. In order to comply with a 45-percent TOC removal requirement with a 15-percent safety factor (Krasner et al, 1996), a system would need to design for a 52-percent TOC removal.

The results using the Raleigh water appear to address several of the outstanding issues: namely, that the step 1 TOC removal requirements for this water is appropriate, the slope criterion did identify the PODR, and evaluation of the PODR required an examination of points beyond the threshold coagulant dose. Figure III–3 shows jar test results for a low-TOC (2.9 mg/L), high-alkalinity (239 mg/L) water from Indianapolis, IN, from the UNC study (White et al., 1997). The TOC removal curve never exceeded the 0.3/10 slope criterion, which means that this water would be exempt from the enhanced coagulation requirements in the 1994 proposed rule. The step 1 TOC removal requirement of 20 percent can be achieved, with an alum dose of ~65 mg/L required in the jar tests. However, the slope of the TOC removal curve shows that this water is not very amenable to enhanced coagulation.

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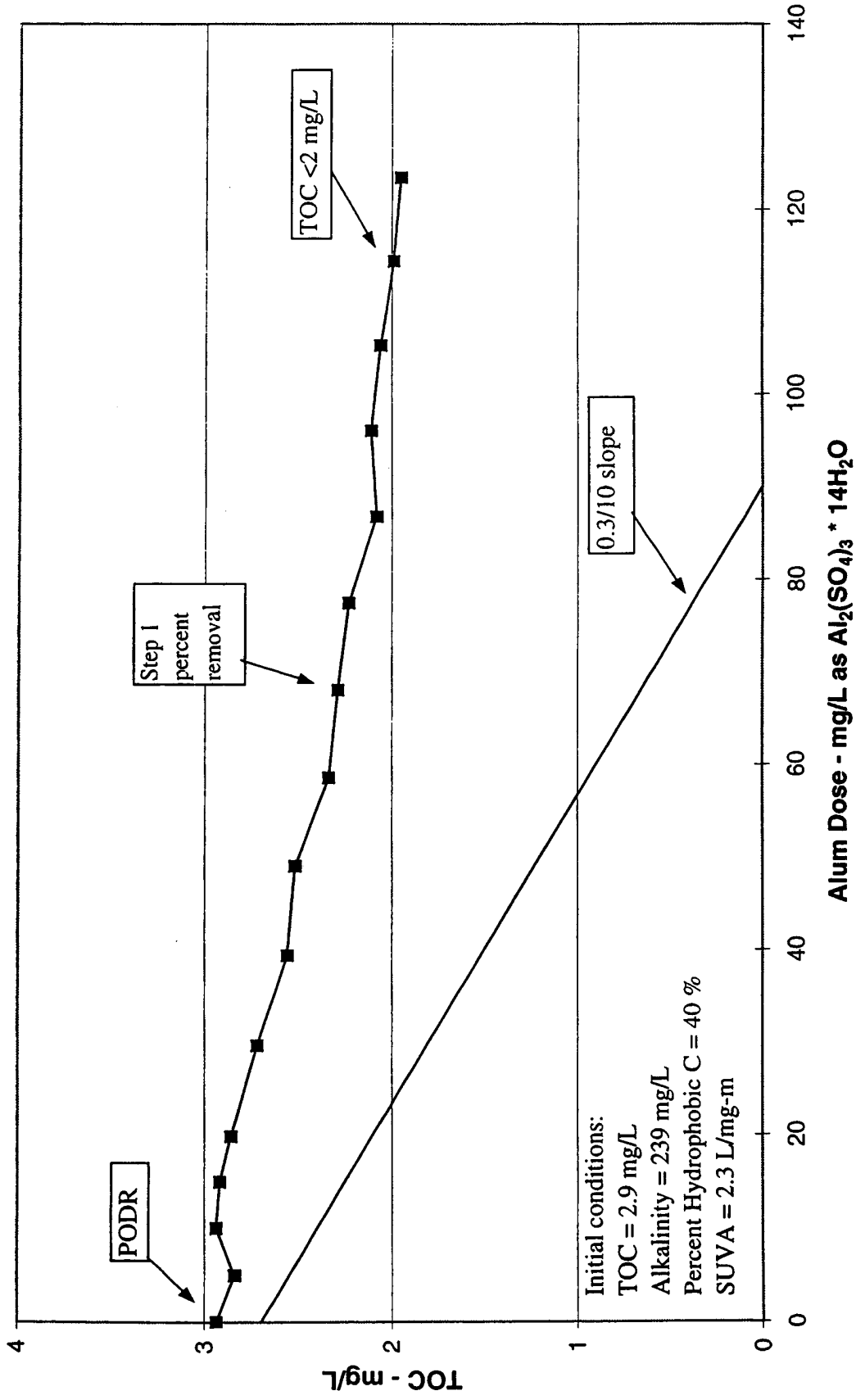
FIGURE III-3: Alum jar-test profile for Indianapolis, Ind.



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A summary of the controlling criterion for each of the 31 waters tested by UNC, based on the 1994 proposed rule criteria, is shown in Table III–2 (adapted from White et al., 1997). Only 14 of the 31 waters met the proposed step 1 percent TOC removal requirements or achieved a settled water TOC concentration <2.0 mg/L at an alum dose less than or equal to that needed to meet the PODR. Those waters that readily met the step 1 TOC removal requirements were mostly moderate-to-high-TOC waters with low alkalinity. The UNC study suggested that a significant number of waters (especially low-TOC, high-alkalinity waters) would probably need to use the step 2 protocol to establish alternative performance criteria.

TABLE III–2.—CONTROLLING CRITERION FOR ENHANCED COAGULATION FOR WATERS EVALUATED IN UNC STUDY, BASED ON 1994 PROPOSED RULE CRITERIA

Source-water TOC, mg/L	Source-water alkalinity, mg/L as $CaCO_3$		
	0–60	>60–120	>120
>2.0–4.0	<2.0 [a]	PODR [b]	N/A [c]
	PODR	PODR	PODR
	PODR	STEP 1 [d]	N/A
	PODR	PODR	
	PODR		
>4.0–8.0	STEP 1	PODR	STEP 1
	STEP 1	PODR	STEP 1
	STEP 1	STEP 1	PODR
		STEP 1	
>8.0	STEP 1	STEP 1	STEP 1
	STEP 1	PODR	PODR
	PDOR	STEP 1	PODR

[a] Settled water TOC less than 2.0 mg/L.
[b] Point of diminishing returns.
[c] Not amenable to enhanced coagulation.
[d] Step 1 required percent removal of TOC.

White and co-workers (1997) examined the relationship between the percent humic (hydrophobic) content of the raw waters in the UNC study and the maximum percent removal of DOC achieved at the high alum doses where little additional TOC removal was observed. Figure III–4 shows that waters with relatively high levels of humic material tended to exhibit higher degrees of DOC removal than those with low humic content. Figure III–5 shows that waters that contained high initial nonhumic (hydrophilic) DOC concentrations tended to have high residual DOC concentrations following coagulation.

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FIGURE III-4: Effect of initial hydrophobic organic content on maximum DOC removal

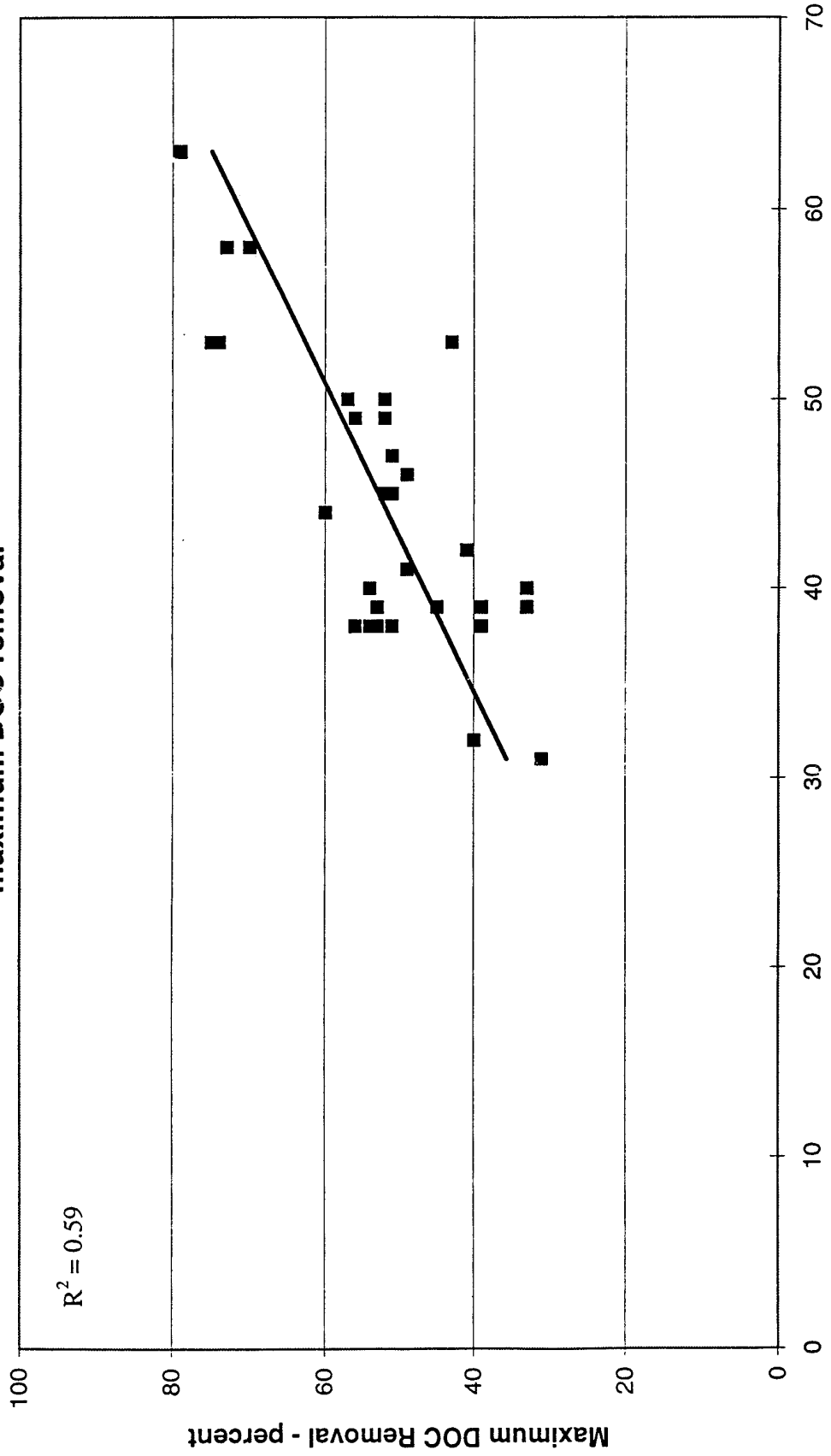

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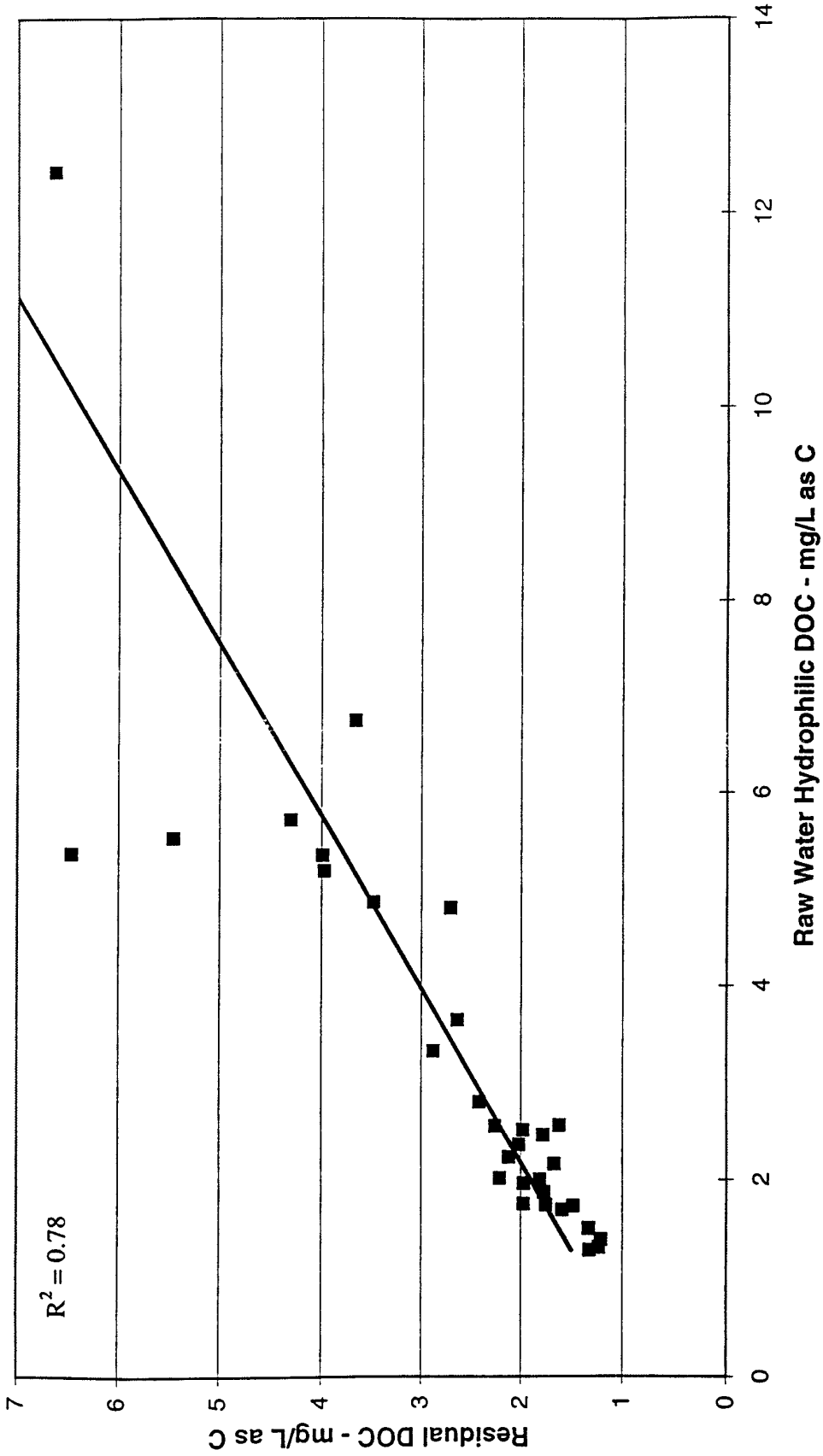
FIGURE III-5: Effect of Hydrophilic DOC concentration on residual DOC concentration after coagulation



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In the UNC study, the humic carbon content of the raw waters was reasonably correlated (r^2=0.74) with their SUVA values (White et al., 1997). Figure III–6 shows that waters with high initial SUVA values (i.e., 3.4–5.7 L/mg-m) exhibited significant reductions in SUVA as a result of coagulation, reflecting substantial removal of the humic (and other UV-absorbing) components of the overall organic matter, whereas waters with low initial SUVA values (i.e., 1.5–2.0 L/mg-m) exhibited relatively low reductions in SUVA. For all of the waters examined, the residual SUVA (i.e., ≤2.4 L/mg-m) tended to plateau at high alum doses, reflecting that the residual DOC was primarily nonhumic organic matter.

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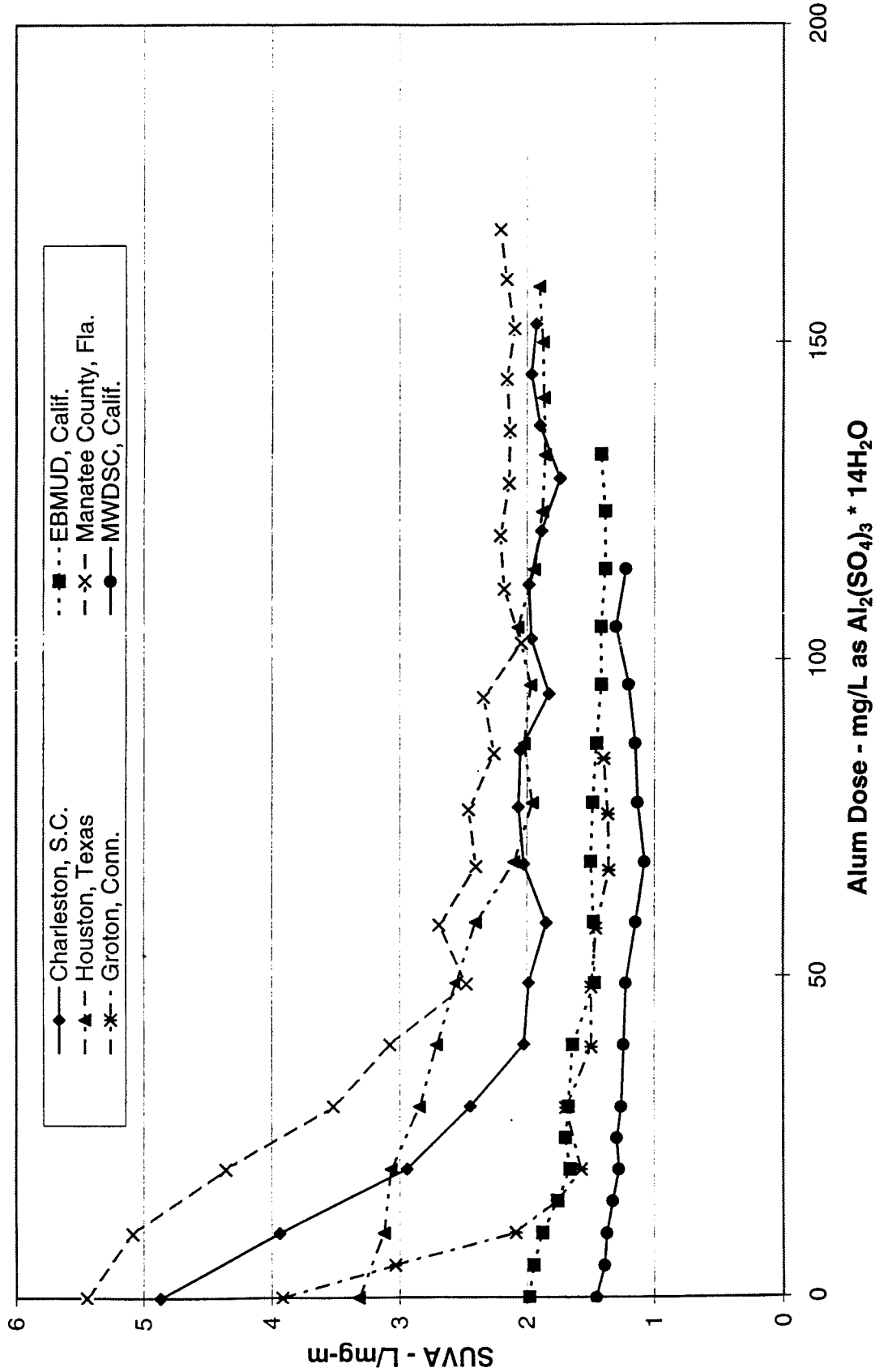

FIGURE III-6: Selected SUVA coagulation profiles

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In the UNC study, for the 14 waters in which the step 1 TOC removal requirements were met before the PODR was reached, the average raw-water SUVA was 3.9 L/mg-m, whereas the average raw-water SUVA of the other 17 waters was 2.6 L/mg-m (White et al., 1997). For most of the 31 waters examined, the PODR was found to occur at alum doses where SUVA had already reached its plateau. These findings suggested that raw-water SUVA values might be utilized in redefining the step 1 TOC removal requirements and that residual SUVA values might be utilized in defining the PODR. Unlike NOM characterizations with XAD resins in a research laboratory, SUVA is an easy parameter that can be determined by laboratories that measure DOC concentrations and UV absorbance.

b. Metropolitan Water District of Southern California/Colorado University Enhanced Coagulation Study. As noted in the UNC study, waters with low TOC and high alkalinity were expected to be the more difficult to treat with enhanced coagulation. Metropolitan Water District of Southern California (MWDSC) and Colorado University at Boulder did detailed studies on two low-TOC waters, one with moderate alkalinity (California State Project Water) and the other with high alkalinity (Colorado River water). In addition to using an XAD–8 resin fractionation to quantify the humic (hydrophobic) versus nonhumic (hydrophilic) content of the NOM, a 1000-dalton (1K) ultrafilter was used to determine what fraction of the bulk or coagulated water was of a lower versus higher molecular weight (Amy et al., 1987).

California State Project Water (with 80 mg/L alkalinity) was jar-treated with incremental alum doses of ~ 622 mg/L (up to a total of 111 mg/L). Figures III–7 and III–8 show that addition of alum at 47 mg/L reduced the raw-water bulk DOC concentration from 4.3 mg/L to 2.6 mg/L (a 39-percent bulk DOC removal); subsequent alum addition resulted in a plateauing of the DOC removal rate (Krasner et al., 1995). Throughout the entire range of alum doses evaluated, little of the low-MW and nonhumic DOC was removed. The high-MW and humic fractions, however, were well removed with increasing alum dosages, demonstrating preferential removal of these fractions. The residual DOC remaining after enhanced coagulation was primarily made up of low-MW and nonhumic material. The latter NOM fractions represent the part of the bulk DOC that is not readily amenable to removal by coagulation.

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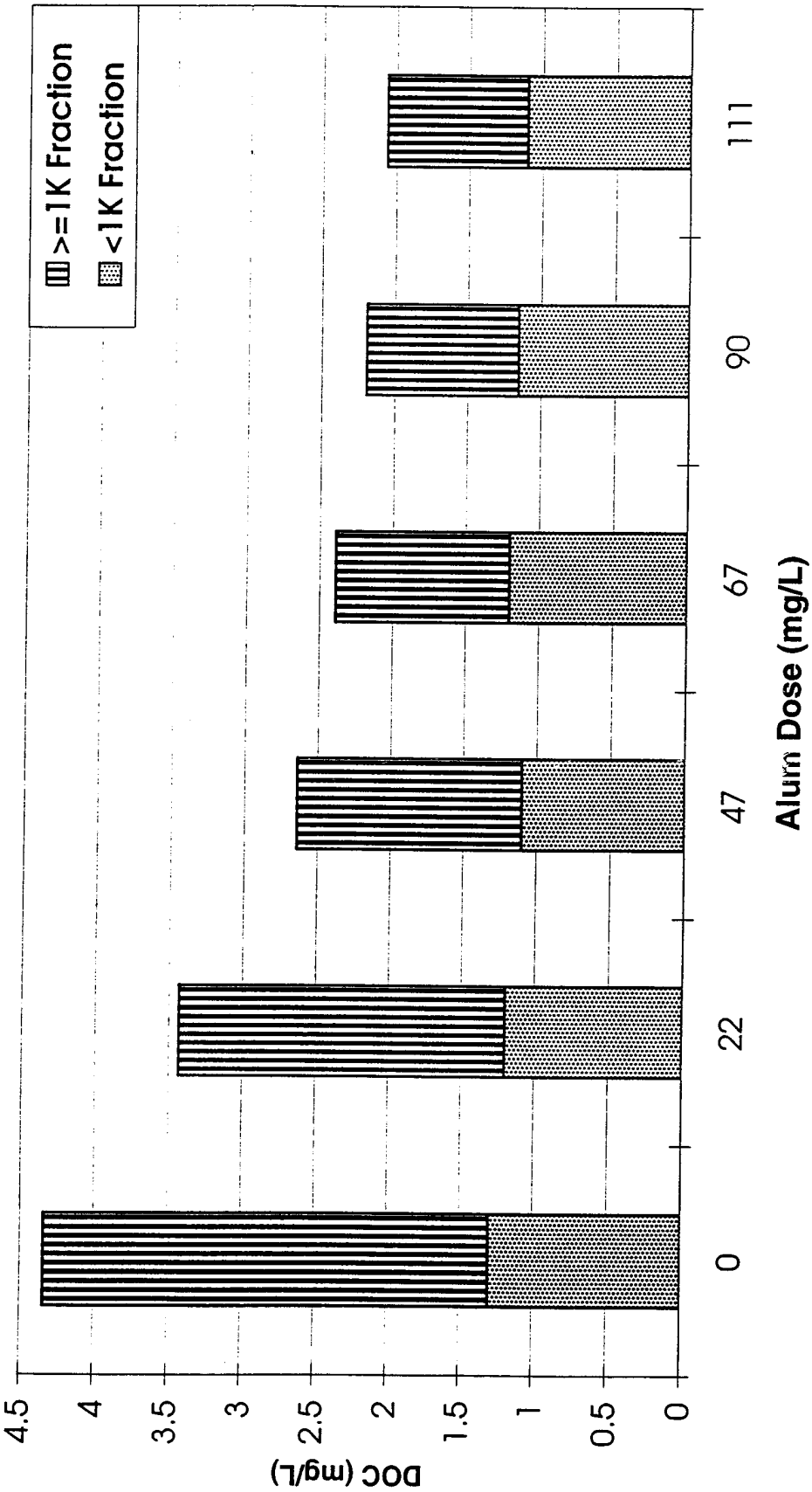
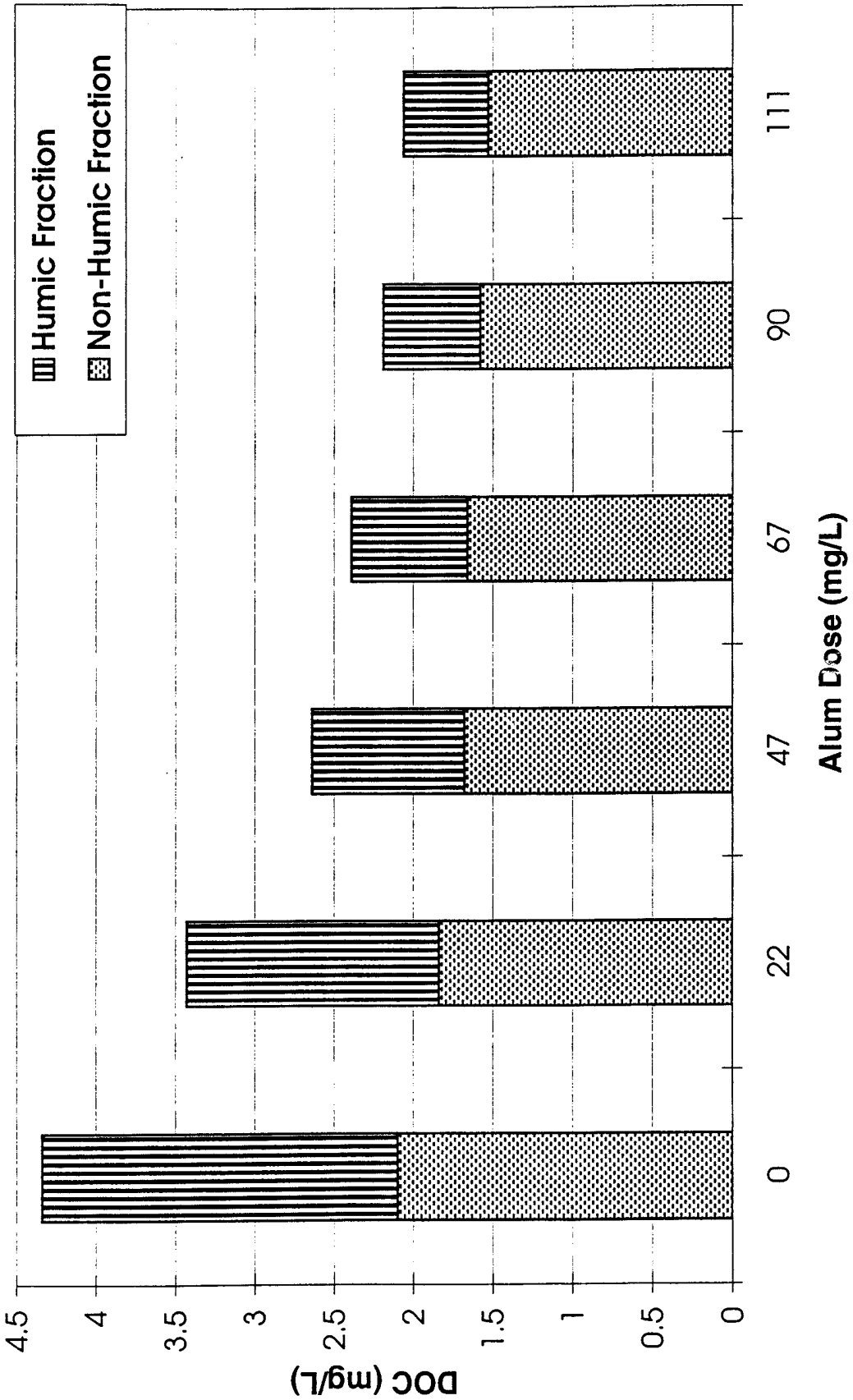


Figure III-7: Impact of Increased Alum Dose on Removal of Molecular Weight Fractions in SPW

Figure III-8: Impact of increased alum dose on removal of humic/non-humic fractions in SPW



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For this sample of California State Project Water, 52 percent of the DOC was humic NOM and the SUVA value was 2.5 L/mg-m (Krasner et al., 1995). Figure III–9 shows that increasing doses of alum reduced the fraction of humic DOC in the residual DOC to 26 percent. In addition, the reduction in SUVA closely paralleled the reduction in the humic content of the residual DOC. SUVA was reduced to 1.7 L/mg-m with 47 mg/L of alum, whereas the addition of 111 mg/L of alum only reduced the value of SUVA to 1.5 L/mg-m.

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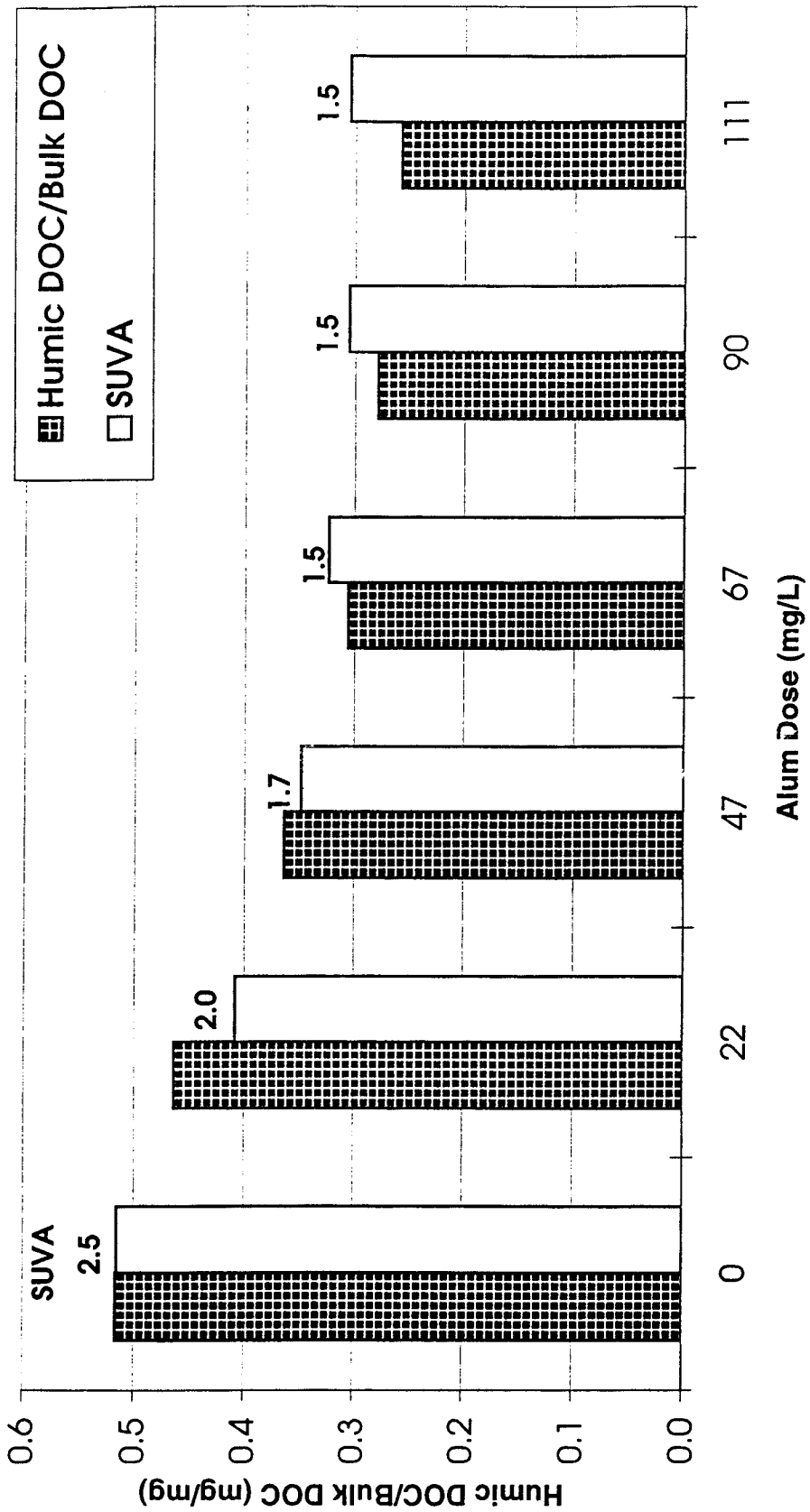
Figure III-9: Impact of Increased Alum Dose on SUVA and Fraction of Humic DOC in SPW



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Colorado River water has a greater amount of low-molecular weight DOC and somewhat more nonhumic DOC than California State Project Water (Krasner et al., 1995). Nonetheless, increased doses of alum did remove DOC in Colorado River water, although not to the same extent as in California State Project Water. Although the alkalinity of Colorado River water (135 mg/L) is higher than that of California State Project Water, the difference in treatability was more likely related to the differences in the NOM characteristics of the two waters. As with California State Project Water, the residual DOC in the coagulated Colorado River water was primarily low-molecular weight and nonhumic NOM (Figures III–10 and III–11). The raw-water Colorado River water had a SUVA value of 1.1 L/mg-m and 44 percent of the DOC was humic NOM. After the addition of 114 mg/L of alum, the humic content of the residual DOC was only reduced to 38 percent and the SUVA value was only reduced to 1.0 L/mg-m (Figure III–12).

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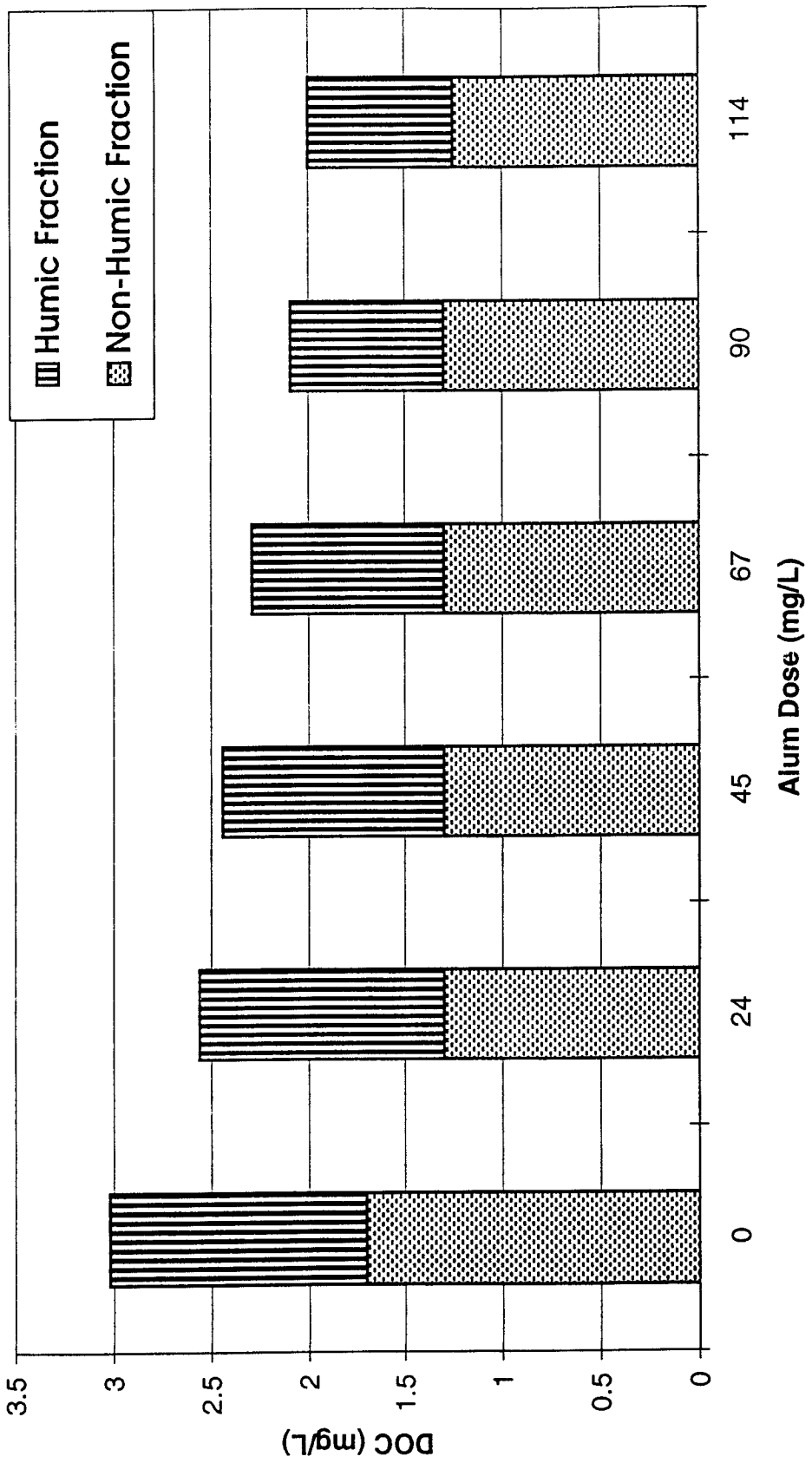
Figure III-10: Effect of Increased Alum Dose on Removal of Humic/Non-Humic Fractions in CRW



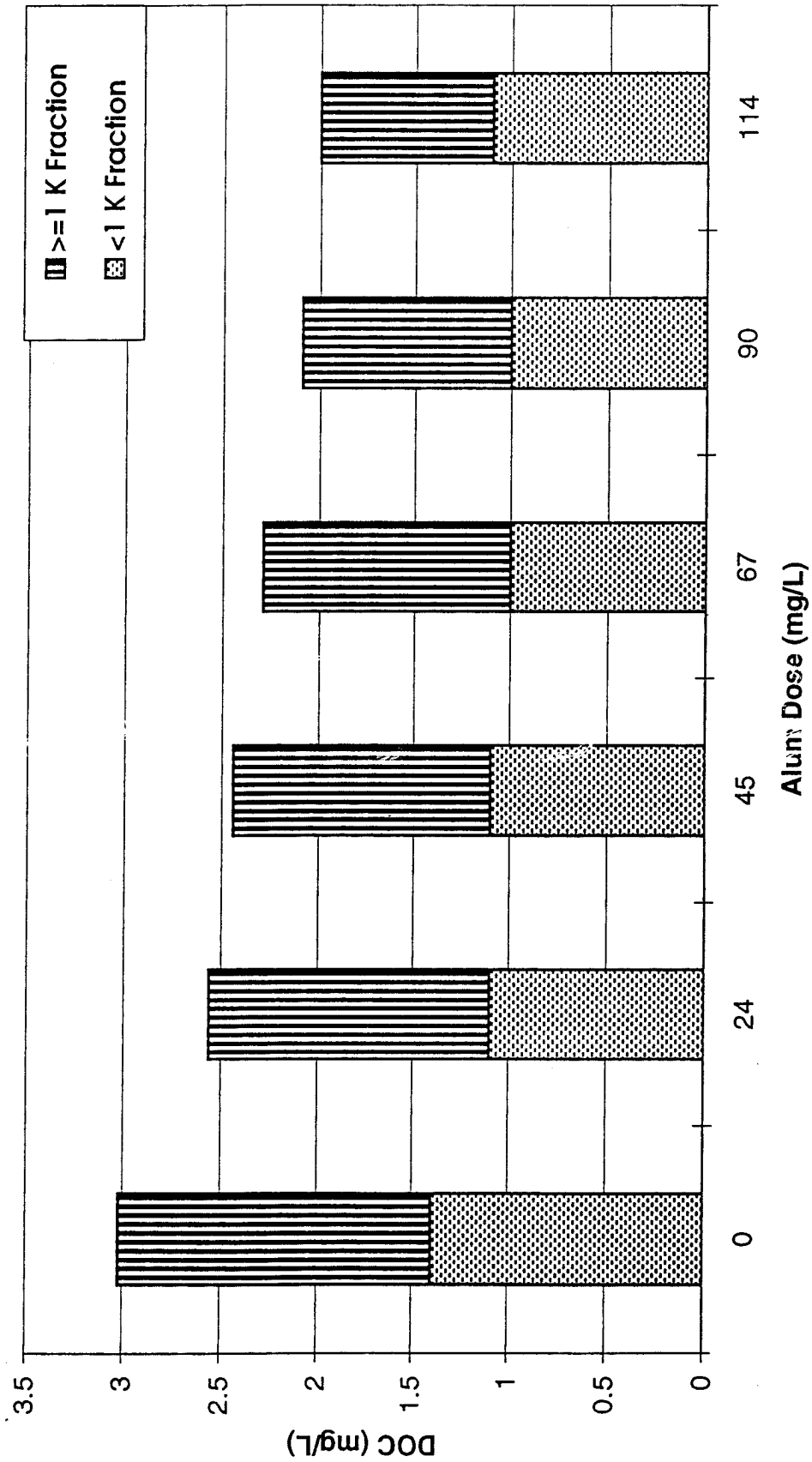
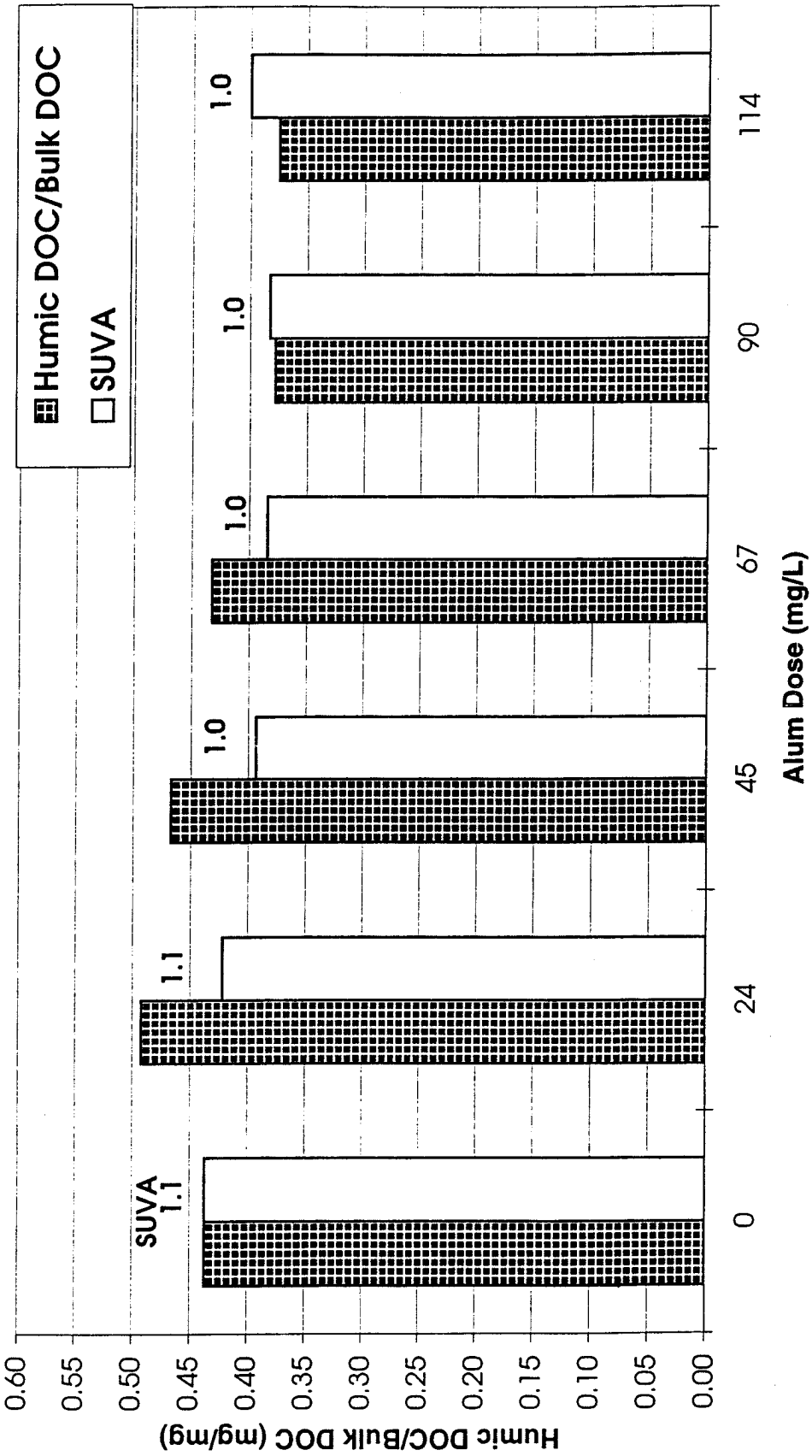


Figure III-11: Impact of Increased Alum Dose on Removal of Molecular Weight Fractions in CRW

Figure III-12: Impact of Increased Alum Dose on SUVA and Fraction of Humic DOC in CRW



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Cheng and co-workers (1995) studied enhanced coagulation of California State Project Water and Colorado River water, as well as the effects of seasonal changes on TOC removal. Several water blends were tested, including 100-percent California State Project Water and Colorado River water, as well as 90–, 80–, 70–, 60–, and 50-percent Colorado River water blends. These blends represent the range of waters that are treated at MWDSC's plants and may be subject to enhanced coagulation treatment. The SUVA values for California State Project Water during this study ranged from 2.8 to 3.8 L/m-mg, whereas the SUVA values for Colorado River water varied from 1.0 to 1.7 L/m-mg (the blends of California State Project Water and Colorado River water contained SUVA values of <3.0 L/m-mg).

Cheng and co-workers (1995) also addressed the issue of curve fitting to examine the TOC removal curves. All data were analyzed by fitting to either an exponential decay-type equation, a third-order polynomial-fit equation or to an isopleth-type equation. The data fit best when the curve-fitting started after the ''threshold'' coagulant dose, and this is consistent with the finding of the UNC group (discussed in section 1.a. above). When the data are fitted to a 100-percent California State Project Water water during October 1993 (Cheng et al., 1995) the data did not fall into an isopleth or exponential-type curve, but rather a third order equation fit. The third order equation fit the data with a very high correlation coefficient, but it smoothed the curve and masked the actual slope of the removal curve.

The results from Cheng and co-workers indicate that a single model could not adequately fit all the data sets (data below the threshold coagulant dose had to be omitted), nor could it fit all the waters tested during various seasons. MWDSC's data better fit the decay-type or polynomial-fit equation than the isopleth, but the isopleth yielded the PODR TOC removal percentages that best matched those of the point-to-point method for all samples, and better matched the TOC removal curve.

c. *Malcolm Pirnie, Inc./Colorado University data collection and analysis.* The UNC/AWWA enhanced coagulation provided substantial new information and addresses some of the outstanding issues raised above, but also raised concern over the number of systems that might seek alternative performance criteria. In order to evaluate the number of systems that may seek alternative treatment and to develop data to support revisions to the proposed requirements, Malcolm Pirnie, Inc. and Colorado University, with funding from the Water Industry Technical Action Fund (WITAF), performed a data collection and analysis project to collect additional data on enhanced coagulation.

Because the Malcolm Pirnie, Inc./Colorado University team assembled enhanced coagulation data from numerous researchers throughout the country, some source waters were tested more than once. If a source water was studied more than once (e.g., Colorado River water), but had similar water quality over time (e.g., comparable TOC, SUVA, alkalinity), the results of the different experiments were averaged so as to not have the database overly influenced by a few water types. On the other hand, if the same source water was evaluated, but the water quality was different, then each experiment was separately considered. In some cases, a source water moved from one box in the 3×3 matrix to another with variations in TOC and/or alkalinity. If the identical sample of water was evaluated with different coagulants, both sets of data were included as separate entries. It is important to note that a number of systems have started to not only enhance their coagulation process, but have switched the type of coagulant they are using to one that improves TOC removal.

Table III–3 provides a summary of the raw-water characteristics of the 127 waters in the Malcolm Pirnie, Inc./AWWA database. When waters in this nationwide database were examined by raw-water TOC, SUVA, and alkalinity, researchers observed that high-TOC (>8 mg/L)/low alkalinity (<60 mg/L) waters had high SUVA (median = 4.9), whereas low-TOC (2–4 mg/L)/high-alkalinity (>120 mg/L) waters had low-SUVA (median = 1.7). For the entire 3×3 matrix, the cumulative probability distribution (10th, 50th, and 90th percentile) of SUVA values typically increased with either increasing TOC or decreasing alkalinity. Because SUVA is an indication of humic NOM content, and it is the humic fraction that is most amenable to enhanced coagulation, this SUVA distribution supports the earlier observation of the UNC research team that step 1 TOC removals were most readily met in high-TOC waters with low alkalinity.

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Table III-3 Summary Raw-Water Statistics for Enhanced Coagulation Database

TOC	Percentile Rank	Alkalinity = ≤ 60				60 ≤ Alkalinity = ≤ 120				Alkalinity ≥ 120			
		ALK.	TOC	UV-254	SUVA	ALK.	TOC	UV-254	SUVA	ALK	TOC	UV-254	SUVA
> 2.0 - 4.0	10th	11	2.2	0.069	2.84	74	2.4	0.054	2.03	126	2.3	0.039	1.43
	50th	52	2.7	0.090	3.38	83	2.8	0.077	2.73	141	3.0	0.053	1.74
	90th	60	3.6	0.127	3.97	113	3.3	0.103	3.09	214	3.5	0.104	3.68
		n = 20 (149)				n = 30 (283)				n = 22 (197)			
> 4.0 - 8.0	10th	20	5.3	0.142	2.38	70	4.1	0.087	1.93	128	4.1	0.067	1.64
	50th	27	6.0	0.229	3.29	96	5.2	0.130	2.48	146	4.8	0.092	1.90
	90th	45	7.0	0.288	4.79	110	6.4	0.217	3.83	202	6.5	0.142	3.01
		n = 6 (77)				n = 14 (172)				n = 18 (169)			
> 8.0	10th	12	13.2	0.505	4.33	86	15.1	0.674	3.80	137	8.6	0.203	2.22
	50th	16	16.0	0.747	4.86	87	17.1	0.697	4.15	218	10.3	0.252	2.60
	90th	28	23.5	1.258	5.45	88	19.0	0.729	4.49	227	13.3	0.357	3.17
		n = 6 (102)				n = 2 (44)				n = 9 (93)			

Note: n = number of raw waters (number of data points).

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From this database, the Colorado University research team (Edwards, 1997; Tseng & Edwards, 1997) developed a model for predicting organic carbon removal during enhanced coagulation, using as input the coagulant dose, coagulation pH, raw-water UV absorbance, and raw-water DOC concentration. The model assumes that all DOC can be divided into two distinct fractions (Figure III–13): DOC that strongly complexes hydroxide surfaces formed during coagulation and DOC that does not (Edwards et al., 1996). Edwards defined these fractions as sorbing and nonsorbing DOC, respectively. In the model, the relative fraction of sorbing and nonsorbing NOM is calculated using an empirical relation based on the value of SUVA (Edwards, 1997).

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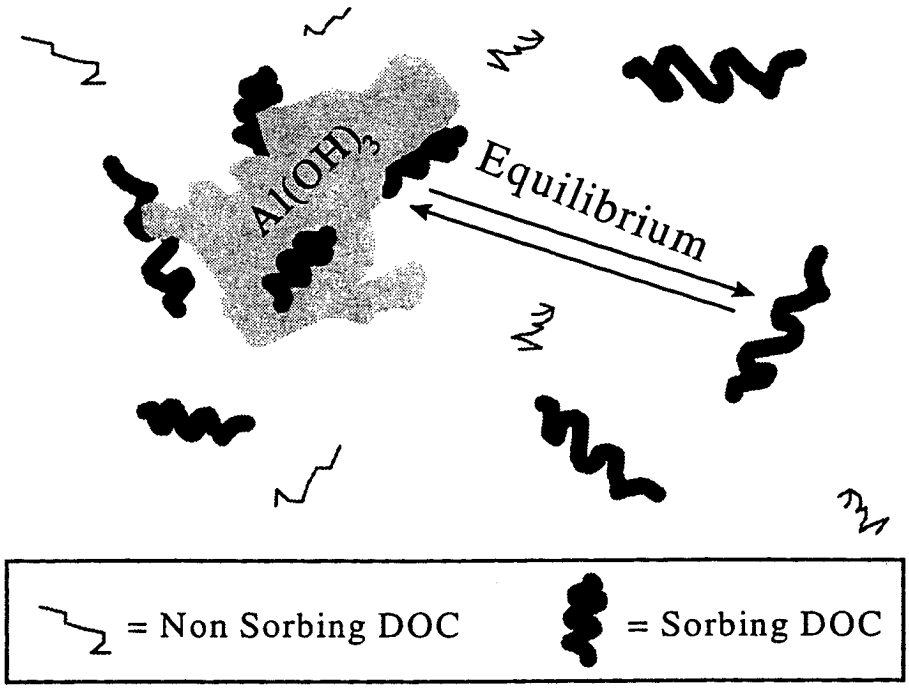
Figure III-13: Basic conceptualization of two hypothetical DOC fractions in natural waters.



Basic conceptualization of two hypothetical DOC fractions in natural waters. The sorbing DOC fraction is in equilibrium with sorbent hydroxide formed during coagulation.

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In the Colorado University modeling effort (Edwards, 1997), the best predictive capability was provided by a site-specific approach using a best-fit sorption constant and nonsorbing DOC fraction for each water quality and coagulant type (Figure III–14). Assuming a typical DOC analytical error of either ±0.25 mg/L or ±5 percent, 81 percent of the model predictions were accurately predicted within analytical precision.

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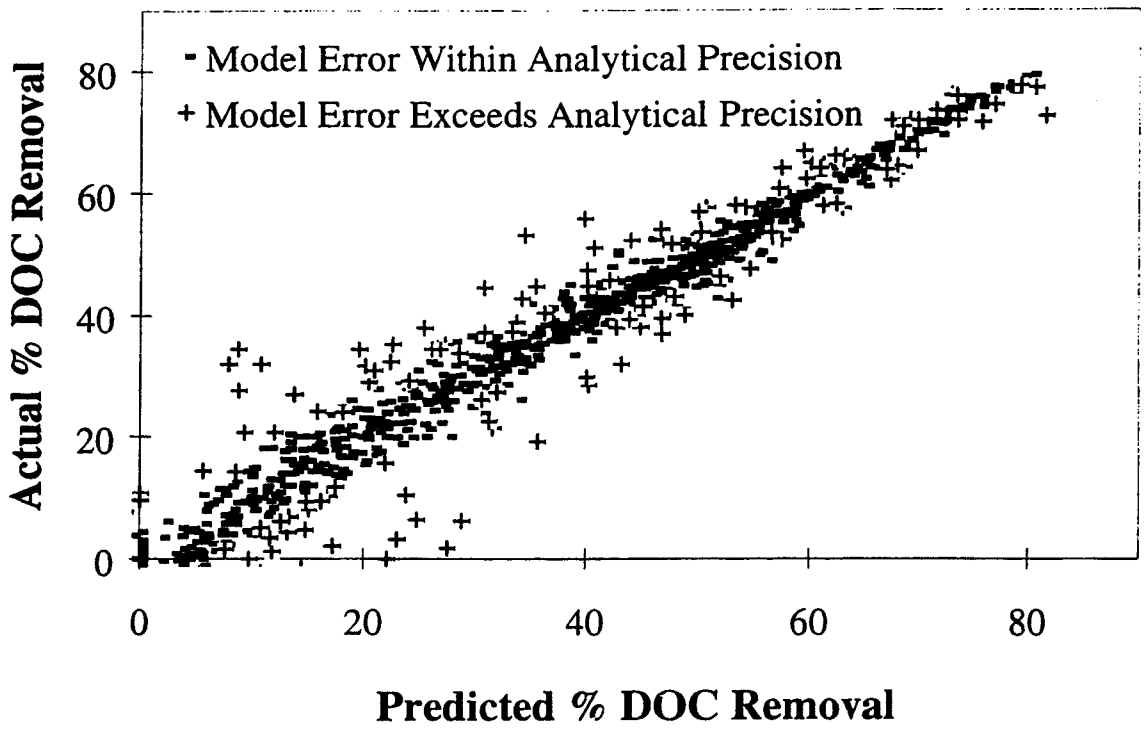
Figure III-14: Actual percentage of DOC removal versus model prediction for DOC model



Actual percentage DOC removal versus model prediction for DOC model calibrated using a site specific sorption constant and non-sorbing DOC fraction. Only 19% of all model predictions exceeded expected error in calculating %DOC removal of either ± 0.25 mg/L or ± 5%, whichever is greater

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The Colorado University DOC/SUVA model was subsequently used to determine the ''maximum'' TOC removal that can be achieved with enhanced coagulation. All nine boxes in the 3×3 matrix (Table III–3) were evaluated using the 10th, 50th, and 90th percentile water qualities. The model was used to determine the amount of sorbable TOC and to examine removal of 100, 90, 80, 70, 60, and 50 percent of the sorbable TOC.

Table III–4 summarizes the results from the maximum TOC removal task. A 10th percentile SUVA value corresponds to a water that is difficult to treat (relative to other waters in that same box), whereas a 50th and 90th percentile SUVA value corresponds to waters that are average and easy to treat, respectively, in that box. The sorbable amount of TOC represents the maximum amount of TOC that can be removed using coagulants with no limit on coagulant dosage. Therefore, these values may not be practical or realistic to achieve. In Table III–4, the 1994 proposed Step 1 TOC removal requirements are listed, along with a 15 percent safety factor. For example, in the low-TOC, low alkalinity box, the current Step 1 TOC removal requirement (40 percent) with a safety factor is 46 percent. In this box, for an easy to treat water (90th percentile SUVA of 3.97), 62 percent of the sorbable TOC would need to be removed to ensure compliance with the proposed requirement; whereas for a difficult to treat water (10th percentile SUVA of 2.84), 71 percent of the sorbable TOC would need to be removed.

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TABLE III-4: Prediction of "Maximum" TOC Removal Based on Colorado University DOC/SUVA Model

Percentile	TOC mg/L	Alkalinity = 0-60 mg/L							Step 1 TOC Rem.	Step 1 TOC Rem. +15%	%Sorb. TOC Rem.: Meet Step1 +15%
		SUVA	TOC Removal (% Sorbable TOC Removal)								
			(100%)	(90%)	(80%)	(70%)	(60%)	(50%)			
10th	>2-4	2.84	65	59	52	46	39	33	40	46	71%
50th		3.38	69	62	55	48	41	35	40	46	67%
90th		3.97	74	67	59	52	44	37	40	46	62%
10th	>4-8	2.38	62	56	50	43	37	31	45	52	83%
50th		3.29	69	62	55	48	41	35	45	52	75%
90th		4.79	80	72	64	56	48	40	45	52	65%
10th	>8	4.33	76	68	61	53	46	38	50	58	76%
50th		4.86	80	72	64	56	48	40	50	58	72%
90th		5.54	86	77	69	60	52	43	50	58	67%

Percentile	TOC mg/L	Alkalinity >60-120 mg/L							Step 1 TOC Rem.	Step 1 TOC Rem. +15%	%Sorb. TOC Rem.: Meet Step1 +15%
		SUVA	TOC Removal (% Sorbable TOC Removed)								
			(100%)	(90%)	(80%)	(70%)	(60%)	(50%)			
10th	>2-4	2.03	59	53	47	41	35	30	30	35	58%
50th		2.73	64	58	51	45	38	32	30	35	54%
90th		3.09	67	60	54	47	40	34	30	35	51%
10th	>4-8	1.93	58	52	46	41	35	29	35	40	69%
50th		2.48	63	57	50	44	38	32	35	40	64%
90th		3.83	73	66	58	51	44	37	35	40	55%
10th	>8	3.80	73	66	58	51	44	37	40	46	63%
50th		4.15	75	68	60	53	45	38	40	46	61%
90th		4.49	78	70	62	55	47	39	40	46	59%

Percentile	TOC mg/L	Alkalinity >120 mg/L							Step 1 TOC Rem.	Step1 TOC Rem. +15%	%Sorb. TOC Rem.: Meet Step1 +15%
		SUVA	TOC Removal (% Sorbable TOC Removed)								
			(100%)	(90%)	(80%)	(70%)	(60%)	(50%)			
10th	>2-4	1.43	55	50	44	39	33	28	20	23	42%
50th		1.74	57	51	46	40	34	29	20	23	40%
90th		3.68	72	65	58	50	43	36	20	23	32%
10th	>4-8	1.64	56	50	45	39	34	28	25	29	51%
50th		1.90	58	52	46	41	35	29	25	29	50%
90th		3.01	67	60	54	47	40	34	25	29	43%
10th	>8	2.22	61	55	49	43	37	31	30	35	57%
50th		2.60	64	58	51	45	38	32	30	35	54%
90th		3.17	68	61	54	48	41	34	30	35	51%

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The next analyses evaluated what TOC removal is ''practical'' to achieve in order to better define the 3×3 matrix. The data analyses were aimed at developing an alternative set of percent TOC removal numbers for step 1 requirements, recognizing that the goal was to select values that could be ''reasonably'' met by 90 percent of the systems implementing enhanced coagulation. Using the database compiled through the Malcolm Pirnie, Inc./AWWA project and summarized in Table III–3, the following nine equations were developed to predict ''90th-percentile'' TOC for a given coagulant dose. Figure III–15 illustrates the shape of the curves for the low-alkalinity waters.

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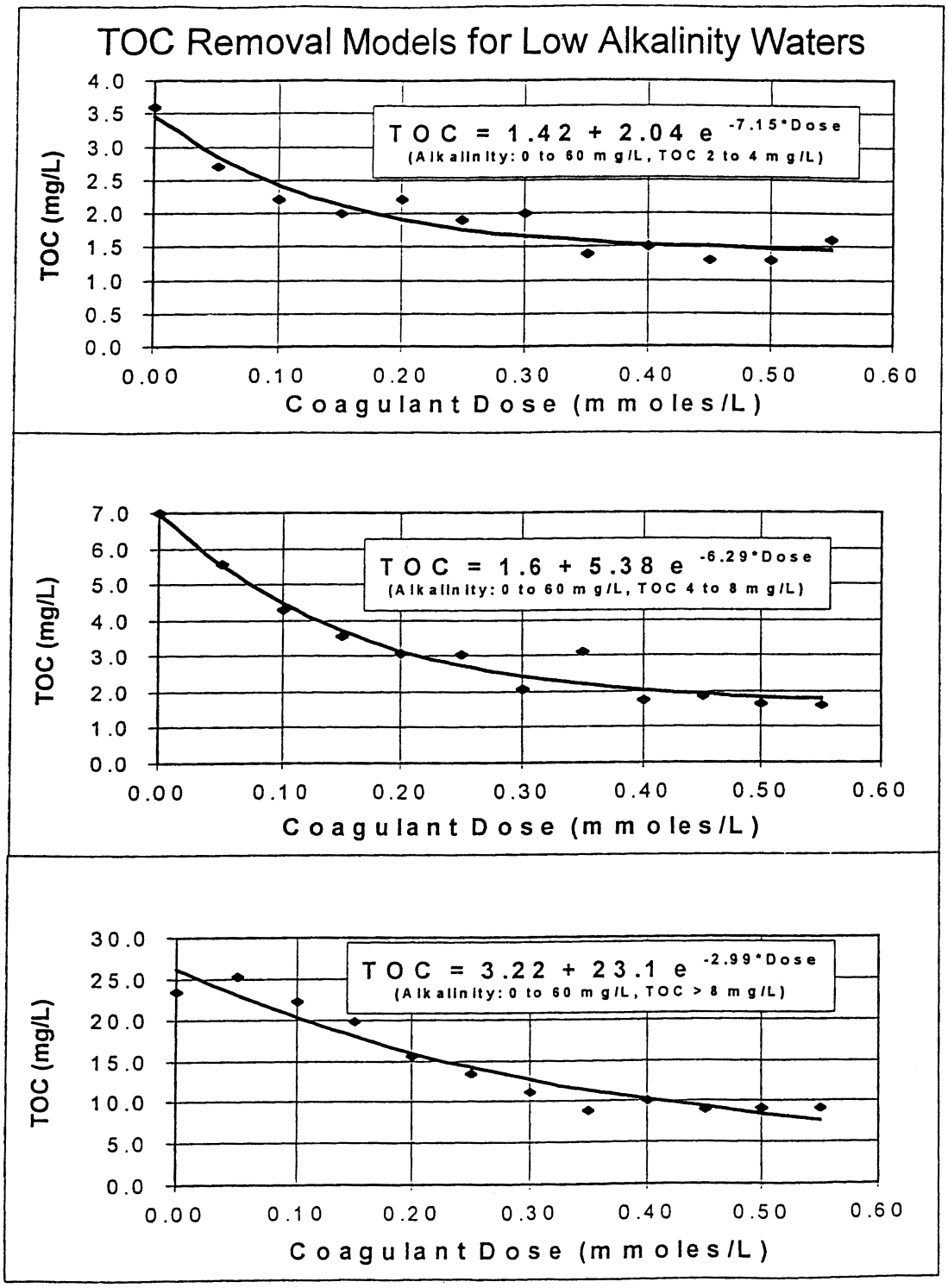
Figure III-15: TOC Removal Models for Low Alkalinity Waters



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The significance of the 90th-percentile data point is that 90 percent of systems (represented by the database) will have a lower residual TOC compared to what is predicted by the equations for a given coagulant dose.

1. $TOC=1.42+2.04 \bullet e^{-7.15 \bullet Dose\ (moles/L)}$ [for low-TOC, low-alkalinity box]
2. $TOC=1.37+2.10 \bullet e^{-3.92 \bullet Dose\ (moles/L)}$ [for low-TOC, medium-alkalinity box]
3. $TOC=2.10+1.27 \bullet e^{-2.73 \bullet Dose\ (moles/L)}$ [for low-TOC, high-alkalinity box]
4. $TOC=1.60+5.38 \bullet e^{-6.29 \bullet Dose\ (moles/L)}$ [for medium-TOC, low-alkalinity box]
5. $TOC=2.11+4.41 \bullet e^{-3.47 \bullet Dose\ (moles/L)}$ [for medium-TOC, medium-alkalinity box]
6. $TOC=2.64+3.30 \bullet e^{-4.83 \bullet Dose\ (moles/L)}$ [for medium-TOC, high-alkalinity box]
7. $TOC=3.22+23.1 \bullet e^{-2.99 \bullet Dose\ (moles/L)}$ [for high-TOC, low-alkalinity box]
8. $TOC=4.88+13.8 \bullet e^{-3.33 \bullet Dose\ (moles/L)}$ [for high-TOC, medium-alkalinity box]
9. $TOC=6.61+6.44 \bullet e^{-3.57 \bullet Dose\ (moles/L)}$ [for high-TOC, high-alkalinity box]

Based upon the above equations, the coagulant dosages for achieving the proposed percent TOC removals and the proposed PODR slope criterion (i.e., 0.3 mg/L TOC per 10 mg/L of alum) were calculated. These calculations indicated that the low-TOC boxes will be at the proposed slope criterion at coagulant dosages lower than what would be required for achieving the proposed step 1 percent TOC removals. The opposite was true for the high-TOC boxes. For the medium-TOC boxes, the calculated coagulant dosages were approximately equal for both criteria. The trends for the different boxes in the matrix are similar to that observed by the UNC research team (Table III–2). Table III–5 summarizes the controlling criteria.

TABLE III–5.—CONTROLLING CRITERION FOR ENHANCED COAGULATION FOR WATERS EVALUATED IN MALCOLM PIRNIE, INC. STUDY, BASED ON MODELING APPROACH

TOC (mg/L)	Alkalinity mg/L		
	0–60	>260–120	>120
>2.0–4.0	PODR	PODR	PODR
>4.0–8.0	Step 1	PODR	Step 1
>8.0	Step 1	Step 1 ...	Step 1

Malcolm Pirnie, Inc. next examined SUVA removal curves (Figure III–16), similar to what was examined by the UNC research team (Figure III–6).

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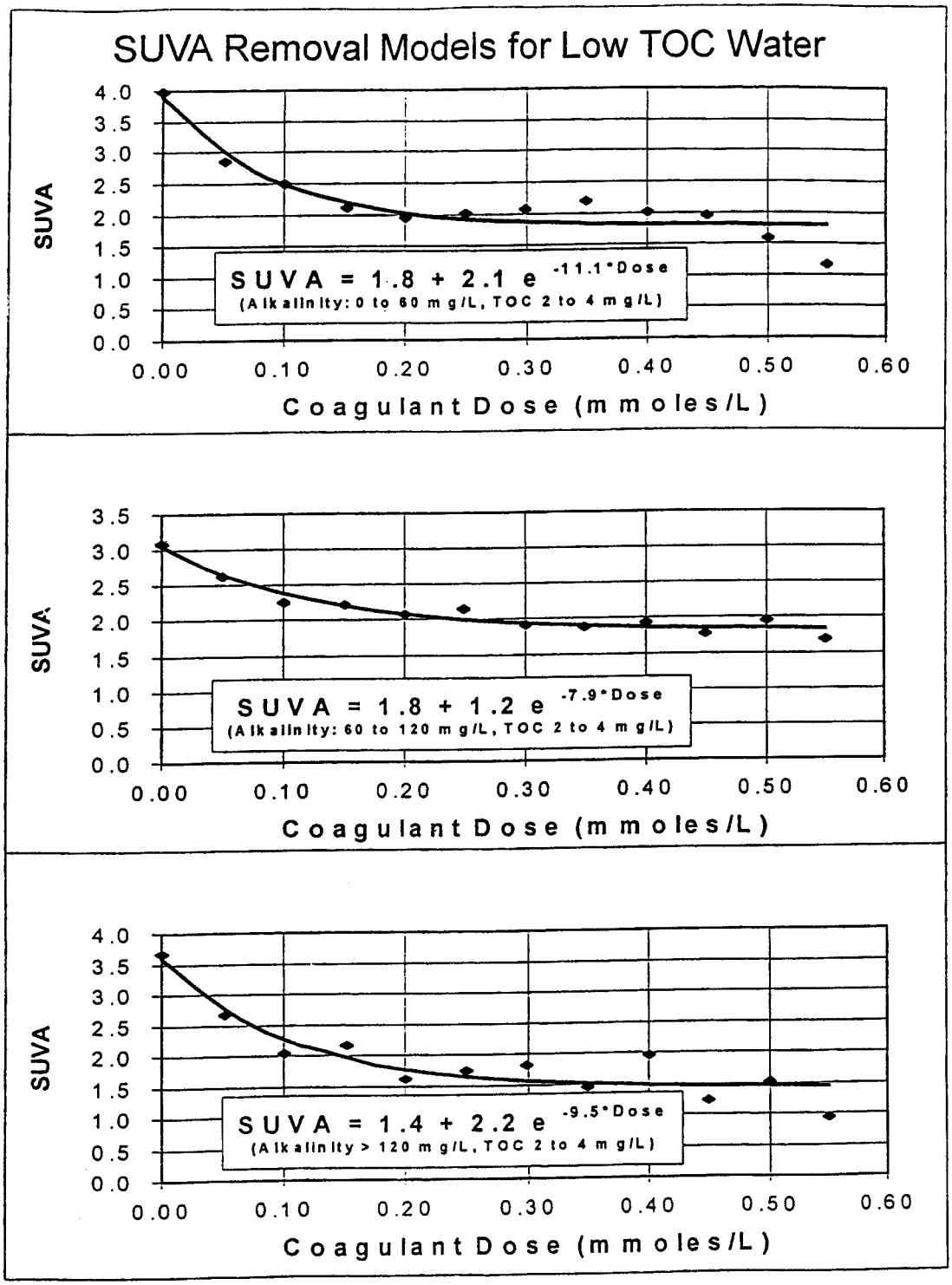
Figure III-16: SUVA Removal Models for Low TOC Waters



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The 90th-percentile SUVA curves were observed to reach asymptotic values with increasing coagulant Dose (Figure III–16 illustrates the shape of the curves for the low-TOC waters). The following seven equations were developed to predict the 90th-percentile SUVA for a given coagulant Dose. The three alkalinity ranges for the high-TOC waters were collapsed into one group due to lack of sufficient data. Similar to the TOC equations, the significance of the 90th-percentile data point is that 90 percent of systems (represented by the database) will have a lower residual SUVA compared to what is predicted by the equations for a given coagulant Dose.

a. $SUVA=1.8+2.1 \bullet e^{-11.1 \bullet Dose\ (moles/L)}$ [for low-TOC, low-alkalinity box]

b. $SUVA=1.8+1.2 \bullet e^{-7.9 \bullet Dose\ (moles/L)}$ [for low-TOC, medium-alkalinity box]

c. $SUVA=1.4+2.2 \bullet e^{-9.5 \bullet Dose\ (moles/L)}$ [for low-TOC, high-alkalinity box]

d. $SUVA=1.9+2.8 \bullet e^{-17.5 \bullet Dose\ (moles/L)}$ [for medium-TOC, low-alkalinity box]

e. $SUVA=1.8+2.0 \bullet e^{-5.2 \bullet Dose\ (moles/L)}$ [for medium-TOC, medium-alkalinity box]

f. $SUVA=2.1+0.95 \bullet e^{-6.0 \bullet Dose\ (moles/L)}$ [for medium-TOC, high-alkalinity box]

g. $SUVA=2.5+2.8 \bullet e^{-3.8 \bullet Dose\ (moles/L)}$ [for high-TOC boxes]

From a theoretical viewpoint, the asymptote of the above equations represents the minimum SUVA that could be achieved for a given data set (box) of the 3x3 matrix. The dosages for the minimum SUVA are related to certain maximum percent TOC removals. However, from a practical standpoint, achieving the minimum SUVA could be extremely difficult. An alternative approach could be to attempt to reach SUVA values which are 20 or 25 percent above minimum SUVA indicated by the above equations. Equations 1 through 9 and equations a. through g. were combined to determine the practical percent TOC removal values that could be achieved. The results for ''minimum SUVA+25%'' are shown in Table III–6.

TABLE III–6.—TOC REMOVALS (%) AT ''MINIMUM SUVA+25%,'' BASED ON MALCOLM PIRNIE, INC. MODELING EFFORT

TOC (mg/L)	Alkalinity (mg/L)		
	0–60	>60–120	>120
>2.0–4.0	35	25	15
>4.0–8.0	35	45	20
>8.0	60	55	35

One limitation of a step 2 based on a settled-water SUVA approach would be that the utilities would have to determine these SUVA values in the absence of any oxidant (such as chlorine, permanganate, or ozone). Addition of oxidant changes the characteristics of the NOM in a manner that disproportionately affects the UV absorbance compared to TOC, thus changing the SUVA values without any actual removal of TOC.

d. Evaluation of current (baseline) TOC removals at full-scale. Full-scale TOC removal data were obtained from 76 treatment plants (Table III–7). These data were obtained from plants in the American Water Works Service Company (AWWSCo) system, plants studied by Randtke et al. (1994), and plants in North Carolina studied by Singer et al. (1995). Note that these data represent a one-time sampling at each plant and no specific attempt was made to meet the proposed TOC removal percentages. Also, the proposed compliance requirements were based on an annual average. Based on current treatment, 83 percent of the systems treating moderate-TOC, low-alkalinity water removed an amount of TOC greater than the proposed step 1 requirement, whereas only 14 percent of the systems treating water with low TOC and high alkalinity met the proposed step 1 requirement. For the other systems treating low- or moderate-TOC water, 29–38 percent met the proposed step 1 requirements with existing treatment. Although all of the high-TOC systems met the proposed TOC removal requirements with current treatment, the number of systems in this database were insignificant (1–2 per box).

TABLE III–7.—TOC REMOVAL AT FULL-SCALE TREATMENT PLANTS

TOC >2.0–4.0 mg/L			Percent of plants that achieve specified TOC removal				
Alkalinity (mg/L)	No. of Plants	Step 1 TOC%	0–10% removal	10–20% removal	20–30% removal	30–40% removal	>40% removal
0–60	14	40	14	14	14	29	***29**
>60–120	11	30	36	0	27	**18**	**18**
>120	7	20	57	29	**14**	**0**	**0**
TOC >4.0–8.0 mg/L			Percent of plants that achieve specified TOC removal				
			0–15% removal	15–25% removal	25–35% removal	35–45% removal	>45% removal
0–60	18	45	0	0	11	6	**83**
>60–120	8	35	12	25	25	**38**	**0**
>120	13	25	31	31	**23**	**15**	**0**
TOC >8.0 mg/L			Percent of plants that achieve specified TOC removal				
			0–20	20–30	30–40	40–50	>50
0–60	2	50	0	0	0	0	**100**
>60–120	2	40	0	0	0	**0**	**100**
>120	1	30	NA	NA	**100**	**NA**	**NA**

*Values in bold represent the percentage of systems that achieved full-scale TOC removal that is greater than the proposed step 1 requirements.

e. *Evaluation of ''optimized'' TOC removal.* An ''optimized'' coagulation database was assembled, utilizing experiments performed by AWWSCo and by Randtke et al. (1994) (Table III–8). This database included experiments in which a combination of coagulant and acid was evaluated. The National Sanitation Foundation (NSF) limit on sulfuric acid addition (to minimize the introduction of trace impurities present in the acid) is 50 mg/L. In examining the database, an attempt was made to limit coagulant doses to ~10–20 times the TOC level. Thus, a water with 3 mg/L TOC might use up to 30–60 mg/L of coagulant (with or without acid), but would not use 100 mg/L of coagulant full-scale. However, a water with 10 mg/L TOC could use 100 mg/L or more of coagulant given the aforementioned ~10–20 multiplier for coagulant dose and TOC. A dose of this magnitude is discouraged because the NSF limits on aluminum sulfate and ferric chloride are 150 mg/L and 250 mg/L, respectively. Because these experiments were performed without these acid and coagulant dose limits as constraints, some waters were evaluated with more realistic chemical doses in the PODR experiments. A judgment was made in deciding which set of conditions was the most realistic for each water evaluated. With these elements in mind, an assessment was made as to which experiment was the most appropriate (controlling criteria) for each water. In some cases, a source water was tested more than once. If the identical sample of water (same TOC, SUVA, alkalinity) was coagulated with different coagulants, with or without acid, the highest TOC removal for that water was chosen, as many systems enhancing their coagulation process are also evaluating switching the type of coagulant.

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TABLE III-8: Analysis of the Optimized Coagulation Database

TOC Removal at "Controlling" Condition				
Statistic	TOC	Alkalinity (mg/L)		
		0-60	>60-120	>120
(% w/SUVA$_r$<2.0)	>2-4 (mg/L)	(13%)	(0%)	(64%)
(no. w/SUVA$_r$>2.0)		(12)**	(7)	(5)
minimum*		26%	16%	2%
25th percentile*		30%	~25%	17%
50th percentile*		39%	27%	20%
75th percentile*		46%	~34%	22%
maximum*		57%	46%	28%
(% w/SUVA$_r$<2.0)	>4-8	(0%)	(36%)	(57%)
(no. w/SUVA$_r$>2.0)		(12)	(6**)	(2**)
minimum*		17%	19%	10%
25th percentile*		46%	34%	N/A
50th percentile*		54%	39%	N/A
75th percentile*		61%	43%	N/A
maximum*		68%	50%	44%
(% w/SUVA$_r$<2.0)	>8	(0%)	(0%)	(0%)
(no. w/SUVA$_r$>2.0)		(7)	(2)***	(4)
minimum*		56%	65%	37%
25th percentile*		56%	N/A	N/A
50th percentile*		68%	68%	44%
75th percentile*		69%	N/A	N/A
maximum*		76%	72%	61%

*Cumulative probability distribution for waters with SUVA$_r$>2.0.

**Number of waters with SUVA$_r$>2.0, excluding waters evaluated w/acid dose>NSF limit.

***Same source water.

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f. ''Case-by-case'' data analyses. A decision was made by the TWG, based on the Malcolm Pirnie, Inc. modeling effort and examination of the case-by-case data, to segment out raw waters with SUVA ($SUVA_r$) <2.0 L/mg-m during the analyses of the optimized coagulation database. This decision was made because including a significant number of low-SUVA waters in the analysis of the boxes results in lowering the amount of TOC that 90 percent of the systems in that box can remove. Thus, the TWG decided to examine what TOC removal could be accomplished by the medium-and high-SUVA waters that remained in each box.

Table III–8 provided a statistical summary of all the waters in each box of the matrix. Listed below are a summary of the key observations:

(1) A majority of the high-alkalinity (>120 mg/L) waters in the low (>2–4 mg/L) and moderate (>4–8 mg/L) TOC boxes have SUVA <2.0 L/mg-m. For many of these waters, optimized coagulation requires very high doses of acid or coagulant, which are not practical to use. Many of these waters are not readily amenable to enhanced coagulation. However, some of the systems that treat these waters will incorporate some level of enhanced coagulation in order to control DBP formation.

(2) For the waters in which the raw-water SUVA was >2.0 L/mg-m, the minimum, 25th percentile, 50th percentile, 75th percentile, and maximum TOC removal for each of the boxes in the 3 x 3 matrix were determined. This analysis allowed for an analysis of the cumulative probability distribution of TOC removal for waters that are amenable to enhanced coagulation.

(3) For example, the high-TOC (>8 mg/L)/low alkalinity (0-60 mg/L) box had a range of TOC removals from 56 to 76 percent. In order to comply with a 50 percent TOC removal (the proposed step 1 value for that box) with a safety factor of 15 percent, a 57 percent TOC removal would be required. The minimum and 25th percentile TOC removal for that box is 56 percent. Thus, it is expected that essentially all of the waters in this box (based on this limited data set and data from other sources) could comply with the proposed step 1 requirement.

(4) If the step 1 requirement for the high-TOC/low-alkalinity box was raised, for example, to 60 percent, then systems would need a 69 percent TOC removal to safely meet such a requirement. The 75th percentile of TOC removal for this box is 69 percent. Thus, raising the step 1 requirement to 60 percent could potentially drive half or more of the systems in this box to need to do step 2 testing for possible alternative performance criteria. Thus, these data suggest that for this and a number of other boxes (all of the high-TOC boxes and probably most of the moderate-TOC boxes), the currently proposed step 1 TOC removals are appropriate. Systems that can achieve higher TOC removals in these boxes will consider doing so in order to more effectively meet the DBP MCLs that have been proposed.

(5) For the low-TOC boxes, even after excluding the low-SUVA waters, the proposed step 1 TOC removal levels still appear too high. In Malcolm Pirnie, Inc.''s modeling of TOC removal at minimum SUVA + 25 percent, it was predicted that the required TOC removals in the low-TOC boxes would be 35, 25, and 15 percent for low-, moderate-, and high-alkalinity, respectively. These predicted TOC removal values are in the range for which the majority of low-TOC waters with SUVA values >2.0 L/mg-m can achieve. Thus, the TWG recommended to the FACA Negotiating Committee-based on Malcolm Pirnie, Inc.''s modeling effort and this case-by-case analysis—a revised set of TOC removal numbers for the low-TOC boxes, keeping in mind that low-SUVA waters would be excluded from the requirement.

(6) The TWG also recommended to the FACA Negotiating Committee an alternative step 2 point of diminishing return (PODR) of settled-water SUVA ≤2.0 L/mg-m. This action will also reduce transactional costs, as presentation of a settled-water SUVA value will be easier than presenting jar-test data. Nonetheless, the jar-test protocol and slope criterion will still be needed for evaluating alternative performance criterion for other waters.

2. New Data on Enhanced Softening

a. AWWARF studies—data on TOC removal. Several studies examined the relationship between increased coagulant dose and TOC removal (Shorney and Randtke, 1996; Clark et al. 1994). These studies indicate that the benefit from increased coagulant dose in TOC removal was dependent on the raw water. In a study funded by AWWARF, Shorney and Randtke (1994) indicated that utilities treating source water relatively low in TOC (i.e., 2.5 to 4 mg/L) and low in turbidity will have the greatest difficulty in removing TOC (Figure III–17 and III–18).

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Figure III-17: The Effect of Increasing Coagulant Dosage on TOC Removal by Softening (100 mg/L CaO) of UT6 Water

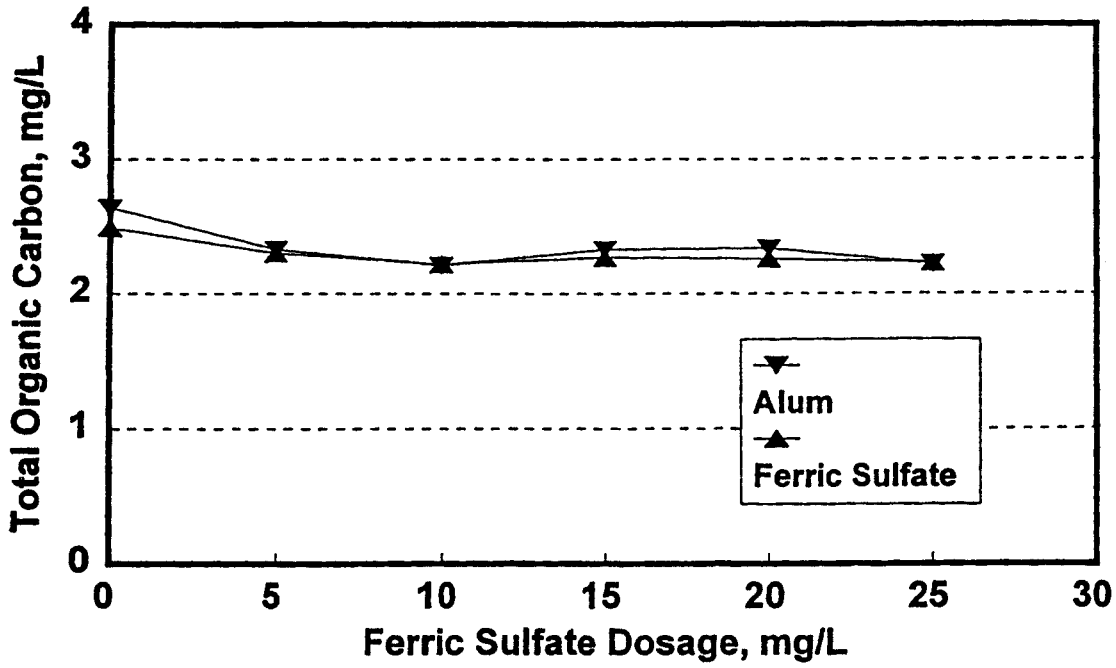

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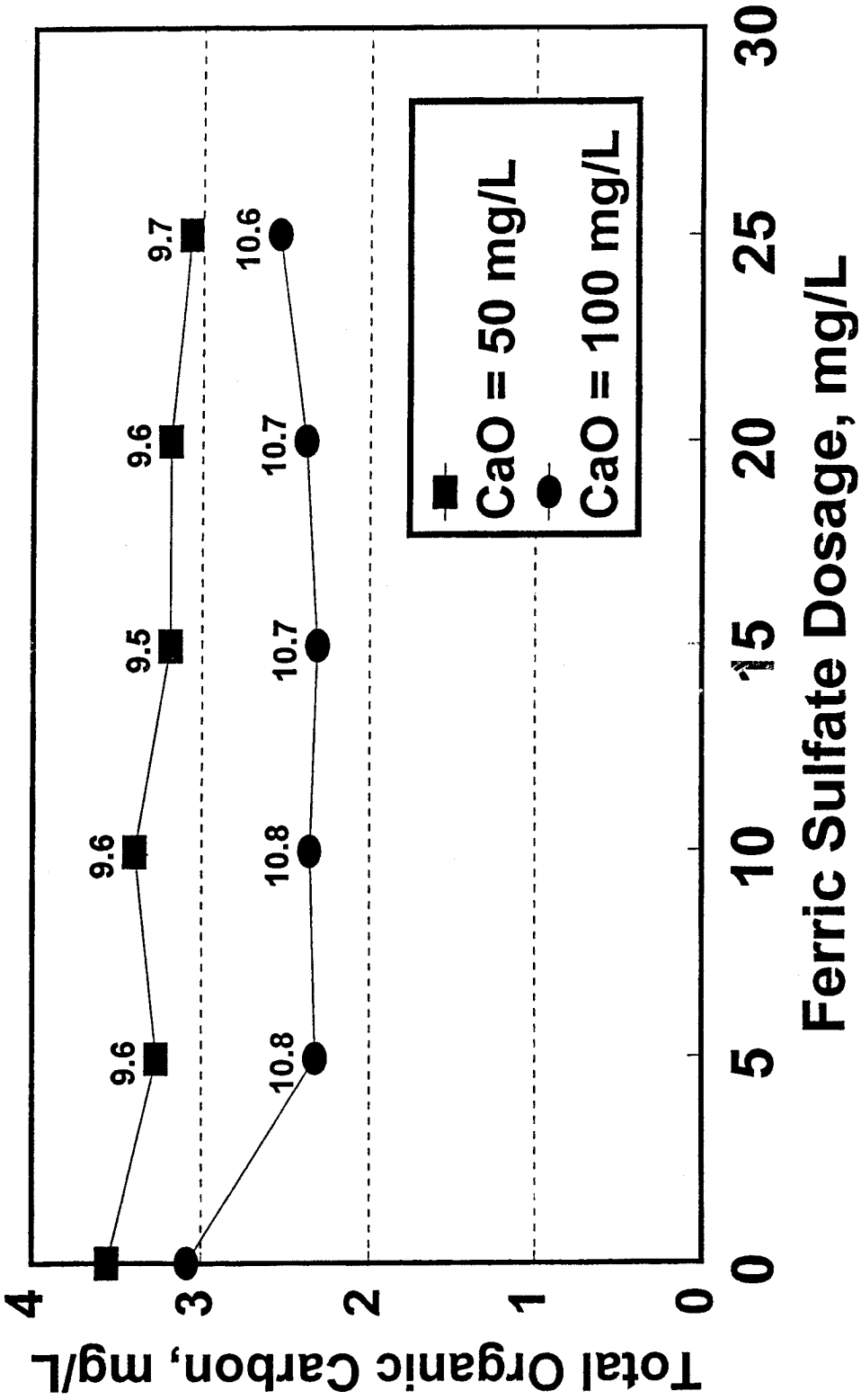
Figure III-18: the Effect of Increasing Coagulant Dosage on TOC Removal by Softening of UT1 Water



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The authors indicate some improved TOC removal from small doses of iron salts (5 mg/L ferric sulfate), but no additional TOC removal during softening occurred with increased coagulant addition (up to 25 mg/L dose) as shown in Figures III–17 and III–18.

In limited jar testing and in pilot testing, the City of Austin (a softening plant) has observed no significant difference in TOC removal with increasing doses of ferric sulfate beyond a low dose. Table III–9 shows the impact of increasing ferric sulfate doses on the turbidity and TOC concentration for jar tests in the City of Austin. The results indicate no significant difference in TOC removal with increasing doses of ferric coagulants, but did show that varying the coagulant dose did impact the turbidity removal as measured by NTU.

TABLE III–9.—IMPACT OF VARYING FERRIC COAGULANT DOSE ON TOC REMOVAL, AUSTIN, TEXAS, 4/9/93, 110 mg/L LIME DOSE, JAR TESTS

Ferric sulfate addition (mg/L)	Treated water turbidity, NTU	Treated water TOC (mg/L)
3	16	2.45
6	15	2.30
9	12	2.46
12	12	2.23
18	5.5	2.31

Pilot testing confirmed the jar test results by showing that increasing ferric sulfate doses beyond that required for turbidity removal proved to have no advantage in additional TOC removal (see Figure III–19).

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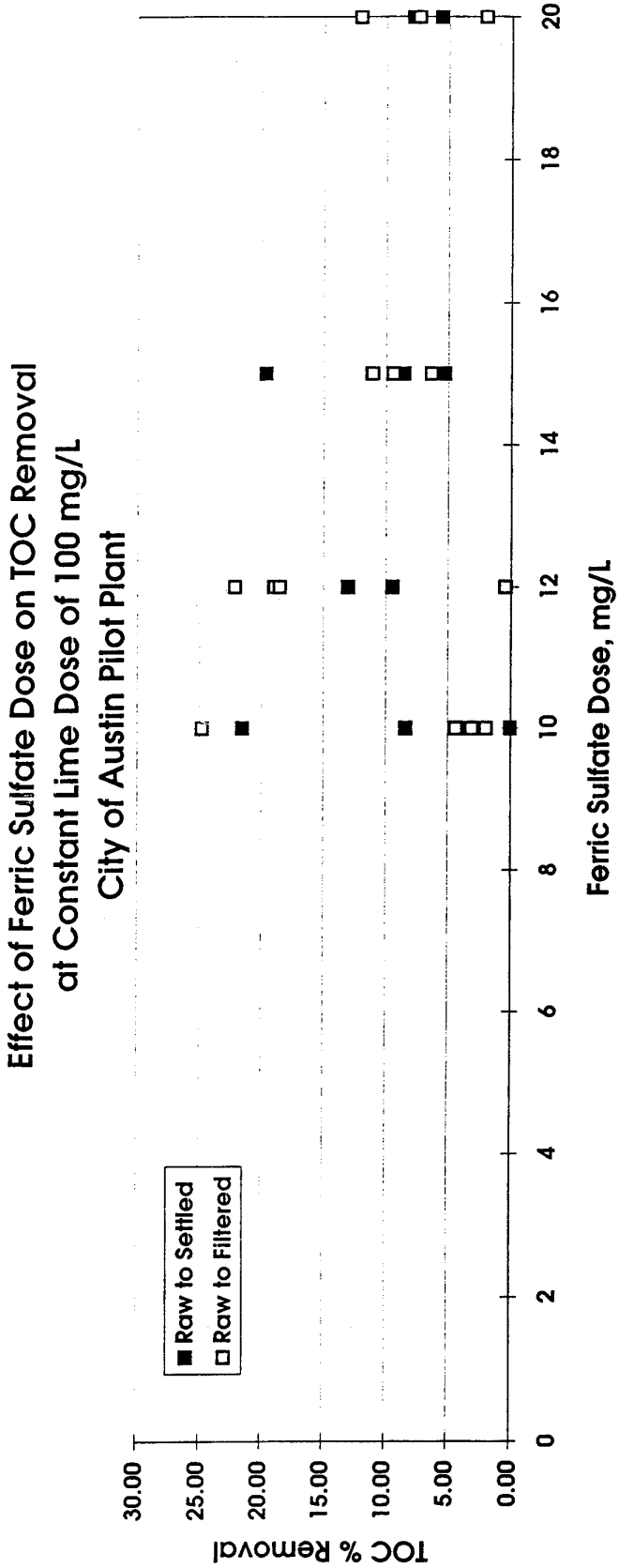

Figure III-19: Effect of Ferric Sulfate Dose on TOC Removal

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Full-scale plant data from St. Louis County Water Company and Kansas City, MO Water Services show that water temperature, turbidity, and raw water TOC levels have direct impact upon the efficiency of lime softening with iron salt coagulants to improve TOC removal.

Multiple jar tests on various waters done by Singer et al. (1996) focused on the relationship between use of lime and soda ash and TOC removal. Using only lime and soda ash (no coagulants), Singer et al. defined the dosages required to meet TOC removal percentages in the matrix. He also defined the dosages required to remove 10 mg/L of magnesium for nine waters that met the alkalinity levels in the right hand column of the matrix (i.e., >120 mg/L). Results of these jar tests are shown in Table III–10. Impacts of the proposed rule would be significant to softening plants if the TOC removal requirements were required to be met by all plants because the requisite lime and soda ash doses were higher than existing doses in the plants. Singer et al. (1996) found the removal of 10 mg/L of magnesium hardness to have less impact, although using the magnesium criteria would make TOC removal levels variable and less significant than meeting the removal levels in the matrix.

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Table III-10: Lime and Soda Doses Required for Various Enhanced Softening Criteria

Utility	% TOC Removal Required	Existing Plant Doses*	Existing pH of Settled Water at Treatment Plant	Doses* to Meet Req'd Percent TOC Removal	Corres-ponding Settled Water pH	Corres-ponding Mg Removal*	Doses to Remove 10 mg/l Mg*	Corres-ponding Settled Water pH	Corres-ponding Percent TOC Removal
Omaha, NE	20.0%	n/a	n/a	140 Lime 51 Soda	10.8	9	150 Lime 72 Soda	11.0	28
Austin, TX	20.0%	100 Lime 0.0 Soda	10.0	158 Lime 77 Soda	11.1	43	126 Lime 0.0. Soda	10.7	9
St. Louis, MO	20.0%	116 Lime 0.0 Soda	9.5	174 Lime 88 Soda	11.0	34	138 Lime 0.0 Soda	10.4	13
Ann Arbor, MI	25.0%	209 Lime 0.0 Soda	11.3	142 Lime 0.0 Soda	10.6	10	142 Lime 0.0 Soda	10.8	29
Adilan, MI	25.0%	146 Lime 0.0 Soda	9.7	161 Lime 0.0 Soda	10.4	17	161 Lime 0.0 Soda	10.4	31
Topeka, KS	25.0%	145 Lime 0.0 Soda	10.2	195 Lime 159 Soda	11.1	47	166 Lime 0.0 Soda	10.9	24
Sioux Falls, SD	30.0%	n/a	n/a	198 Lime 0.0 Soda	10.7	77	118 Lime 0.0 Soda	9.6	16
St. Paul, MN	30.0%	145 Lime 0.0 Soda	11.0	140 Lime 60 Soda	10.7	18	81 Lime 0.0 Soda	9.9	19
Ft. Lauder-dale, FL	30.0%	168 Lime 0.0 Soda	9.6	216 Lime 123 Soda	10.9	9	239 Lime 172 Soda	11.0	33

Notes: *Lime doses in mg/L as CaO/Soda Ash doses in mg/l as Na_2CO_3, *Mg removal expressed in mg/l as $CaCO_3$, n/a = not applicable

From Singer, et al, "Enhanced Coagulation and Enhanced Softening for the Removal of Disinfection By-Product Precursors: An Evaluation," Report to AWWA Disinfectants/Disinfection By-Products Technical Advisory Workgroup of the Water Utility Council, December 1996.

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b. Shorney and coworkers—data on use of SUVA. As discussed previously, SUVA may be a practical method for determining which PWSs would be required to perform enhanced coagulation and enhanced softening. SUVA has been found to be a good indicator of humic content and it is the humic material that is best removed by coagulation. Shorney et al. (1996) report raw water SUVA values <3 in the harder (softened) source waters that have high levels of both turbidity and hardness. SUVA is defined as the UV absorbance measured as (m^{-1}) divided by the DOC concentration (mg/L). Typically, SUVA values <3 L/mg-m are representative of largely non-humic material, whereas SUVA values in the range of 4–5 L/mg-m represent mainly humic material (Edzwald & Van Benschoten, 1990). Shorney et al. (1996) report that coagulation and softening decreased SUVA, as expected, resulting in SUVA values between 1 and 2 L/mg-m. The decrease in SUVA, by treatment, also corresponded to a decrease in the apparent molecular weight. Austin's pilot work indicated that for their water, no additional TOC removal was observed with increasing lime and coagulant doses, demonstrating the difficulty in coagulation (see Figure III–20). Austin's water typically has a SUVA of approximately 2, indicating that most of the TOC in that water is non-humic and therefore likely to be difficult to coagulate. Concurrent work to fine-tune the enhanced coagulation criteria has yielded extensive justification for using SUVA values below 2 to define raw waters that have hard-to-treat TOC.

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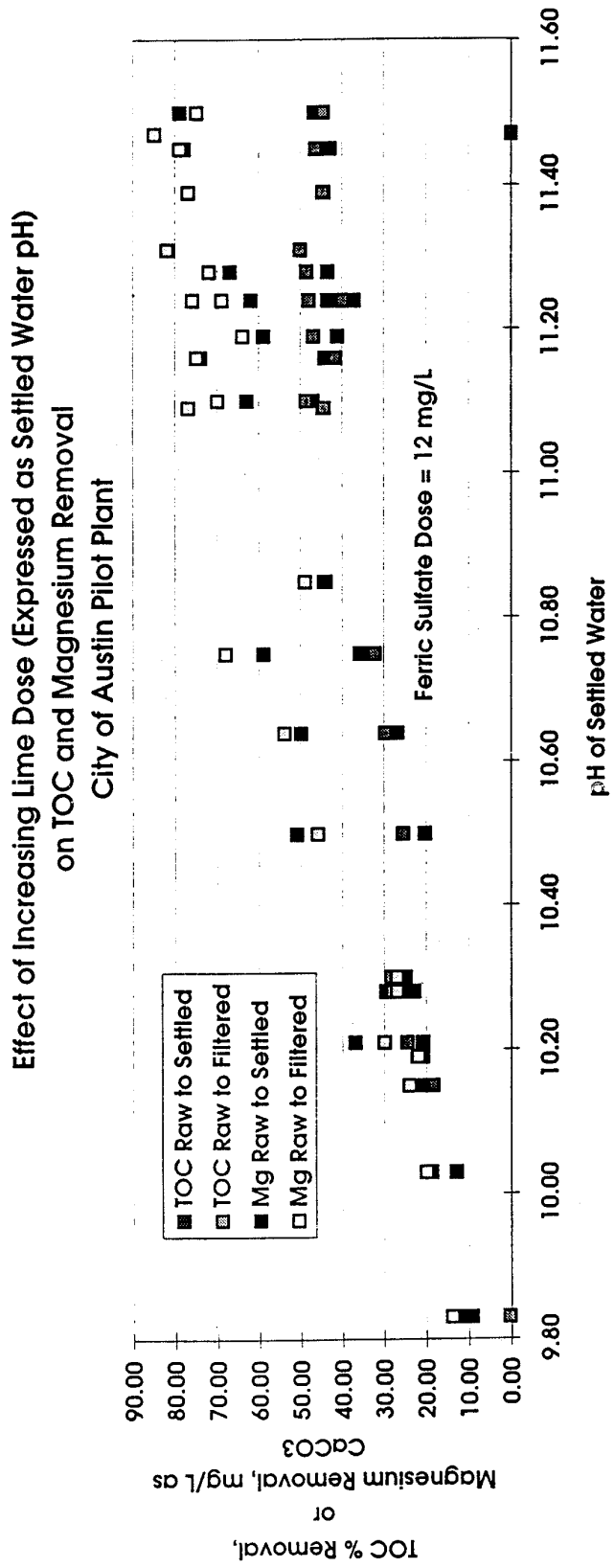

Figure III-20: Effect of Increasing Lime Dose (Expressed as Settled Water pH) on TOC and Magnesium Removal City of Austin Pilot Plant

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c. Malcolm Pirnie, Inc. modeling. Efforts to model the removal of TOC in softening systems were included in an American Water Works Association (AWWA) study done by Malcolm Pirnie, Inc. A database was compiled consisting of all the known and accessible jar test, pilot, and full-scale data from softening studies that investigated TOC removal. The database was used to develop some predictive equations for TOC removal for each raw water TOC level (as identified in Table III–1 of this Notice). Comparison of the predictive equations to case-by-case analyses of the same data base showed the equations to be fairly accurate for the low TOC waters (median removal levels of 20–25 percent) and medium TOC waters (median removal levels of 40 percent). Insufficient data made analysis unreliable for the high TOC group.

d. ICR mail survey. In order to obtain additional information on the current TOC removals being achieved by softening plants, a survey was sent to all the Information Collection Rule (ICR) softening utilities (49 plants) requesting that they fill out a single page of information with yearly average, maximum and minimum values for multiple operating parameters for each softening plant. The survey also asked for information regarding the use of coagulants. Most of the plants reported using a coagulant in addition to lime (88%) and some used multiple coagulants. Iron salts were the most frequently used coagulants, but alum, polymers, and starch were also used. Of the 49 plants responding to the survey, there was sufficient data to perform an analysis of TOC removal for 41 plants. The distribution of the number of responding plants in each TOC category is shown in Table III–11.

TABLE III–11.—DISTRIBUTION OF RESPONDING PLANTS BY TOC CONCENTRATION

Raw TOC (mg/L)	Number of plants responding	Number reporting sufficient data to calculate %TOC removal
0–2	5	5
>2–4	11	8
>4–8	20	17
>8	4	3

The data were analyzed with two goals in mind: to find the appropriate TOC removal levels for the rule matrix for softening plants and to determine what would define an appropriate step 2 for softening systems. To address the first question, the average TOC percent removals for each TOC group were plotted on a percentile basis and are shown in Figure III–21 (Clark et al., 1997) for the 2–4 mg/L TOC, and Figure III–22 for the 4–8 mg/L TOC (Clark et al., 1997).

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Figure III-21: Percent TOC Removal ICR Softening Plants with Raw TOC 2-4 mg/L.

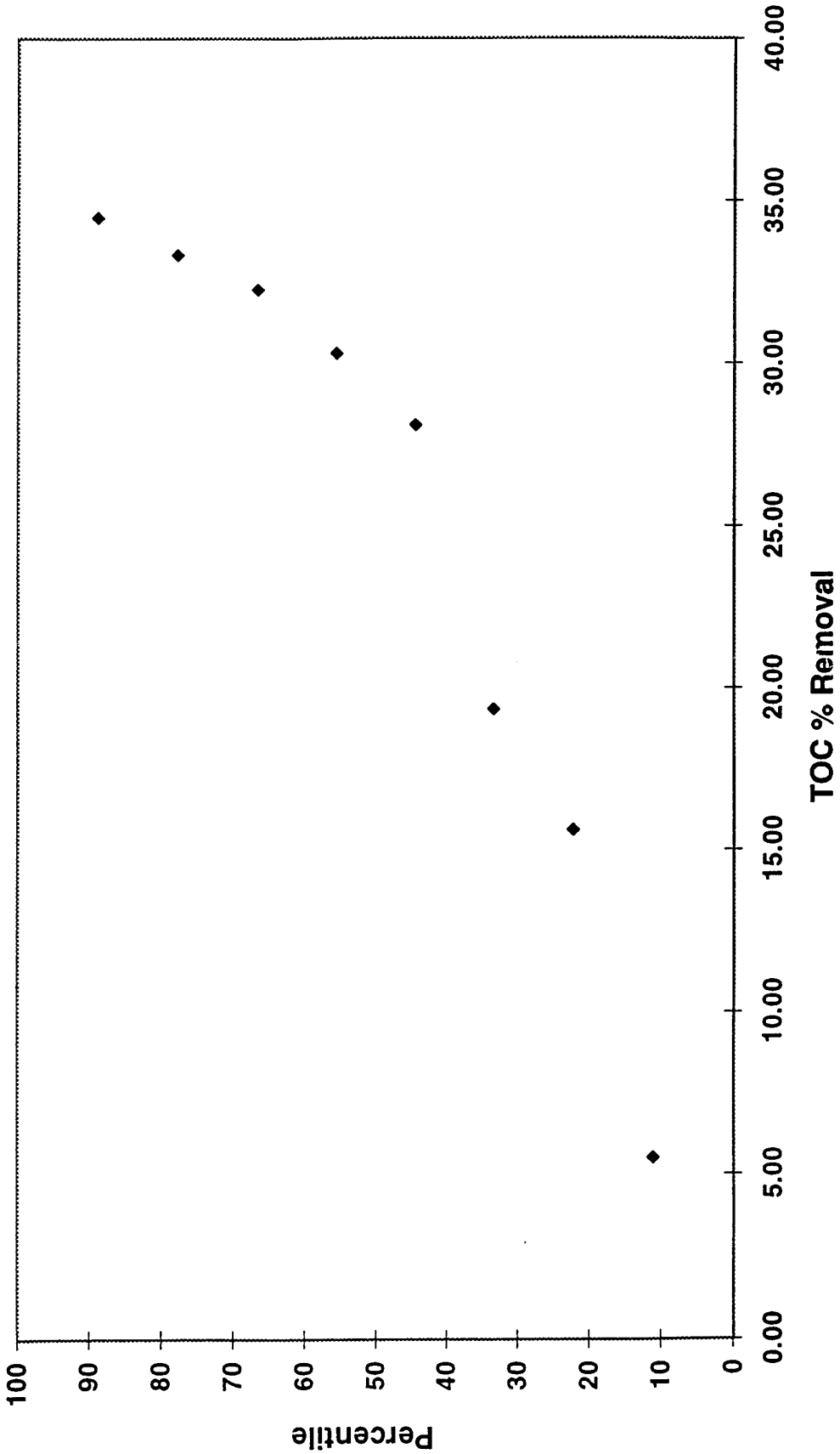

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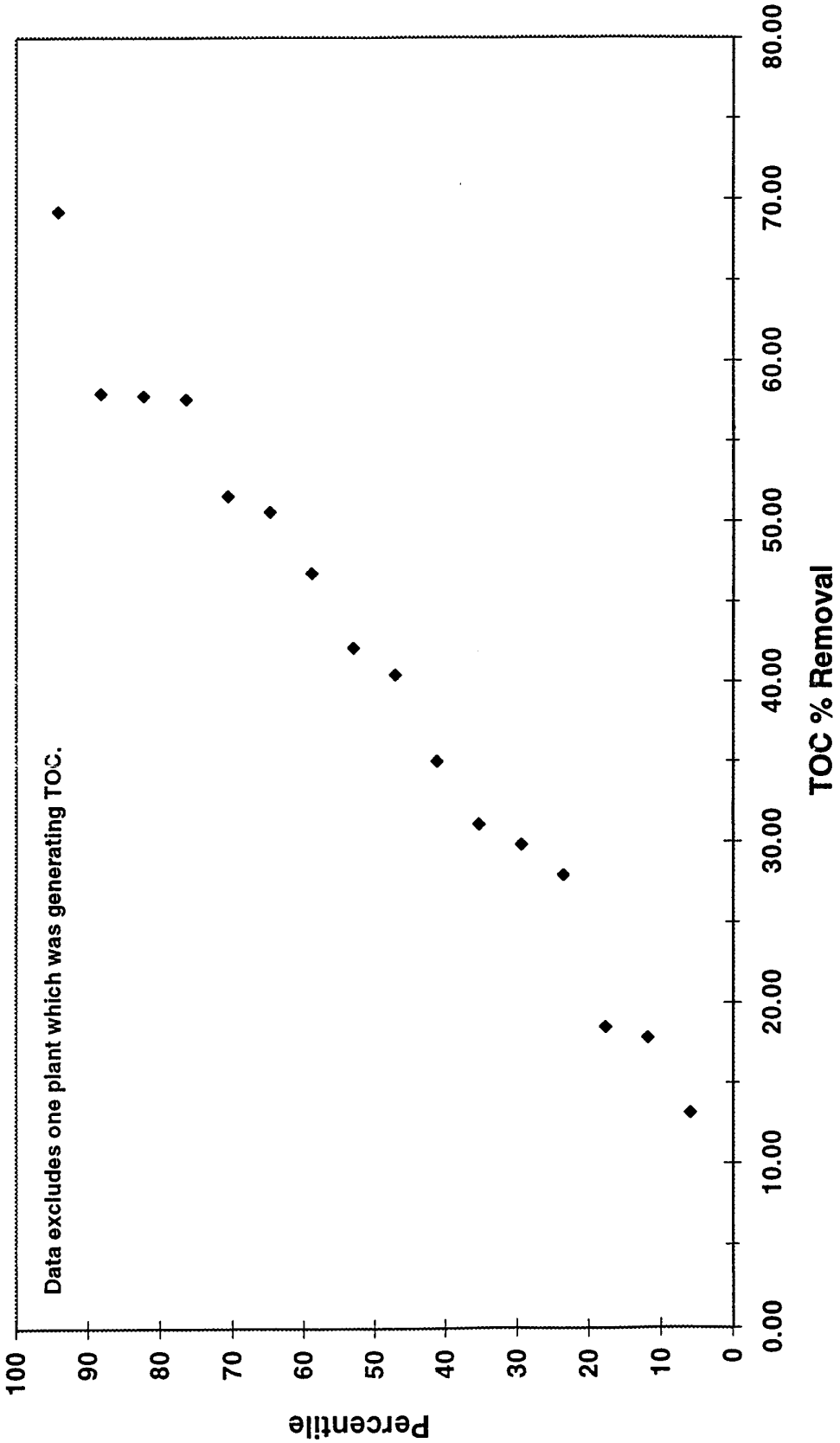
Figure III-22: Percent TOC Removal ICR Softening Plants with Raw TOC 4-8 mg/L



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To examine the percentage of plants that would meet the proposed requirements, the survey data were analyzed and the results are shown in Table III–12. The results in Table III–12 indicate that the relative impact of meeting the TOC removal requirement in the proposed rule would be greatest in the low TOC group (>2–4 mg/L) .

TABLE III–12.—PERCENTAGE OF SOFTENING PLANTS MEETING CURRENT PROPOSED REQUIREMENTS

Raw TOC (mg/L)	Proposed 1994 required percent removals	Percentage of plants that met requirements
>2–4	20	60
>4–8	25	80
>8	30	66

To address the second question regarding Step 2 criteria, the survey results for percent removal TOC and lime dose were plotted to examine the relationship between them (see Figure III-23) and to determine whether a point of diminishing returns can be identified for lime addition. Figure III–23 indicates that no correlation can be discerned, the data are highly variable, and no point of diminishing returns corresponding to a specific lime dose addition can be identified. The wide variation in water quality (e.g., pH, alkalinity, type of TOC), as well as the differences in coagulant usage, probably contributed to data variability.

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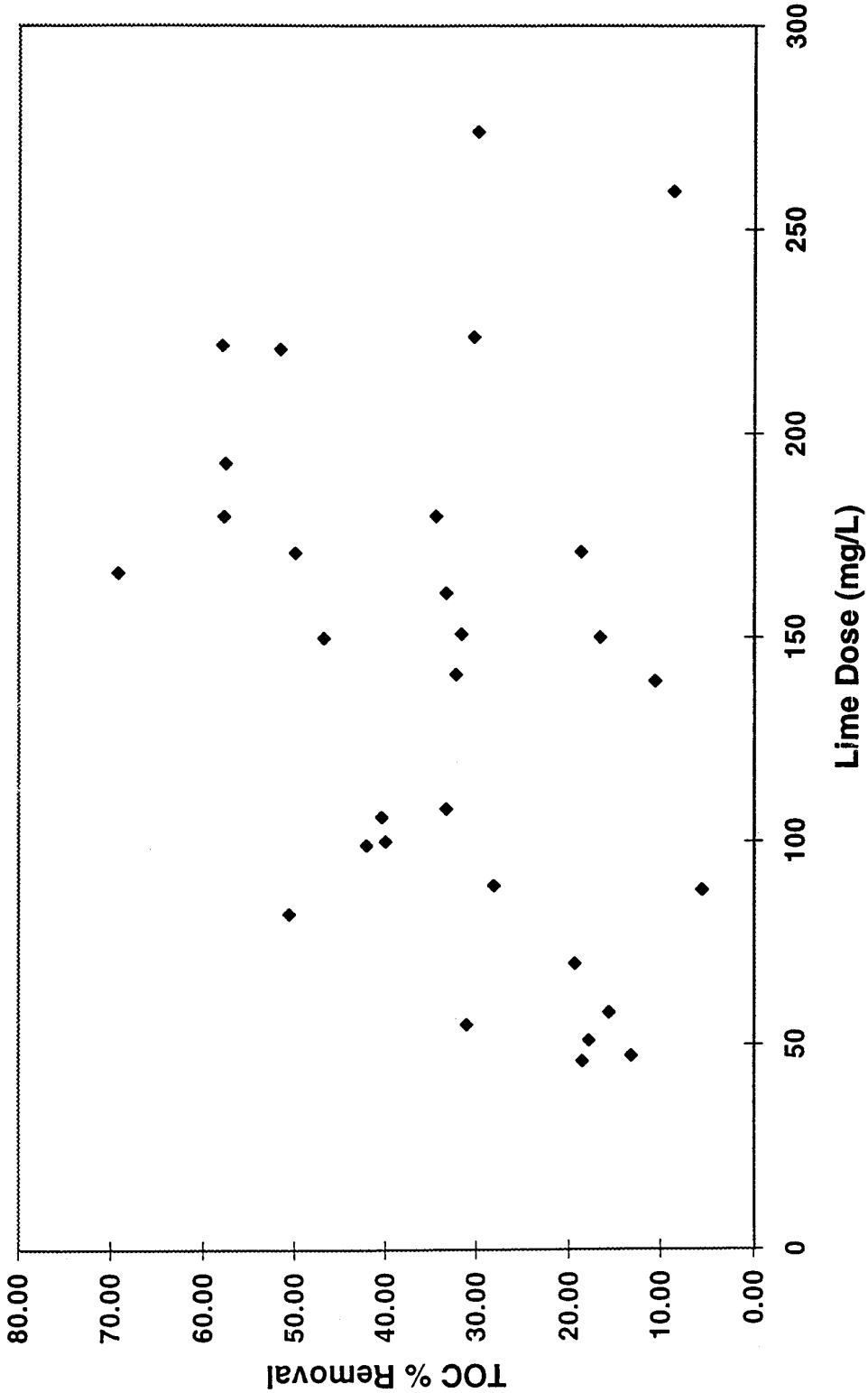

Figure III-23: Relationship of Lime dose to TOC Removal ICR Softening Plants

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Another important issue for softening systems is the pH level used in the softening process. As the lime dose is increased, the pH of the softening process increases and the character of the precipitate changes; as the pH rises above 10, the major precipitate formed changes from calcium carbonate to magnesium hydroxide. The TOC percent removal in the survey data was plotted versus the pH of softening and is shown in Figure III–24 . The data show that at higher softening pH levels, generally greater percentages of TOC are removed. Also as the lime dose is increased alkalinity is consumed and if the lime dose is high enough to deplete the raw water alkalinity, soda ash must be added to maintain the precipitation process. Crossing either one of these thresholds (either changing the dominant precipitate from calcium carbonate to magnesium hydroxide or changing from a lime softening system to a lime/soda softening system) constitutes a major change in the treatment process. Magnesium hydroxide floc do not act the same as calcium carbonate floc either in settling or in sludge treatment and the plant design for the two precipitates would be significantly different. Forcing a plant to increase pH to the point of having to add soda ash would also be a significant treatment change due to pH adjustment problems and because the precipitate would likely be changing at the same time. Most softening plants are normally operated without soda ash addition because of the high cost of soda ash, the additional sludge production, the increased chemical addition to stabilize the water and the increased sodium levels in the finished water (Randtke et al., 1994 and Shorney et al., 1996).

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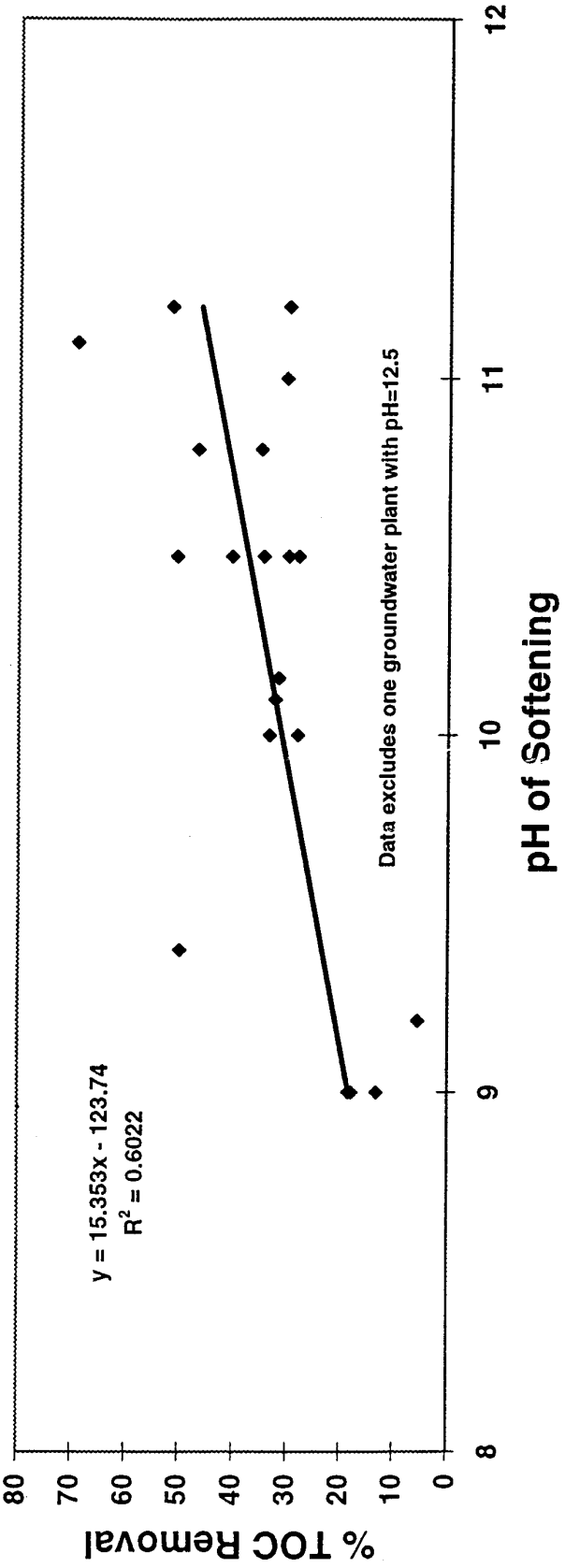

Figure III-24: pH of Softening and TOC Removal ICR Softening Plants

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Raising the pH by adding lime can have other impacts such as depleting alkalinity and potentially causing corrosion problems. To determine what finished water alkalinity most softening plants produce, the survey data was plotted for finished water alkalinity and TOC percent removal (see Figure III–25 (Clark et al., 1997)). With only a few outliers and regardless of the percent TOC removal, most plants produce finished water with alkalinity between 30 and 60 mg/L as $CaCO_3$.

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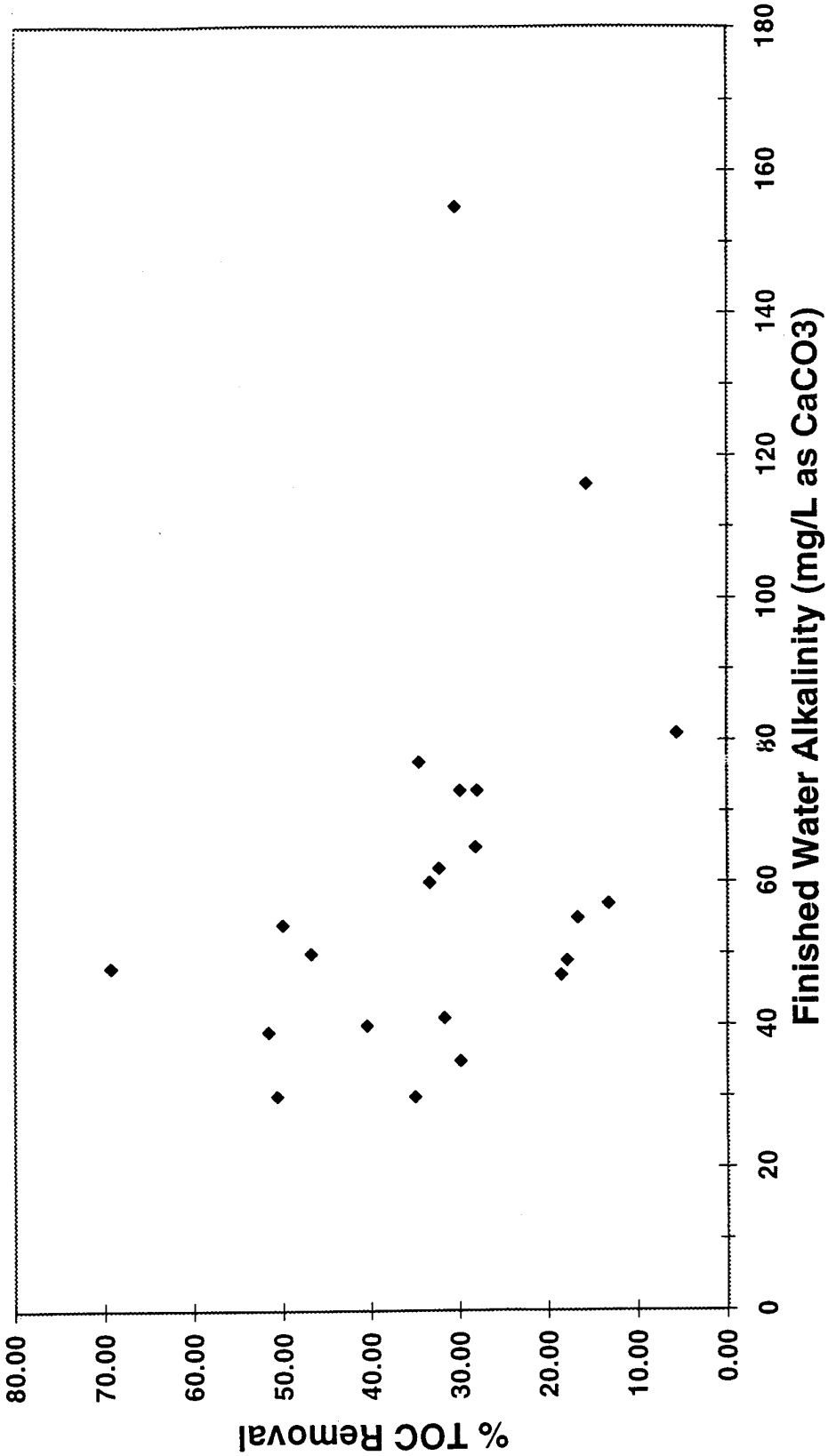
Figure III-25: Relationship between Finished Water Alkalinity and TOC Removal ICR Softening Plants



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The survey obtained basic information on disinfection practices in softening plants. Forty percent of the plants responding predisinfect. Softening plants predisinfect for the same reasons that conventional coagulation plants do, that is, to comply with Surface Water Treatment Rule Disinfection requirements, to oxidize iron and manganese, to control zebra mussels and Asiatic clams, and to control taste and odor problems. Disinfectants in use in softening plants are as follows:

- 28% of plants use free chlorine for both primary and secondary disinfection.
- 50% of plants use free chlorine/chloramine.
- 10% of plants use chloramine.
- 7% of plants use chlorine dioxide/chloramine.
- 5% of plants use ozone/chloramine.

In spite of the fact that some 78% of softening plants are using free chlorine for at least a portion of their disinfection, the reported yearly average THMs indicate that 90 percent of plants are currently meeting an 80 μg/L level for THMs (see Figure III–26 (Clark et al., 1997)). All reporting softening plants have average HAA5 levels below 60 μg/L (see Figure III–27 (Clark et al., 1997)). For the majority of softening plants, minor adjustments to disinfection practices may bring them into compliance with the proposed total THM and HAA5 MCLs, as long as predisinfection credit is allowed. Without predisinfection credit, these plants could face the major impact of having to provide disinfection time after sedimentation, and for at least one of the reporting utilities, that could mean significantly increasing the free chlorine contact time to get the maximum CT credit by making up for a shortened detention time. The end result for that system will likely be an increase in finished water total THMs over what are being produced using predisinfection credit. However, these site-specific issues will need to be addressed individually, as removing the precursors by enhanced softening will also remove some of the chlorine demand resulting in less disinfectant addition to obtain the necessary residual.

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Figure III-26: Average THMs for ICR Softening Plants

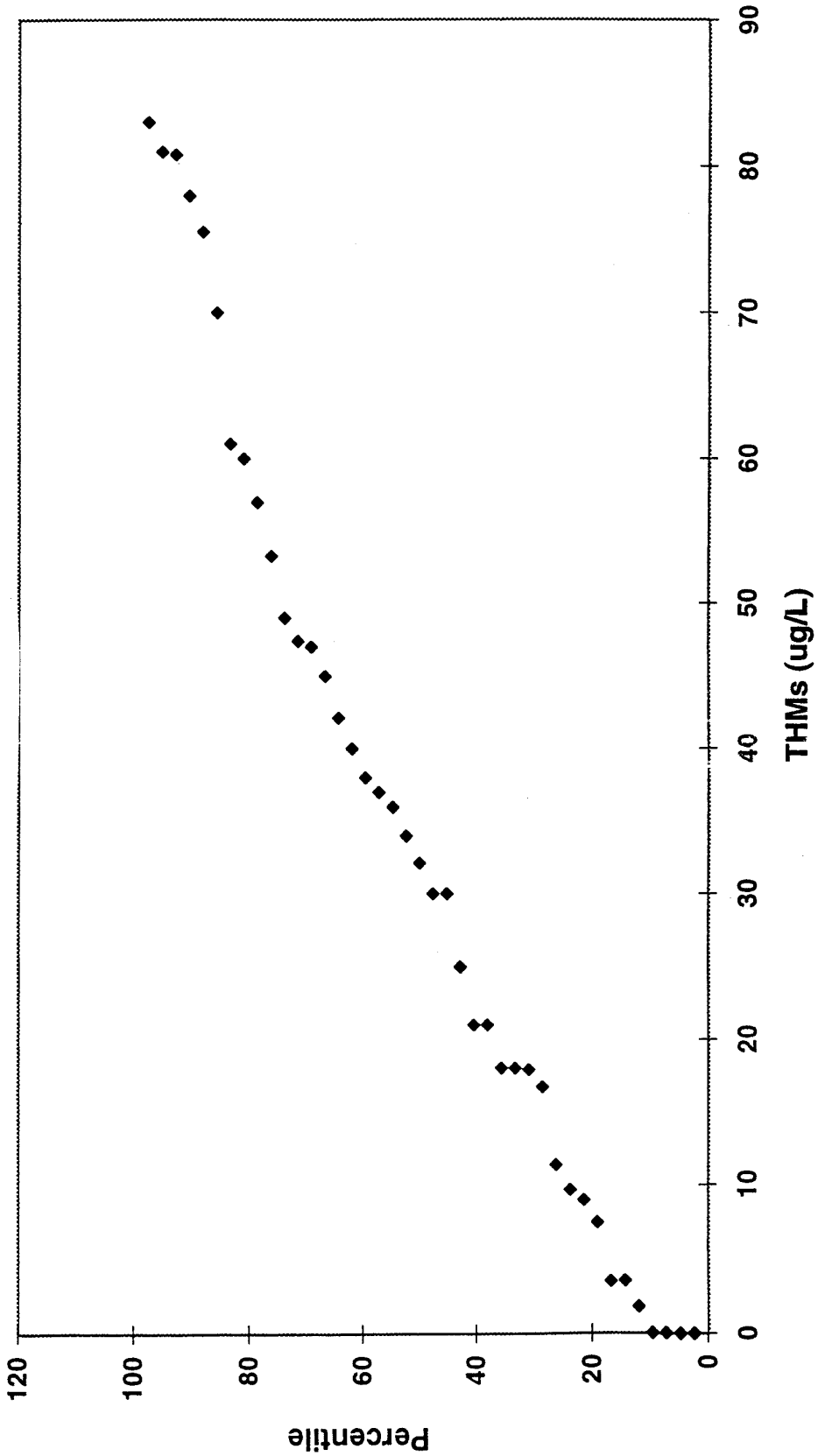

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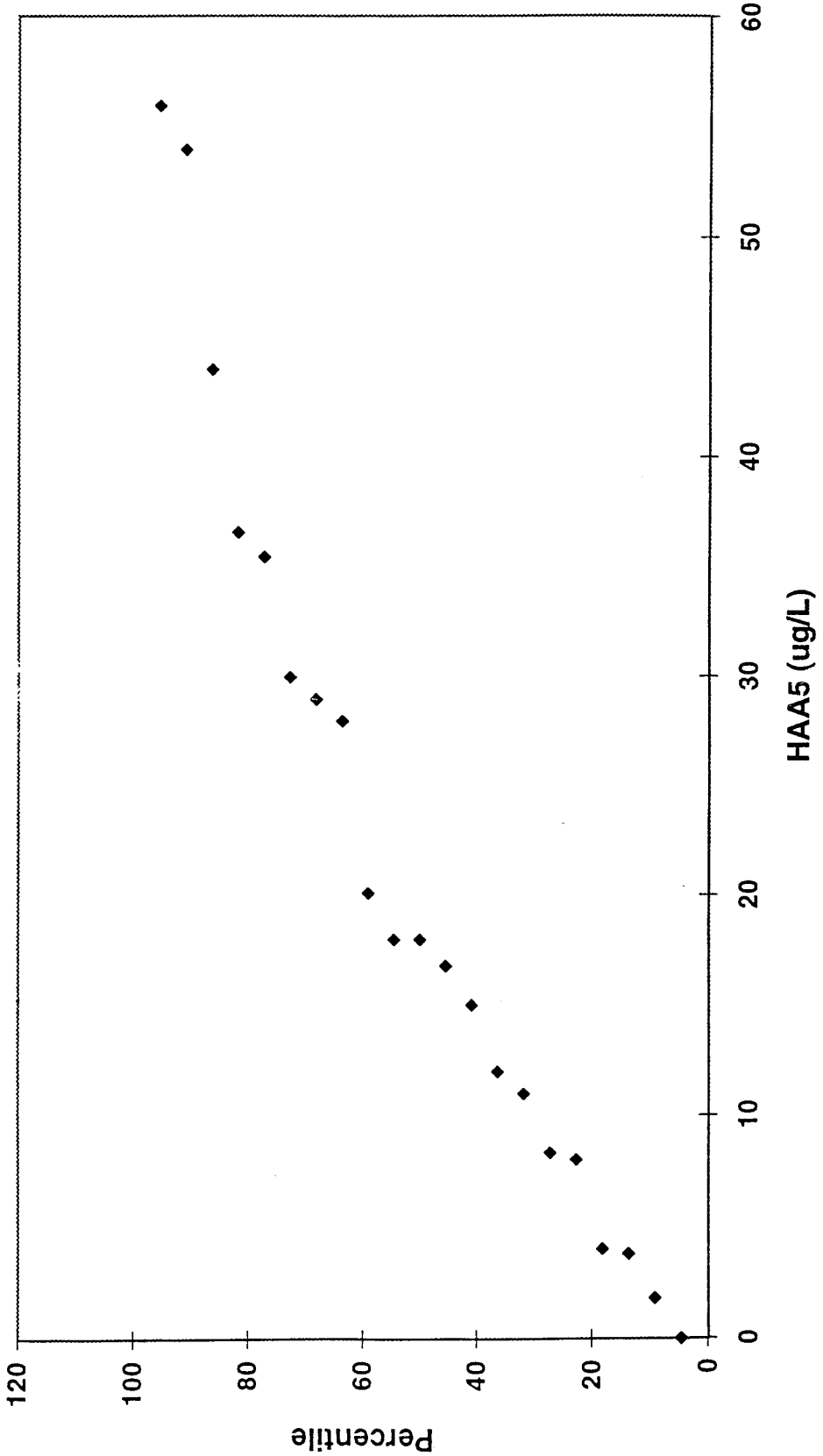
Figure III-27: Average HAA5 for ICR Softening Plants



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C. Summary of Key Enhanced Coagulation and Enhanced Softening Observations

Based on the data and analysis outlined above, the M/DBP Advisory Committee has recommended the following revisions to the proposed enhanced coagulation and softening requirements to address the outstanding issues on the use of this technology to control DBP precursors (see Table III–13). The top row has been modified from the proposal by lowering the values by 5%. Enhanced softening systems are required to comply with the column for alkalinity > 120 mg/L as $CaCO_3$.

TABLE III–13.—1997 PROPOSED REQUIRED REMOVAL OF TOC BY ENHANCED COAGULATION/ENHANCED SOFTENING FOR SURFACE-WATER SYSTEMS USING CONVENTIONAL TREATMENT

Source water TOC, mg/L	Source water alkalinity, mg/L as $CaCO_3$		
	0–60a (percent)	>60–120 [a] (percent)	>120 [a b] (percent)
>2.0–4.0	35.0	25.0	15.0
>4.0–8.0	45.0	35.0	25.0
>8.0	50.0	40.0	30.0

[a] Not applicable to waters with raw-water SUVA ≤ 2.0 L/mg-m.
[b] Systems practicing precipitative softening must meet the TOC removal requirements in this column.

For waters with TOC >4.0 mg/L (6 of the 9 boxes in the 3 x 3 matrix), the TWG felt that 90 percent of these waters can meet the 1994 proposed step 1 TOC removal requirements. For waters with TOC >2.0–4.0 mg/L, the Committee recommended that the TOC removal requirements be 35, 25, and 15 percent for low-, moderate-, and high-alkalinity waters, respectively. For low-TOC waters with raw-water SUVA >2 L/mg-m, the TWG felt that 90 percent of the systems treating such waters will be able to comply with the revised step 1 TOC removal levels.

The Committee recommended that waters with raw-water SUVA ≤2.0 L/mg-m be given an exemption to enhanced coagulation and enhanced softening. SUVA is an indicator of the humic content of a water. Coagulation removes humic matter, so waters with low-SUVA values contain primarily nonhumic matter, which is not amenable to enhanced coagulation. The use of a raw water SUVA < 2.0 liter/mg-m as a criterion for not requiring a system to practice enhanced coagulation or softening should be added to those proposed in § 141.135(a)(1)(i)–(iv).

For systems practicing enhanced coagulation (in any of the 9 boxes in the matrix) that can not meet the step 1 removal values, a step 2 protocol needs to be used to develop alternative TOC removal requirements. In addition to the current proposed PODR of the slope criterion of 0.3 mg/L of TOC removal per incremental 10-mg/L alum dose, the TWG developed another PODR (a second option for the protocol), which is a settled-water SUVA ≤2.0 L/mg-m. At this point, the residual TOC is mainly composed of nonhumic matter that is not amenable to enhanced coagulation; therefore, it is not productive to add additional coagulant. Because oxidants can destroy UV, but not TOC, SUVA must be determined on water that has not been exposed to oxidants. Thus, using a settled-water SUVA ≤2.0 L/mg-m as a PODR should be done on jar-tested water (as the slope criterion is done) unless the full-scale plant is not using preoxidation/predisinfection. The TWG believes that these revised requirements will result in a limited amount of transactional costs for the PWSs and their primacy agencies. The Committee recommended this option to EPA.

Enhanced softening systems that cannot meet the removal percentages specified in the TOC removal matrix must demonstrate that they have met alternative performance criteria, e.g., depressed the alkalinity to a minimum level or lowered settled water SUVA ≤ 2.0 L/mg-m. Also, systems that remove a minimum of 10 mg/L of magnesium hardness (as $CaCO_3$) from their raw water are exempt for enhanced softening requirements. Lime softening plants would not be required to perform lime-soda ash softening, and no softening plant will be required to lower treated effluent alkalinity below 40 mg/L (as $CaCO_3$), as part of any Step 2 procedure.

Because the determination of SUVA requires measurement of DOC, the TWG believed that guidance on this determination is necessary. DOC is determined on filtered samples, but it is important that the filter paper does not leach DOC. Protocols and quality assurance measures to ensure that SUVA is properly measured are discussed in the analytical methods section.

Another exception to enhanced coagulation in the proposed 1994 rule was for systems that treated water with <4.0 mg/L TOC and >60 mg/L alkalinity that achieved TTHMs <0.040 mg/L and HAA5 <0.030 mg/L. Waters with low TOC and moderate-to-high alkalinity were expected to be some of the more difficult to treat with enhanced coagulation, so this exception encouraged systems treating such waters to explore alternative technologies (e.g., ozone/chloramines) that could reduce DBP levels significantly below the proposed Stage 1 MCLs (i.e., <50 percent of the proposed Stage 1 MCLs). The analysis of the optimized coagulation database (Table III–10 in the draft NOA) confirms this point. Thus, the Committee recommended maintaining this exception to enhanced coagulation.

D. Request for Public Comment on Enhanced Coagulation and Enhanced Softening Issues

The 1994 proposal required that TOC compliance monitoring be performed before continuous disinfection. If there are no limits to where a PWS can add a disinfectant for compliance with disinfection requirements, EPA must address the question of where the TOC compliance monitoring point should be located. Two possible compliance monitoring locations (pre- and post-filtration) are discussed below. Pre-filtration sampling may not give utilities complete TOC removal credit because a small portion of the TOC may bind with coagulant but remain in suspension and fail to settle; it would pass through the sedimentation basin and be removed by the filter. Even though the TOC would be removed by the filter and prevented from entering the distribution system to form DBPs, PWSs would not receive TOC removal credit with a pre-filtration sampling point. Post-filtration sampling would ensure utilities receive credit for all TOC removed by the treatment train. It is possible, although unlikely, that some utilities would use filtration to buttress their TOC removal capability in place of optimizing the enhanced

coagulation process. EPA solicits comment on where the TOC compliance monitoring point should be located. EPA also requests comment on the modifications to enhanced coagulation TOC removal concentrations and other provisions for enhanced coagulation outlined above. Finally, EPA requests comment on the modifications to the requirements for enhanced softening.

IV. Disinfection Credit

A. 1994 Proposal

The proposed 1994 DBP Stage I rule discouraged the overuse of disinfectants prior to precursor (measured as TOC) removal by not allowing credit for compliance with disinfection requirements in the SWTR prior to removal of a specified percentage of TOC, at treatment plants using conventional treatment. The proposed IESWTR options, scheduled to be promulgated concurrently with the Stage 1 DBPR, were intended to include microbial treatment requirements to prevent increases in microbial risk. The purpose of not allowing predisinfection credit was to maximize removal of TOC prior to the addition of chlorine or chloramines, thus minimizing disinfection byproduct (DBP) formation.

Many drinking water systems use preoxidation to control a variety of water quality problems such as iron and manganese, sulfides, zebra mussels, Asiatic clams, and taste and odor. The 1994 proposed rule did not preclude the continuous addition of oxidants to the influent to the treatment plant to control these problems. However, the proposed regulations did not allow credit for compliance with disinfection requirements prior to precursor removal through enhanced coagulation or enhanced softening. Enhanced coagulation and enhanced softening processes would decrease the concentration of TOC and UV absorbing compounds, thereby decreasing the precursor concentration and the chlorine demand. Thus, analysis supporting the proposed rule concluded that many plants would be able to comply with the Stage 1 MCLs for THMs and HAA5 of 0.080 mg/L and 0.060 mg/L, respectively, by reductions in DBP levels as a result of reduced disinfection practice in the early stages of treatment. Also, enhanced coagulation and enhanced softening was thought to lower the formation of other unidentified DBPs as well. The 1994 proposal assumed that addition of disinfectant prior to TOC removal would initiate DBP formation through contact of the chlorine with the TOC thus effectively ''mooting'' the value of the EC step. Finally, the analysis underlying the 1994 proposed elimination of the preoxidation credit assumed that the addition of disinfectant was essentially ''mutually exclusive'' of the goal to reduce DBP formation by the removal of TOC. As discussed below, new data developed since 1994 suggests this may not be the case.

In the 1994 proposal, preoxidation credit was allowed for some systems that met any of the following criteria:

—Credit may be taken prior to precursor removal when the water temperature was less than 5 °C and the total THM (TTHM) and HAA5 quarterly averages are no greater than 0.040 mg/L and 0.030 mg/L, respectively.

—PWSs which purchase water from another entity were allowed to include this credit if the TTHM and HAA5 quarterly averages are no greater than 0.040 mg/L and 0.030 mg/L, respectively. If these DBP averages are higher, then the systems may use a ''C'' of 0.2 mg/L or the measured value (whichever is lower) and the actual contact time. The credit is allowed from the disinfectant feed point, through a closed conduit, and ending at the delivery point in the treatment plant.

—For ozone, disinfection credit would be allowed prior to enhanced coagulation, if ozonation is followed by biologically active filtration (BAF), to ensure the control of the ozonation byproducts by BAF.

—For chlorine dioxide, disinfection credit would be allowed if the PWS could demonstrate 95 percent efficient yield of chlorine dioxide from sodium chlorite (i.e., the chlorine dioxide feed stream must contain less than five percent per weight free chlorine residual).

EPA solicited comments on several issues related to the predisinfection credit requirements:

—Whether preoxidation was necessary in water treatment to control the various water quality problems such as iron and manganese oxidation, control of taste and odor, zebra mussels and Asiatic clams?

—Would the addition of a preoxidant before precursor removal by enhanced coagulation or enhanced softening produce excessive DBP levels?

B. New Information Since 1994 Proposal

At the time of the proposed rule, EPA intended to use data from the ICR to develop the IESWTR (specifically risk-based disinfection requirements). For the reasons outlined in section I.E., the ICR monitoring data will not be available for consideration as part of developing the IESWTR. In light of this, M/DBP FACA members agreed that the IESWTR should include requirements for a disinfection benchmark to assure no significant reductions in existing levels of microbial inactivation while PWSs complied with the Stage 1 DBP requirements, unless they met certain site-specific conditions. In a separate NODA concerning the IESWTR published today, EPA describes the disinfection benchmark requirements that it intends to promulgate by November 1998. The Advisory Committee was specifically concerned about maintaining the same level of disinfection while (1) not compelling many more systems to install either substantial replacement contact time or an alternative disinfectant after precursor removal than were predicted in 1994 and (2) still allowing systems to meet the TTHM and HAA5 MCLs. This was an issue because MCL compliance predictions in the 1994 proposal were based on assumptions that (1) TTHM and HAA5 formation would be limited by precursor removal, which would limit the number of systems having to install alternative disinfectants or advanced precursor removal (GAC or membranes) and (2) systems would, where possible, receive necessary inactivation credit through addition of contactors located after precursor removal processes. Several committee members were concerned that these assumptions would result in systems installing costly technologies or contact basins in order to meet DBP MCLs that would prove unnecessary when EPA was able to develop a risk-based ESWTR. However, if systems could continue to receive inactivation credit for all disinfection used and still meet DBP MCLs, these costly alternatives to achieve compliance could be avoided. The following is information considered by committee members that led to the recommendation to allow disinfection credit for disinfection used, as is currently allowed.

1. ICR Mail Survey—Predisinfection Practices

To obtain information on the current predisinfection practices of systems, a survey was sent out to utilities participating in the ICR. The results of the survey of 329 surface water treatment plants indicated that 80 percent (263) of these plants use predisinfection for one or more reasons. A detailed breakdown of the reasons cited is shown below:

Predisinfection reason	Number of "yes" responses (% of total)
Taste and Odor Control	114 (35%)
Turbidity Control	38 (12%)
Algae Growth Control	177 (54%)
Inorganic Oxidation	104 (32%)
Microbial Inactivation	222 (67%)
Other	27 (8%)

The survey indicated that the majority of the plants using predisinfection were doing so for multiple reasons. The main reported reason for predisinfection was microbial inactivation, followed by algae control, taste and odor and inorganic oxidation. Seventy-seven percent of plants that predisinfected reported that their current levels of *Giardia lamblia* inactivation would be lowered if predisinfection was discontinued and no subsequent additional disinfection was added to compensate for change in practice. Eighty-one percent of plants that predisinfected would have to make major capital investments to make up for the lost logs of *Giardia lamblia* inactivation. Thus, to maintain the same level of microbial protection currently afforded, additional contact time would have to be provided if predisinfection was eliminated. Most of the surveyed plants also used preoxidation to control for taste and odor, algae growth or inorganic oxidation. Therefore, many PWSs would have had to continue use of a predisinfectant for these problems and also provide additional contact time for disinfection credit.

The survey also demonstrated that many utilities were unfamiliar with the concept of log inactivation of *Giardia lamblia* and did not know how to determine it, since the SWTR only requires unfiltered systems to make this calculation. Instead, many utilities reported the ratio of CT values, which is the ratio of the actual CT to the required value, instead of actual log inactivation.

In addition to the ICR mail survey, results from EPA's Comprehensive Performance Evaluations (CPE) of a total of 307 PWSs (4 to 750 mgd) reported that 71 percent of the total number of plants used predisinfection and 93 percent of those that predisinfected used two or three disinfectant application points during treatment.

Based on the above information, EPA believes that predisinfection is used by a majority of PWSs for microbial inactivation, as well as other drinking water treatment objectives.

2. Summers et al.—Impact of Chlorination Point on DBP Production

In developing the 1994 proposal, EPA assumed that the removal of precursors by enhanced coagulation or enhanced softening had to precede Cl_2/chloramine addition in order to lead to reduction of DBPs. Four investigators tested the validity of this assumption. Summers (Summers et al., 1997) summarized the findings of the four investigators concerning the impact of moving the point of chlorination during coagulation, flocculation and sedimentation on DBP formation for a representative range of waters and treatment conditions. In addition, studies were carried out at the University of Cincinnati under the sponsorship of EPA, the American Water Works Association (Water Utility Council-Water Industry Technical Action Fund) and the Chlorine Chemistry Council (Solarik et al., 1997). The results of these studies are summarized here.

Sixteen source waters have been evaluated to date. The waters were selected to proportionately represent the national source water distribution in the enhanced coagulation 3 x 3 (TOC—alkalinity) matrix as estimated from AWWA water industry database (WIDB). Waters were chosen to represent the >2.0–4.0 mg/L and >4.0–8.0 mg/L TOC ranges. For TOC >8.0 mg/L, prechlorination would generally not be a suitable option, as experience and computer modeling have shown that prechlorination of these waters under the conditions of this study is likely to yield TTHM and HAA5 values that exceed the 0.080 mg/L and 0.060 mg/L proposed MCLs, respectively. WIDB TOC data indicate that less than 10 percent of the surface waters have TOC concentrations greater than 8.0 mg/L.

The study was conducted using a bench-scale batch jar testing procedure with chlorine added at different times to simulate full-scale continuous flow conditions with chlorine added at different points. Alum ($Al_2(SO_4)_3 \bullet 18H_2O$) was used as the coagulant for all waters and two alum doses were examined for 14 of the 16 waters evaluated. The baseline dose was set at the level required for turbidity control, while a second increased dose was set at the level necessary to meet the required percent TOC removal in the 3 X 3 enhanced coagulation matrix. In three cases, the required TOC removal was achieved by baseline coagulation. The jar tests were carried out at ambient laboratory temperature, (22°C).

Chlorine was added to four parallel jars at four different times during the coagulation, flocculation and sedimentation process for both the baseline coagulant dose and the increased coagulant dose: 1) 3 minutes before rapid mixing (Pre-RM), (2) at the end of rapid mixing (Post-RM), (3) in the middle of flocculation (Mid-Floc), and (4) at the end of sedimentation (Post-Sed). Additionally, the raw uncoagulated water was adjusted to the settled water pH and chlorinated. The DBP results from the raw uncoagulated water served as a basis for comparison. The chlorine doses were chosen to yield a free chlorine residual of 0.6 ± 0.4 mg/L after 3 hours of total contact time at ambient pH (6.1–8.1) and laboratory temperature (22°C). The 3 hour reaction time is representative of that of a typical coagulation, flocculation and sedimentation process train. At the end of the 3 hour incubation time, the reaction was quenched and DBPs were assessed. Settled water was also chlorinated under uniform formation conditions (UFC) (Summers et al., 1996) to represent distribution system DBP formation. A more detailed experimental approach is presented elsewhere (Solarik et al., 1997, Summers et al., 1997).

Impact of Point of Chlorination

The impact of moving the point of chlorination downstream for both baseline and increased dose coagulation is shown in Figures IV.1, IV.2, and IV.3 for TOX, TTHM, and HAA5 concentrations, respectively. The distribution of data is shown as box and whisker plots indicating the mean and median, the 10th, 25th, 75th, and 90th percentiles, and any data that lies outside the 10th and 90th percentiles. Moving the point of chlorination further downstream decreased the concentration of DBPs formed after three hours of contact time with free chlorine. The DBP concentrations shown in these three figures are not intended to represent occurrence levels of DBPs in the distribution system, only those which were formed under the conditions of this study. Figures IV.4, IV.5, and IV.6 show the percent decrease in DBP formation relative to that formed in the raw uncoagulated water.

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Figure IV. 1: Impact of point of chlorination on TOX formation

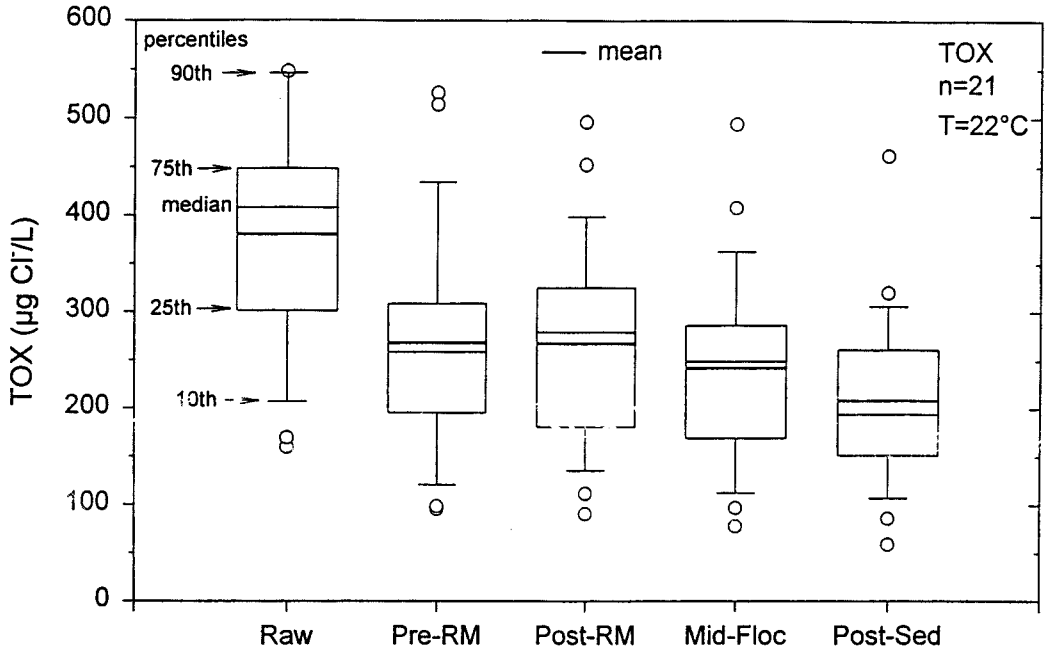

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Figure IV.2: Impact of point of chlorination on TTHM formation

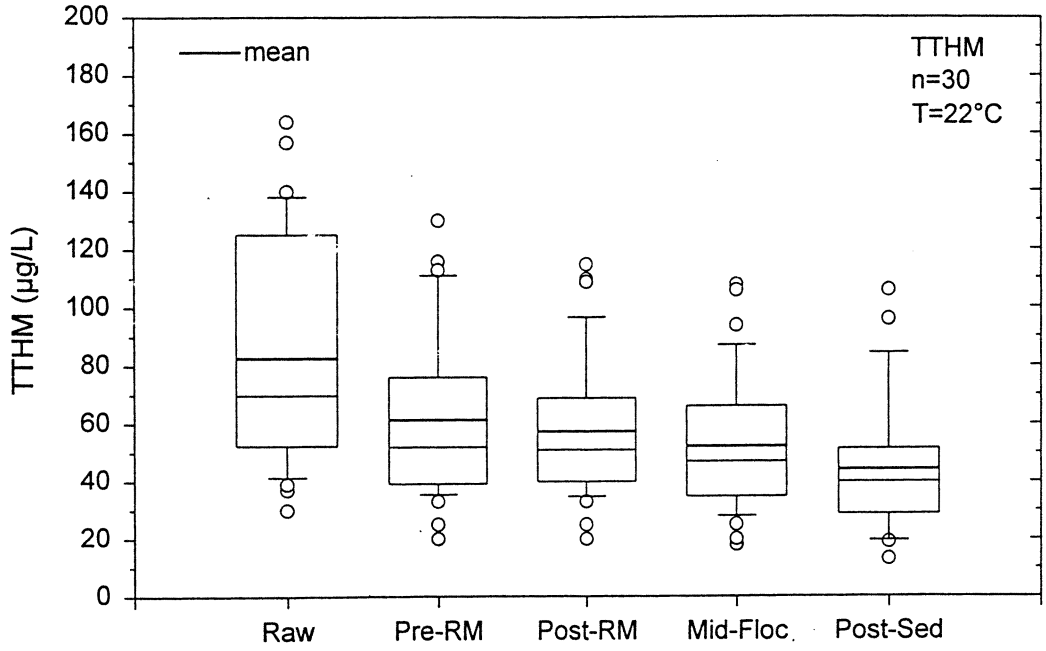

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Figure IV.3: Impact of point of chlorination on HAA5 formation

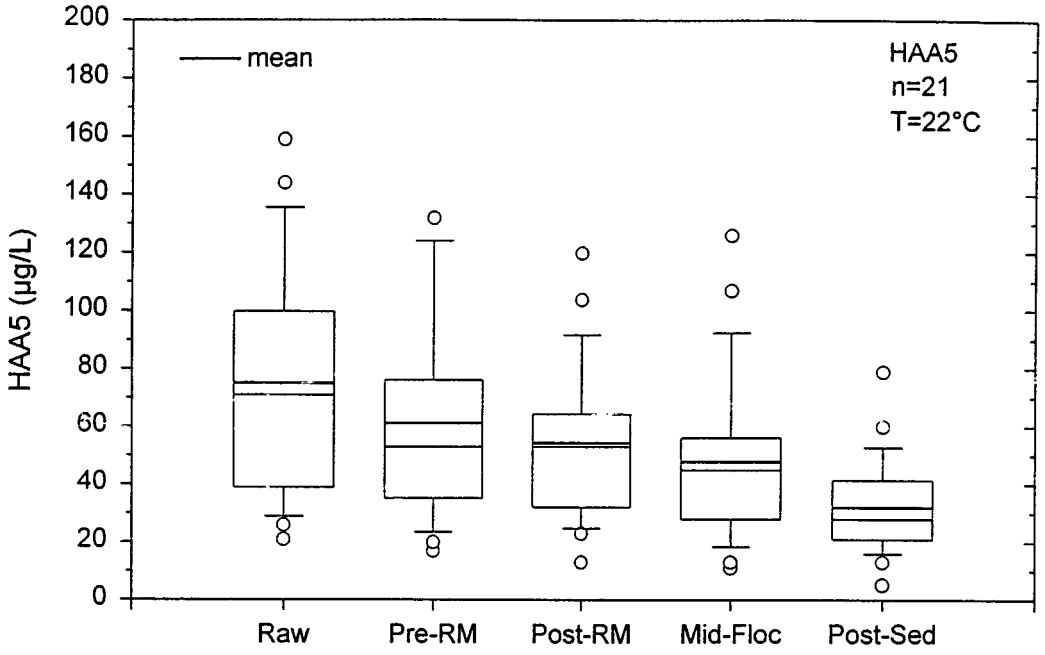

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Figure IV.4: Impact of point of chlorination on percent decrease in TOX formation for all waters (compared to raw)

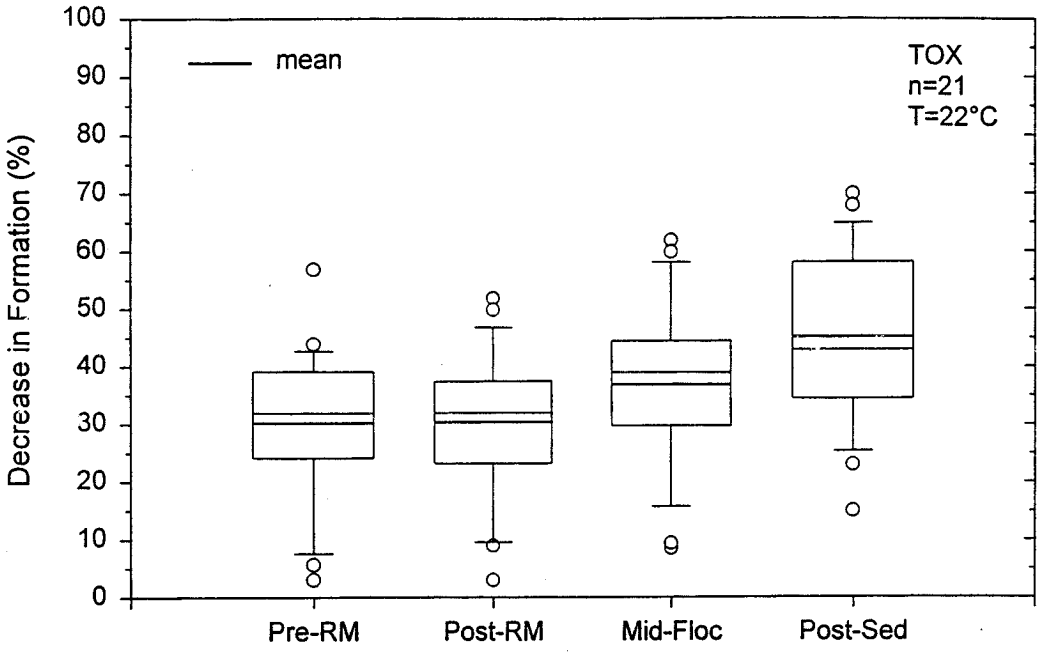

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Figure IV.5: Impact of point of chlorination on percent decrease in TTHM formation for all waters (compared to raw)

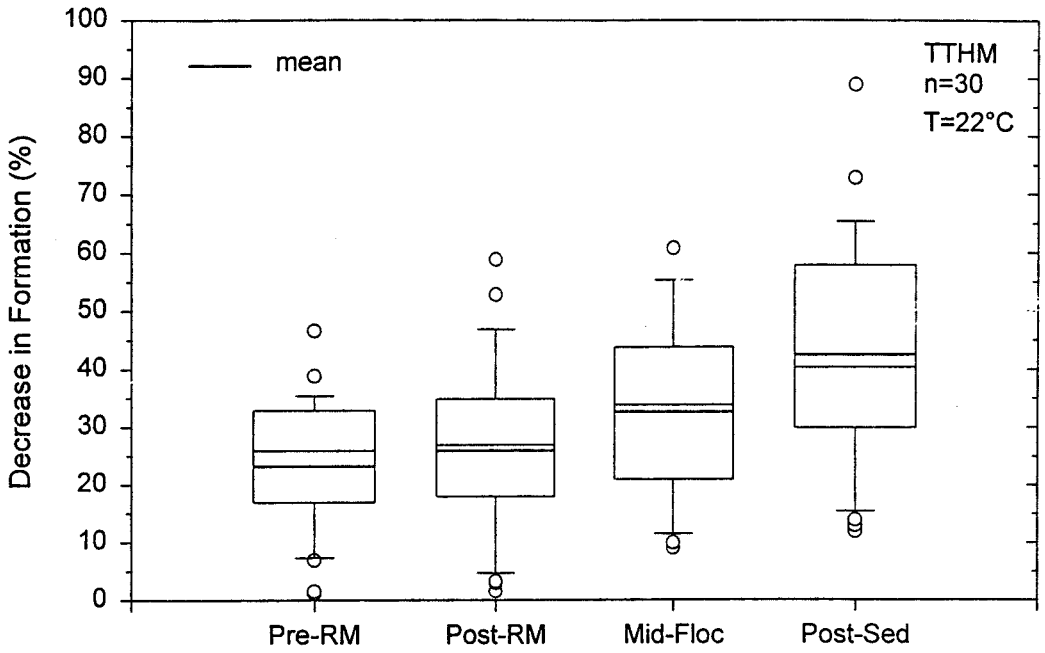

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Figure IV.6: Impact of point of chlorination on percent decrease in HAA5 formation for all waters (compared to raw)

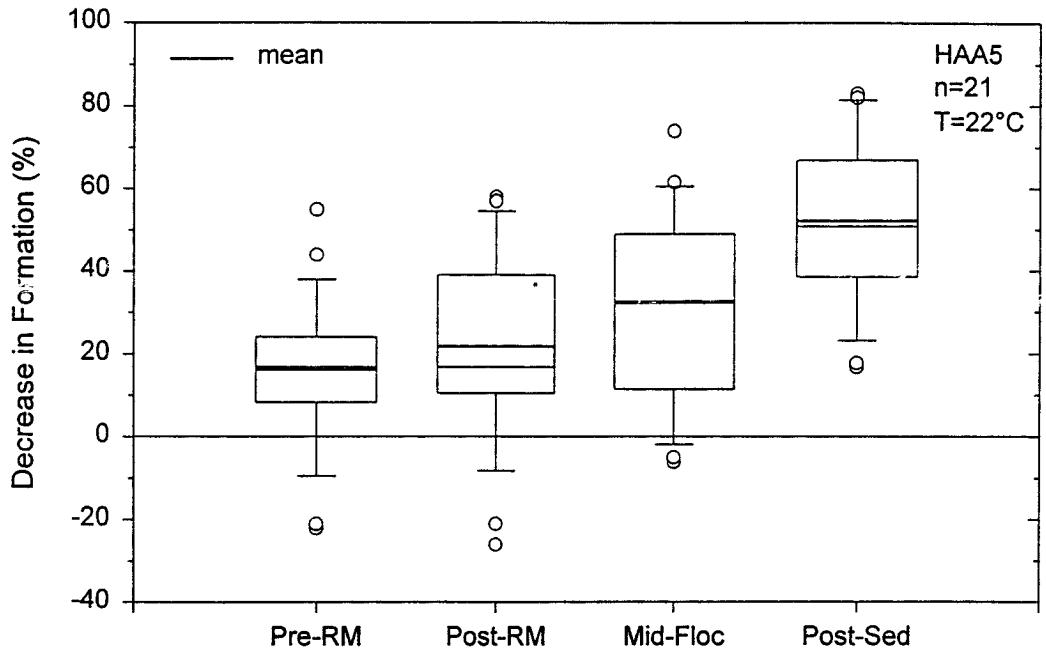

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Figure IV.7: Impact of point of chlorination and percent TOC removal on percent decrease in TOX formation for all waters (compared to raw)

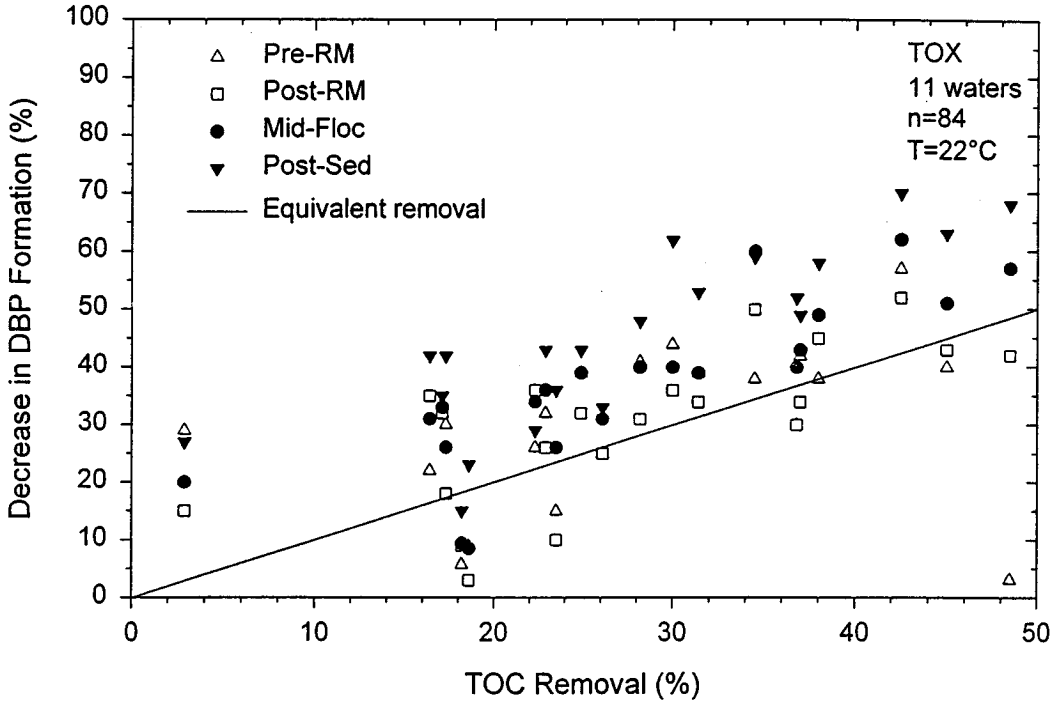

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Figure IV.8: Impact of point of chlorination and percent TOC removal on percent decrease in TTHM formation for all waters (compared to raw)

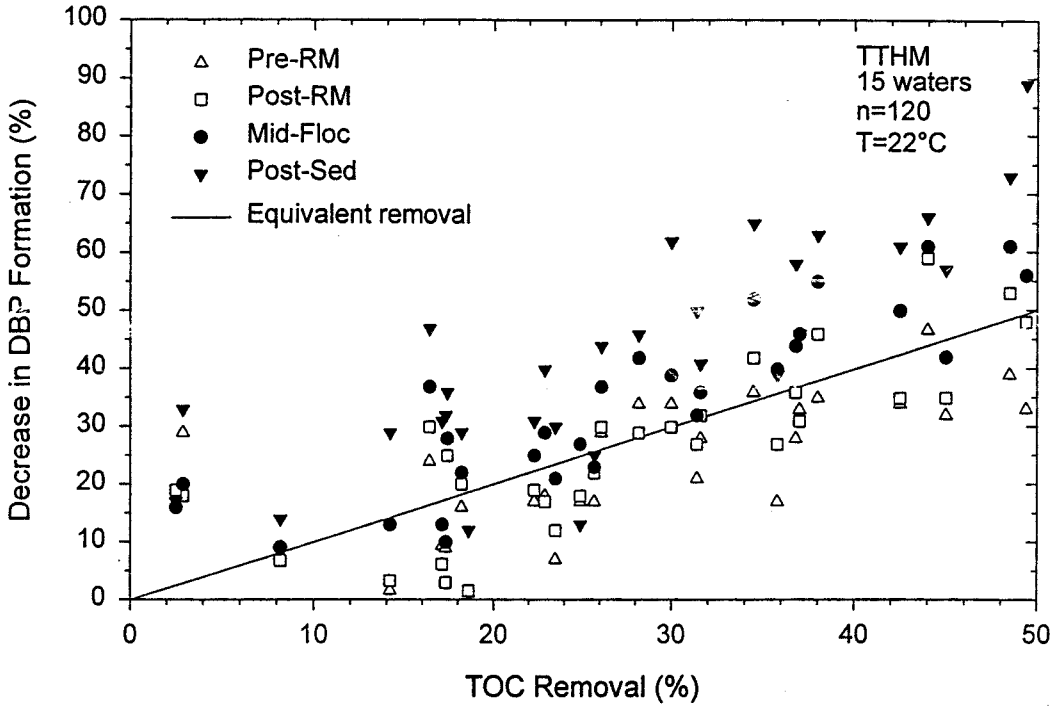

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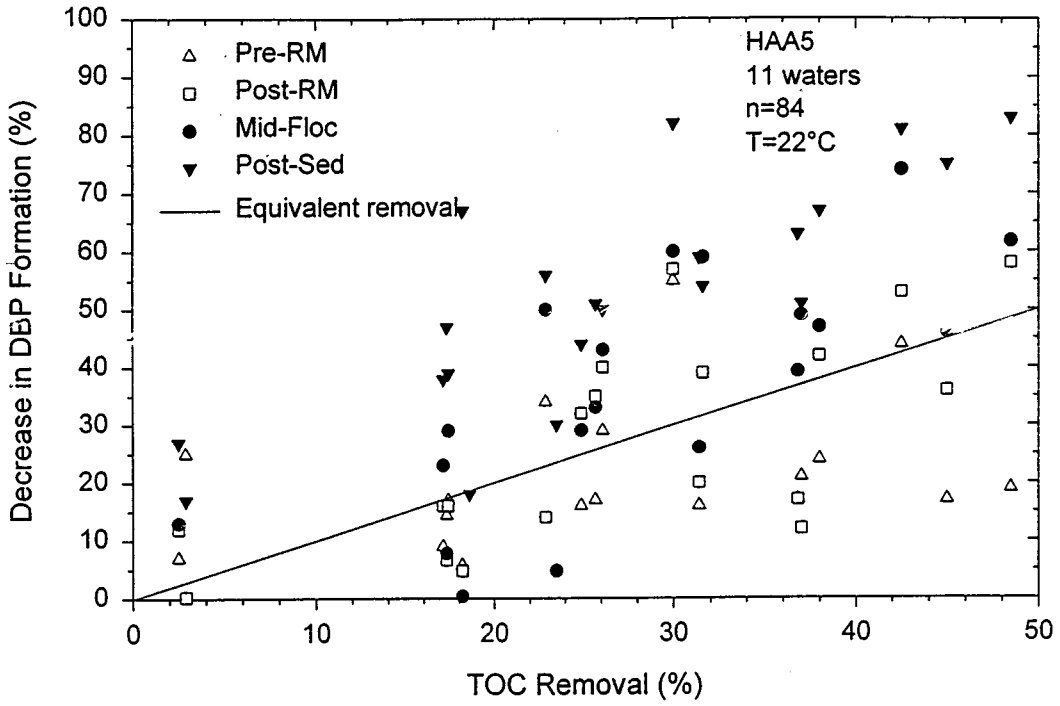
Figure IV.9: Impact of point of chlorination and percent TOC removal on percent reduction in HAA5 formation for all waters (compared to raw)



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The decrease in DBP formation was calculated by subtracting the DBP concentration formed upon chlorination at a given point in the jar test from that formed upon chlorination of the raw waters. Chlorinating 3 minutes prior to rapid mixing (Pre-RM) led to a median 32, 26 and 17 percent decrease in TOX, TTHM, and HAA5 concentrations, respectively, relative to those formed upon chlorination of the raw uncoagulated water. Prechlorinating more than 3 minutes prior to rapid mixing was shown to increase the DBP formation relative to Pre-RM.

For TOX, TTHM, and HAA5, moving the point of chlorination downstream in the coagulation, flocculation, and sedimentation process decreased DBP formation and the chlorine demand by providing additional time for NOM removal before chlorine could react with the NOM to form DBPs. While having only a small impact on average for TOX, TTHM, and HAA5 formation, moving the point of chlorination from Pre-RM to Post-RM was very beneficial for some waters. As expected, the largest benefit for all parameters investigated was observed by moving the point of chlorination to after sedimentation, which resulted in the lowest DBP formation. On average, the benefit of moving the point of chlorination downstream was greater for HAA5 than for TOX and TTHM.

The median, 10th and 90th percentile (shown in brackets) decrease in TOX formation as a result of moving the point of chlorination from Pre-RM to (1) post-RM was −5.4 percent (−17 and 16 percent); (2) mid-Floc was 6.1 percent (−6.8 and 19 percent); and (3) post-Sed was 17 percent (4.5 and 34 percent).

The median, 10th and 90th percentile (shown in brackets) decrease in TTHM formation as a result of moving the point of chlorination from Pre-RM to (1) post-RM was 1.9 percent (−5.9 and 18 percent); (2) mid-Floc was 13 percent (0.4 and 28 percent); and (3) post-Sed was 25 percent (6.5 and 43 percent).

The median, 10th and 90th percentile (shown in brackets) decrease in HAA5 formation as a result of moving the point of chlorination from Pre-RM to (1) post-RM was 5.3 percent (−11 and 23 percent); (2) mid-Floc was 19 percent (−5.7 and 53 percent); and (3) post-Sed was 40 percent (26 and 67 percent).

The impact of percent TOC removal and point of chlorination on TOX, TTHM, and HAA5 formation are shown in Figures IV.7, IV.8, and IV.9, respectively. Increased TOC removal resulted in decreased DBP formation. In general, moving the point of chlorination from raw water to Mid-Floc and Post-Sed resulted in a percent decrease in DBP formation that was equivalent to or greater than the percent TOC removal achieved. Thus, in this study, precursor removal was a more effective DBP control strategy when used in conjunction with delaying the point of chlorination until Mid-Floc or later.

Impact of Alum Dose

Coagulation conditions of the waters at baseline conditions were determined based on turbidity control. The median alum dose used for baseline coagulation conditions was 30 mg/L (10th and 90th percentile were 15 and 48 mg/L, respectively). Under these conditions, the median TOC removal was 24 percent (10th and 90th percentiles were 6.5 and 38 percent, respectively). For this study, the alum dose was increased from the baseline case by a median value of 22 mg/L (the 10th and 90th percentiles were 15 and 35 mg/L, respectively). Increasing the alum dose resulted in a median increase in TOC removal to 33 percent (10th and 90th percentile were 18 and 48 percent, respectively). Thus, at the higher alum doses, DBP formation was decreased. For nine of the waters studied, increasing the alum dose from baseline coagulation conditions resulted in TOC removal equivalent to or greater than those required by the 3 × 3 enhanced coagulation matrix. This yielded a median increase in the percent TOC removal of 14 percent. Table IV.1 summarizes the median benefit associated with moving the point of chlorination downstream under baseline coagulation and with increasing the alum dose to achieve enhanced coagulation on DBP formation. DBP formation resulting from chlorine addition at Pre-RM under baseline coagulation conditions was used as a point of reference. The data in the table indicates that even when prechlorination is practiced, TOX, TTHM, and HAA5 formation can be reduced by moving from conventional to enhanced coagulation. For TOX and TTHM, the benefits of moving to enhanced coagulation are greatest when Post-Sed chlorination is used. Furthermore, the benefits are greater for the control of HAA5 formation than for the control of TOX and TTHM formation.

TABLE IV.1.—IMPACT OF POINT OF CHLORINATION AND ENHANCED COAGULATION ON DBP FORMATION USING PRE-RM DBP FORMATION UNDER BASELINE COAGULATION CONDITIONS AS BASIS FOR COMPARISON

	Median benefit (%)					
	TOX (n=7)		TTHM (n=9)		HAA5 (n=6)	
	Baseline coagulation	Enhanced coagulation	Baseline coagulation	Enhanced coagulation	Baseline coagulation	Enhanced coagulation
Pre-RM	.....	11	.....	17	.....	4.7
Post-RM	0.3	10	1.6	21	5.3	21
Mid-Floc	3.9	23	8.7	36	14	36
Post-Sed	11	40	21	48	35	61

3-Hour DBP Formation Relative to Distribution System DBP Formation

Chlorination with a 3-hour holding time before quenching the reaction resulted in a significant formation of DBPs. The 3-hour period was chosen as it is typical of reaction times in conventional treatment plants. To get a general sense of short-term DBP formation kinetics, DBP formation for chlorinated settled water held for 3 hours was compared to DBP formation of settled water chlorinated under UFC (24 hour holding time). The data indicate that 3-hour chlorination resulted in a high percentage of DBP formation that would normally be measured in the distribution system. The median DBP concentrations formed in 3 hours were 61, 44, and 46 percent of distribution system formation for TOX, TTHM, and HAA5, respectively. This can be thought of as in-plant DBP formation relative to distribution system formation for systems with 3-hour post sedimentation contact.

Summary

The results of this study indicate that enhancing the coagulation process, while maintaining prechlorination, can result in decreased DBP formation (especially for TOX and TTHM) with greater benefits being realized by moving the point of chlorination to post rapid mixing or further downstream for HAA5 and to mid flocculation or post sedimentation for TOX and TTHM. Compared to prechlorinating three minutes before rapid mixing, the greatest DBP reduction was realized by moving the point of chlorination to post-sedimentation, with a median decrease of 17, 25, and 40 percent in TOX, TTHM, and HAA5 formation, respectively. However, operational and regulatory constraints may limit the extent to which the point of chlorination can be moved downstream in the process train, since one requirement in the IESWTR may be a disinfection benchmark; which would require some plants making significant changes in disinfection practice (including moving the point of disinfection) to design the change to maintain their level of Giardia inactivation at or above a site-specific level. This may limit the degree to which some plants can delay the point of chlorination without seeking State approval and potentially modifying their treatment train to make up lost Giardia inactivation later in the plant.

C. Summary of Key Observations

TWG analyses indicated that most PWSs, using enhanced coagulation or enhanced softening as required, would be able to meet MCLs of 0.080 mg/L and 0.060 mg/L for TTHM and HAA5, respectively, while maintaining existing disinfection practice. This analysis also indicated that significant precursor removal and DBP reduction can still be achieved with predisinfection left in place. Although in most cases the reduction in DBP formation is not as great as would be accomplished in moving the point of disinfection to after enhanced coagulation, the Advisory Committee recommended balancing the need to maximize precursor removal against the need to substantially maintain existing levels of microbial protection that is provided by many plants through predisinfection. However, as noted above, another key implication of Summers' work is that some PWSs that only add disinfectant just prior to coagulant addition (e.g., rapid mix), could achieve significant additional DBP reduction without sacrificing meaningful disinfection credit by moving the point of disinfectant addition from just before to just after the point of coagulant addition.

The Advisory Committee recommended that PWSs continue to receive credit for compliance with applicable disinfection requirements for disinfectants applied at any point prior to the first customer consistent with the existing provisions of the 1989 Surface Water Treatment Rule.

EPA will develop guidance on the uses and costs of oxidants that control water quality problems (e.g., Asiatic clams, zebra mussels, iron, manganese, algae, taste and odor) and whose use will reduce or eliminate the formation of DBPs of public health concern.

D. Request for Public Comments

EPA requests comment on continued disinfection credit for all disinfectant use prior to the first customer.

V. Analytical Methods

EPA is requesting comment on the addition, and in one case the deletion, of analytical methods for the disinfectants and DBPs listed below. These potential changes are based on information received during the public comment period or on new information that has become available since the July 1994 proposed rule.

A. Chlorine Dioxide

The proposed DBP rule included the same three methods for analyzing chlorine dioxide (ClO_2) that are approved under the SWTR and ICR regulations. Two of these methods, Standard Methods 4500.ClO_2 C (APHA 1992) and 4500.ClO_2 E (APHA 1992), are amperometric methods. The third method proposed was Standard Method 4500.ClO_2 D (APHA 1992), a colorimetric method using the color indicator N,N-diethyl-p-phenylenediamine (DPD).

EPA received several comments stating that these methods to calculate ClO_2 concentration are intrinsically inaccurate because free chlorine, chloramines and chlorite are subtracted from the measurement, causing a propagation of errors. However, they stated that the DPD method is sufficiently accurate for monitoring ClO_2 residuals in drinking water and is relatively easy to perform.

Method 4500.ClO_2 C was cited as an outdated, inaccurate and time consuming method, subject to interferences from oxidants commonly found in drinking water (Dietrich, 1992). Significant, positive interferences have been described by Gates (1988), and attributed to mono-and dichloramines by Haller and Listek (1948). Method 4500.ClO_2 E is a better method because it utilizes differences in the physical properties of ClO_2, as opposed to chemical detection of anionic oxychlorocompounds (Aieta et al., 1984). Therefore, EPA requests comments on omitting Method 4500.ClO_2 C from the list of approved methods for the analysis of chlorine dioxide for compliance with the MRDL for chlorine dioxide. Comments on omitting it from 40 CFR 141.74 (SWTR analytical methods) are also requested.

B. Haloacetic Acids

In 1994, EPA proposed two methods for the analysis of five haloacetic acids—Method 552.1 (USEPA, 1992b) and Standard Method 6233B (APHA 1992). Both methods use capillary column gas chromatographs equipped with electron capture detectors. The two methods differ in the sample preparation steps. Method 552.1 uses solid phase extraction disks followed by an acidic methanol derivitization. Method 6233B is a small volume liquid-liquid (micro) extraction with methyl-t-butyl ether, followed by a diazomethane derivitization. Standard Method 6233B was revised (and renumbered 6251B (APHA 1995)) to include bromochloroacetic acid, for which a standard was not commercially available in 1994. Recognizing these improvements, EPA approved Method 6251B for analysis under the 1996 Information Collection Rule (40 CFR Part 141 or USEPA, 1996b). Several commenters requested that the revised and renumbered method, Method 6251B, also be approved for the analysis of haloacetic acids under the Stage 1 DBP regulations.

In 1995 EPA published a third method for HAAs, Method 552.2 (EPA 1995), and subsequently approved it for HAA analysis under the 1996 Information Collection Rule (40 CFR Part 141 or USEPA, 1996b). Method 552.2 is an improved method, combining the micro extraction procedure of Standard Method 6233B with the acidic methanol derivitization procedure of Method 552.1. It is capable of analyzing nine HAAs. EPA received comments requesting approval of Method 552.2 for HAA5 analyses required under this section.

EPA requests comment on the technical adequacy of using Methods 552.2 and 6251B (formerly 6233B) for analyzing haloacetic acids. Method 552.1 would continue to be approved for the analysis of haloacetic acids.

C. Total Trihalomethanes (TTHMs)

Three methods are approved for the analysis of total trihalomethanes

(TTHMs) under 40 CFR 141.24(e). These same methods were proposed under the 1994 Stage I DBP proposal. One of the three methods, EPA Method 551, was revised to Method 551.1, rev. 1.0 (EPA 1995). Method 551.1 is approved for ICR monitoring under 40 CFR 141.142.

Method 551.1 has several improvements upon Method 551. The use of sodium sulfate is strongly recommended over sodium chloride for the MTBE extraction of DBPs. This change was in response to a report indicating elevated recoveries of some brominated DBPs due bromide impurities in the sodium chloride (Xie, 1995). EPA's NERL laboratories confirmed this finding in samples that were not extracted immediately after the sodium chloride was added.

Other changes to Method 551.1 include a buffer addition to stabilize chloral hydrate, elimination of the preservative ascorbic acid, and modification of the extraction procedure to minimize the loss of volatile analytes. The revised method requires the use of surrogate and other quality control standards to improve the precision and accuracy of the method.

D. Bromate

The proposed rule required systems that use ozone to monitor for bromate ion. EPA proposed Method 300.0 (Determination of Inorganic Anions by Ion Chromatography)(USEPA, 1993a) for the analysis of bromate and chlorite ions. Method 300.0 is used in many laboratories because it can analyze bromide, chloride, fluoride, nitrate, nitrite, orthophosphate, sulfate, bromate, chlorite and chlorate ions. The cost of bromate ion analysis was estimated to range from $50 to $100 per sample.

At the time of the proposal, EPA was aware that Method 300.0 was not sensitive enough to measure bromate ion concentration at the proposed MCL of 0.010 mg/L (10 µg/L). EPA recognized that modifications to the method would be necessary to increase the method sensitivity. Studies at that time indicated that changes to the injection volume and the eluent chemistry would decrease the detection limit below the MCL. There was also an issue concerning whether bromate formation could be reliably controlled to levels below 10 µg/L when ozone is used as part of the treatment process. Most commenters agreed that Method 300.0 was not sensitive enough to determine compliance with a MCL of 10 µg/L bromate ion, given that MCLs are set no less than 5 times the MDLs. One commenter did achieve a MDL for bromate ion in the 1–2 µg /L range under research laboratory conditions.

Since the proposal, EPA has improved Method 300.0 and renumbered it as Method 300.1. EPA intends to approve this method for use in the final rule; it is available for review in the Docket. Method 300.1 specifies a new, high capacity ion chromatography (IC) column that is used for the analysis of all anions listed in method instead of requiring two different columns as specified in Method 300.0. The new column has a higher ion exchange capacity that improves chromatographic resolution and minimizes the potential for chromatographic interferences from common anions at concentrations typically 10,000 times greater than bromate ion. For example, quantification of 5.0 µg/L bromate is feasible in a matrix containing 50 mg/L chloride. Minimizing the interferences permits the introduction of a larger sample volume to yield a method detection limit of 2 µg/L. Sample analysis time is approximately 30 minutes per sample.

An IC column's capacity is directly proportional to its operating back pressure at a given flow rate and the older IC systems may not be able to tolerate the higher back pressures required when using these new IC columns. Consequently, in order to perform this analysis, some laboratories with IC systems over 15 years old may need to upgrade their instrumentation to current technology. Newer instruments can easily be operated under these conditions.

As in Method 300.0, Part A of the revised method contains procedures for measuring the common anions of bromide, nitrate, nitrite, fluoride, chloride, sulfate and phosphate. Part B contains procedures for measuring the disinfection byproduct anions of bromate, chlorite and chlorate. Bromide ion is also included in Part B to determine its potential presence as a disinfection byproduct precursor.

The anions are split into two distinct parts due to the disparity in the relative concentrations expected in drinking water. Method 300.1 analyzes mg/L levels of the Part A common anions and µg/L levels of the Part B inorganic disinfection byproducts and bromide ion. To accommodate this, the recommended sample volume injected for Part A is 10 µL and for Part B is 50 µL, when using a 2 mm diameter column. The lower injected sample volume for Part A is required to compensate for their higher (mg/L) concentrations. If this injected volume is not reduced, poor analyte response characteristics are observed and the integrity of the data is compromised. The higher injected sample volume for Part B is required to yield low detection limits for the inorganic disinfection byproducts, specifically bromate. Analysis for Part A and Part B cannot be concurrent without sacrificing analytical integrity and therefore a separate 30 minute analysis must be done for each concentration range.

To preserve samples for chlorite, chlorate, and bromate analyses, the method requires the addition of ethylenediamine (EDA) at a final sample concentration of 50 mg/L. EDA is primarily used as a preservative for chlorite. Chlorite is susceptible to degradation both through catalytic reactions with dissolved iron salts and reactivity towards free chlorine which exists as hypochlorous acid/hypochlorite ion in most drinking water as a residual disinfectant. EDA serves a dual purpose as a preservative for chlorite by chelating iron as well as any other catalytically destructive metal cations and removing hypochlorous acid/hypochlorite ion by forming an organochloramine. EDA also preserves the integrity of bromate concentrations by binding with hypobromous acid/hypobromite which is an intermediate formed as a byproduct of the reaction of ozone or free chlorine with bromide ion. If hypobromous acid/hypobromite is not removed from the matrix, further reactions may form bromate ion.

Method 300.1 was validated for the inorganic DBPs and bromide by conducting nine replicate analyses at two different fortified levels of seven water matrices including reagent water, simulated high ionic strength water, untreated surface water, untreated ground water, chlorinated drinking water, chlorine dioxide treated drinking water, and ozonated drinking water. Holding time studies have been incorporated into these validation studies with aliquots of each fortified matrix currently being stored as unpreserved and EDA preserved at 4°C. These stored sample matrices will be monitored out to 30 days to determine appropriate holding times. MDL determinations have been completed in both reagent water and high ionic strength water. Results of these validation studies are included in the method.

With Method 300.1, EPA projects that more laboratories will achieve lower detection limits for bromate and report data having better precision and accuracy. Compliance monitoring for low levels of bromate ion will require an appropriate certification process to ensure that the measurements are accurate. Although there may be a

limited number of laboratories that will be qualified to do such analyses, there should be adequate laboratory capacity for bromate ion compliance monitoring. EPA estimates that 250 treatment plants utilizing ozone will be monitored for bromate once per month, for a total of 3,000 samples per year.

E. Chlorite

The proposed rule required monitoring for the chlorite ion for those systems using chlorine dioxide for disinfection. The proposed rule included Method 300.0 (ion chromatography) for chlorite analysis. Other methods using amperometric and potentiometric techniques were considered, but EPA decided that only the ion chromatography method (300.0) would produce results with the precision needed for compliance determinations. Several commenters suggested that EPA permit other methods for chlorite.

Since the proposed rule, Method 300.1, which uses ion chromatography, was developed for bromate ion (as discussed above). Since Method 300.1 can also be used to analyze for chlorite ion, EPA requests comment on allowing both Methods 300.0 and 300.1 as approved methods for the analysis of chlorite ion.

F. Total Organic Carbon (TOC)

The proposed rule included two methods for analyzing TOC: Standard Method 5310 C and 5310 D (APHA 1992). These methods were selected because they cite a detection limit ≤0.5 mg/L and a precision of ± 0.1 mg/L TOC. Standard Method 5310 B (18th edition) was considered, but not proposed because the method had a detection limit of 1 mg/L. The proposal stated that if planned improvements to the instrumentation in 5310 B were successful, the next version would be considered for promulgation.

Improvements were made to method 5310B and were included in a revised method in the 19th edition of Standard Methods (APHA 1995). Based on these improvements, method 5310B (19th edition) was approved for TOC analyses under the Information Collection Rule. Several commenters requested that Standard Methods 5310B also be approved for TOC analysis under this rule because the newer instrumentation achieves a detection limit of 0.5 mg/L TOC.

Since the ICR was promulgated, another revision of 5310 B was published in the supplement to the Standard Methods 19th Edition (APHA 1996). EPA intends to approve this method for the analysis of TOC. EPA requests comments on the technical equivalency of Methods 5310 B, C, and D in the Supplement to Standard Methods 19th Edition and those same methods in the 19th Edition.

G. Specific Ultraviolet Absorbance (SUVA)

Specific Ultraviolet Absorbance at 254 nm (SUVA) is an indicator of the humic content of a water. Waters with low SUVA values contain primarily non-humic matter and are not amenable to enhanced coagulation. As discussed in section III, systems may demonstrate that enhanced coagulation or enhanced softening is unnecessary if the raw water after being filtered through a 0.45 µm filter has a SUVA below 2 L/mg-m.

SUVA is a calculated parameter obtained by dividing a sample's ultraviolet light absorbance at a wavelength of 254 nm (UV_{254}), by the dissolved organic carbon (DOC), and multiplying by 100:

$$SUVA = 100\ (cm/m)\ [\ UV_{254}\ (cm^{-1})/DOC\ (mg/L)]$$

Two separate analytical methods are necessary to make this measurement: 1) UV_{254} and 2) DOC.

1. UV_{254}. EPA approved Standard Methods 5910 (APHA 1995) for measuring UV_{254} under the Information Collection Rule and intends to approve its use under the disinfection byproducts rule. EPA requests comments on this and other methods for measuring UV_{254}.

2. DOC. Standard Methods (19th Edition-Supplement)(APHA 1996) defines DOC as the fraction of TOC that passes through a 0.45 µm-pore-diameter filter. DOC is measured by performing an analysis for TOC on the sample filtrate. Filtration eliminates particulate organic matter but may contaminate the sample if carbon-containing compounds leach from the filter. Standard Methods 5310 B, 5310 C and 5310 D require that filters be rinsed before use and checked for their contribution to DOC by analyzing a filtered blank. Contact with organic material such as plastic containers, rubber tubing, etc. must be kept to a minimum to prevent contamination. EPA requests comments on the approval of Standard Methods 5310 B, 5310 C and 5310 D for measuring DOC for the SUVA calculation.

EPA is aware of several issues relating to the measurement of SUVA that are not addressed in the methods above. In determining SUVA, DOC and UV_{254} are both to be measured from the same sample filtrate, which is prepared by filtering a raw water sample through a pre-washed 0.45 µm filter paper. Standard Methods 5910 (UV) recommends to wash the filter with 50 mL of organic-free water to avoid contamination, however, more rinsate may be necessary to eliminate the DOC.

Because disinfectants/oxidants (chlorine, ozone, chlorine dioxide, potassium permanganate) can destroy UV but not DOC, SUVA needs to be determined on water prior to the application of disinfectants/oxidants. In the raw water, this is usually not a problem. If disinfectants/oxidants are applied in raw-water transmission lines upstream of the plant, then raw-water SUVA should be based on a sample collected upstream of the point of disinfectant/oxidant addition.

For determining settled-water SUVA, if the plant applies disinfectants/oxidants prior to the settled water sample tap, then settled-water SUVA should be determined in jar testing. Finally, the use of iron-base coagulants can interfere with UV measurements, as dissolved iron can penetrate the filter paper.

To address these issues in more detail, EPA intends to provide guidance on SUVA measurements in the Guidance Manual for Enhanced Coagulation (USEPA, 1997d). The manual will include guidance on sampling, sample preparation, filter type, pH, interferences to UV, high turbidity waters, quality control, etc. EPA requests comment on other issues that should be addressed in the guidance, as well as any recommendations on how the above issues should be addressed.

H. Summary of Key Observations

Since the 1994 proposal, improvements have been made to the analytical methods for trihalomethanes, haloacetic acids, total organic carbon, bromate ion and chlorite ion. EPA received comments to include Method 552.2 and 6251B for HAAs, and Method 5310B for TOC. Commenters made a general suggestion to approve methods promulgated under the ICR rule in the Stage 1 DBP rule. EPA intends to approve these methods and if appropriate, promulgate their most recent versions. EPA also intends to approve Method 300.1, the revised method for bromate ion, and permit its use for chlorite ion.

I. Request for Public Comments

1. EPA requests additional comments on omitting Method 4500.ClO_2 C from the list of approved methods for the analysis of chlorine dioxide.

2. EPA requests additional comments on the approval of EPA Method 552.2

and Standard Method 6251B for analyzing haloacetic acids.

3. EPA requests comment on replacing Method 300.0 with Method 300.1 for the analysis of bromate ion.

4. EPA requests comment on allowing both Method 300.0 and 300.1 as approved methods for the analysis of chlorite ion.

5. EPA requests comments on the technical equivalency of Methods 5310 B, C and D in the Supplement to Standard Methods, 19th edition and those same methods in the 19th edition of Standard Methods for measuring TOC and DOC.

6. EPA requests comments on the methods and filtration procedures for measuring SUVA.

VI. MCLs for TTHM, HAAs, Chlorite and Bromate

A. 1994 Proposal

The 1994 proposal for Stage 1 of the DBPR included MCLs for total trihalomethanes (TTHMs), the sum of five haloacetic acids (HAA5), bromate and chlorite at 0.080, 0.060, 0.010 and 1.0 mg/L, respectively (EPA, 1994b). In addition to the proposed MCLs, Subpart H systems—utilities treating either surface water or groundwater under the direct influence of surface water—that use conventional treatment (i.e., coagulation, sedimentation, and filtration) or precipitative softening would be required to remove DBP precursors by enhanced coagulation or enhanced softening. The removal of total organic carbon (TOC) would be used as a performance indicator for DBP precursor control.

As part of the proposed rule, EPA estimated that 17% of PWSs would need to change their treatment process to alternative disinfectants (ozone or chlorine dioxide) or advanced precursor removal (GAC or membranes) in order to comply with the Stage 1 requirements. This evaluation was important to assist in determining whether the proposed MCLs were achievable and at what cost. This evaluation required an understanding of the baseline occurrence for the DBPs and TOC being considered in the Stage 1 DBPR, an understanding of the baseline treatment in-place, and an estimation of what treatment technologies systems would use to comply with the Stage 1 DBPR requirements.

For systems switching to ozone or chlorine dioxide, separate MCLs were proposed for inorganic DBPs associated with their usage: bromate and chlorite, respectively. Although the theoretical 10^{-4} risk level for bromate is 5 μg/L, an MCL of 0.010 mg/L (10 μg/L) was proposed (because available analytical detection methods for bromate were reliable only to the projected practical quantification limit (PQL) of 10 μg/L (USEPA, 1994b). For chlorite, the MCL goal (MCLG) was 0.08 mg/L, due (in part) to data gaps that required higher uncertainty factors in the MCLG determination. The Chemical Manufacturer's Association (CMA) agreed to fund new health effects research on chlorine dioxide and chlorite—with EPA approval of the experimental plan—to resolve these data gaps.

In the preamble to the proposed rule, EPA requested comment on several issues related to the MCLs and requested any new information that may influence the MCLs. For bromate, EPA requested comment on whether there were ways to set (or achieve) a lower MCL (i.e., 0.005 mg/L [5 μg/L]) and whether the PQL for bromate could be lowered to 5 μg/L in order to allow compliance determinations for a lower MCL in Stage 1 of the proposed rule.

For chlorite, EPA requested comment on the appropriate MCL (i.e., at the MCLG, at the proposed MCL, or above the MCLG but below the proposed MCL), the feasibility of achieving a particular MCL, and whether there were other benefits to chlorine dioxide disinfection that should be considered when balancing the health risks associated with chlorite.

B. New Information Since 1994 Proposal

1. TTHM and HAA5 MCLs

At the direction of the Advisory Committee, the Technologies Working Group (TWG) reviewed MCL compliance predictions developed for the 1994 proposal because of concern by several Committee members that modifications to the rule would result in more PWSs not being able to meet the TTHM and HAA MCLs without installation of higher cost technologies such as ozone or GAC. The members were particularly concerned that allowing disinfection inactivation credit prior to precursor removal (by enhanced coagulation or enhanced softening) in order to prevent significant reductions in microbial protection would result in higher DBP formation and force systems to install alternative disinfectants, or advanced precursor removal to meet TTHM and HAA5 MCLs. As discussed earlier in today's Notice in Section IV. (Disinfection Credit), PWSs can achieve significant reduction in DBP formation through the combination of enhanced coagulation (or enhanced softening) and moving the point of disinfection downstream from coagulant addition, while preventing significant reduction in microbial protection. The TWG's analysis of the cumulative effect of these changes was that there would be no significant increase in the percentage of PWSs that would need to install higher cost technologies to meet TTHM and HAA5 MCLs and no significant reduction in microbial protection. The TWG estimated that 6.4% (based on WIDB data) to 15% (based on AWWSCo data) of PWSs would install alternative disinfectants or advanced precursor removal technologies based on the new information presented in this Notice, which is less than estimated in the 1994 proposal. It is now estimated that these other systems will either switch to chloramines or move the point of predisinfection, which are low cost means of compliance. EPA has included a detailed discussion of the TWG's prediction of technology choices in Section VIII of this Notice. EPA continues to believe the proposed MCLs are achievable without large-scale technology shifts. EPA requests comment on the new information and related analysis outlined in Section VIII.

2. Bromate

The proposed MCL of 0.010 mg/L for bromate was based on a projected practical quantitation level (PQL) that would be achieved by improved methods. The PQL of the revised method is approximately 0.010 mg/L for bromate, as discussed in Section V (Analytical Methods). EPA is not aware of any new information that would lower the PQL for bromate and thus allow lowering the MCL. As a result, EPA concluded that the proposed bromate MCL is appropriate and requests comment on this position.

3. Chlorite

The proposed chlorite MCL of 1.0 mg/L was supported by the Regulatory Negotiation Committee because 1.0 mg/L is the lowest level practicably achievable by typical systems using chlorine dioxide, from both treatment and monitoring perspectives. Since the proposed MCLG of 0.08 mg/L contained several uncertainty factors because of data gaps, i.e., lack of two-generation reproductive study, CMA funded a 2-generation reproductive study with chlorite, with EPA approval of the study design. CMA has submitted this study for EPA review. EPA has not completed its review of the study at the time of this Notice. EPA intends to publish the results of its review in a future Notice of Data Availability, along with any possible modifications to regulatory requirements that its review may justify.

EPA has included a more complete discussion of this issue earlier in this Notice (Section II. Health Effects) and the CMA study is available for review in the Docket. In addition, an EPA sponsored peer-review of the CMA study is included in the Docket. EPA is requesting comments on the conclusions of this peer review report.

VII. Regulatory Compliance Schedule and Other Compliance-Related Issues

A. Regulatory Compliance Schedule

Background

During the 1992 Disinfectants/Disinfection Byproducts Regulatory Negotiation (reg-neg) that resulted in the 1994 proposed Stage 1 DBPR and proposed IESWTR, there was extensive discussion of the compliance schedule and applicability to different groups of systems and coordination of timing with other regulations.

In addition to the Stage 1 DBPR, the Negotiating Committee agreed that EPA would a) propose an interim ESWTR which would apply to surface water systems serving 10,000 or more people, and b) at a later date, propose a long-term ESWTR applying primarily to small systems under 10,000. Both of these microbial rules would be proposed and promulgated so as to be in effect at the same time that systems of the respective size categories would be required to comply with new regulations for disinfectants and DBPs. Finally, although the GWDR was not specifically addressed during the reg-neg, EPA anticipated that it would be promulgated at about the same time as the IESWTR and Stage 1 DBPR.

EPA proposed a staggered compliance schedule, based on the reg-neg results. The Negotiating Committee and EPA believed that such a process was needed for the rules to be properly implemented by both States and PWSs. Also, EPA proposed a staggered schedule to achieve the greatest risk reduction by providing that larger water systems were to come into compliance earlier than small systems (to cover more people earlier), and surface water systems were to come into compliance earlier than ground water systems (since the potential risks of both pathogens and DBPs were considered generally higher for surface water systems). Large and medium size surface water PWSs (serving at least 10,000 people) constitute less than 25% of community water systems using surface water and less than 3% of the total number of community water systems, but serve 90% of the population using surface water and over 60% of the population using water from community water systems. These large PWSs are also those with experience in simultaneous control of DBPs and microbial contaminants. EPA proposed that these systems be required to comply with the Stage 1 DBPR and IESWTR 18 months after promulgation of the rules and that States would be required to adopt the rules no later than 18 months after promulgation. These 18 month periods were prescribed in the 1986 SDWA Amendments.

Surface water PWSs serving fewer than 10,000 people were to comply with the Stage 1 DBPR requirements 42 months after promulgation, to allow such systems to simultaneously come into compliance with the LTESWTR. This compliance date reflected a schedule that called for the LTESWTR to be promulgated 24 months after the IESWTR was promulgated and for PWSs then to have 18 months to come into compliance. Such a simultaneous compliance schedule was intended to provide the necessary protection from any downside microbial risk that might otherwise result when systems of this size attempted to achieve compliance with the Stage 1 DBPR.

Ground water PWSs serving at least 10,000 people would also be required to achieve compliance with the Stage 1 DBPR 42 months after promulgation. A number of these systems, due to recently installing or upgrading to meet the GWDR (which EPA planned to promulgate at about the same time as the Stage 1 DBPR), were expected to need some period of monitoring for DBPs in order to adjust their treatment processes to also meet the Stage 1 DBPR standards.

1996 Safe Drinking Water Act Amendments

The SDWA 1996 Amendments affirmed several key principles underlying the M-DBP compliance strategy developed by EPA and stakeholders as part of the 1992 Regulatory Negotiation process. First, under Section 1412(b)(5)(A), Congress recognized the critical importance of addressing risk/risk tradeoffs in establishing drinking water standards and gave EPA the authority to take such risks into consideration in setting MCL or treatment technique requirements. Second, Congress explicitly adopted the staggered M-DBP regulatory development schedule developed by the Negotiating Committee. Section 1412(b)(2)(C) requires that the standard setting intervals laid out in EPA's proposed ICR rule be maintained even if promulgation of one of the M-DBP rules was delayed. As noted above, this staggered regulatory schedule was specifically designed as a tool to minimize risk/risk tradeoff. A central component of this approach was the concept of ''simultaneous compliance'' which provides that a PWS must comply with new microbial and DBP requirements at the same time to assure that in meeting a set of new requirements in one area, a facility does not inadvertently increase the risk (i.e., the risk ''tradeoff'') in the other area.

The SDWA 1996 Amendments also changed two statutory provisions that elements of the 1992 Negotiated Rulemaking Agreement were based upon. As outlined above, the 1994 Stage 1 DBPR and ICR proposals provided that 18 months after promulgation large PWSs would comply with the rules and States would adopt and implement the new requirements. Section 1412(b)(10) of the SDWA as amended now provides that drinking water rules shall become effective 36 months after promulgation (unless the Administrator determines that an earlier time is practicable or that additional time for capital improvements is necessary—up to two years). In addition, Section 1413(a)(1) now provides that States have 24 instead of the previous 18 months to adopt new drinking water standards that have been promulgated by EPA.

Discussion

In light of the 1996 SDWA amendments, developing a compliance deadline strategy that encompasses both the Stage 1 DBPR and IESWTR, as well the related LTESWTR and Stage 2 DBPR, is a complex challenge. On the one hand, such a strategy needs to reflect new statutory provisions. On the other, it needs to continue to embody key reg-neg principles reflected in both the 1994 ICR and Stage 1 DBPR proposals; principles that both Congressional intent and the structure of the new Amendments, themselves, indicate must be maintained.

An example of the complexity that must be addressed is the relationship between the principles of risk/risk tradeoff, simultaneous compliance, and the staggered regulatory schedule adopted by Congress. Under the 1996 SDWA amendments, the staggered regulatory deadlines under Section 1412(b)(2)(C) call for the IESWTR and Stage 1 DBPR to be promulgated in November 1998 and the LTESWTR in November of 2000. However, a complicating factor reflected in the Negotiated Rulemaking Agreement of 1992 and contained in the 1994 ICR, IESWTR, and Stage 1 DBPR proposals, is that Stage 1 applies to all PWSs, while IESWTR applies only to PWSs over 10,000, and the LTESWTR covers

remaining surface water systems under 10,000.

One approach might be to simply provide that each M-DBP rule becomes effective 3 years after promulgation in accordance with the new SDWA provisions. For surface water systems over 10,000, each plant would be required to comply with related microbial and DBP requirements at the same time thereby minimizing potential risk/risk tradeoffs. For surface water systems under 10,000, however, this approach would result in a very large number of smaller plants complying with DBP requirements two years before related LTESWTR microbial provisions became effective, thereby creating an unbalanced risk tradeoff situation that the Negotiating Committee, EPA, and Congress each sought to avoid.

As this example suggests, given the staggered regulatory development schedule developed by stakeholders in the reg-neg process and adopted by Congress, there is a difficult inconsistency between the principle of avoiding risk tradeoffs, simultaneous compliance, and simply requiring all facilities to comply with applicable M-DBP rules three years after their respective promulgation. The challenge, then, is to give the greatest possible meaning to each of the new SDWA provisions while adhering to the fundamental principles also endorsed by Congress of addressing risk-risk tradeoffs and assuring simultaneous compliance.

A further question that must be factored into this complex matrix is how to address the relationship between promulgation of a particular rule, its effective date, and its adoption by a primacy State responsible for implementing the Safe Drinking Water Act. Under the 1994 IESWTR and Stage 1 DBPR proposals, the rule's 18 month effective date was the same as the 18 month date by which a State was required to adopt it. This approach reflected the 18 month SDWA deadlines applicable during reg-neg negotiations and at the time of proposal.

The difficulty with requiring PWS compliance and State implementation by the same date is that States may not have enough lead time to adopt rules, train their own staff, and develop policies to implement and enforce new rules by the deadline for PWS compliance. In situations where the new rules are complex and compliance requires state review and ongoing interaction with PWSs, successful implementation can be very difficult, particularly for States with many small systems that have smaller staffs and fewer resources to anticipate the requirements of final rules. As noted above, Congress addressed this issue by extending the time for States to put their own rules in place from 18 months to two years after federal promulgation and, then, by generally providing for a one year interval before PWSs must comply (three years after promulgation). As a result, the 18 month interval contemplated by the 1994 proposals is no longer applicable, and the approach of setting the same date for PWS compliance and State rule implementation is no longer consistent with the phased approach laid out in the new SDWA amendments.

A final set of issues that must be addressed in connection with the Stage 1 DBPR proposal are compliance deadlines for ground water systems that currently disinfect. Reflecting the Negotiated Rulemaking Agreement, the 1994 proposal provided that ground water systems serving at least 10,000 that disinfect must comply three and one half years (42 months) after Stage 1 DBPR promulgation. Small ground water systems serving fewer than 10,000 that disinfect would be required to come into compliance five years (60 months) after Stage 1 DBPR promulgation. Again, the challenge here is to reconcile new statutory compliance provisions with the principles of simultaneous compliance, avoiding risk/risk tradeoffs, and deference to Congress' clear intent to preserve the ''delicate balance that was struck by the parties in structuring the negotiated rulemaking agreement''. (Joint Explanatory Statement of the Committee on Conference on S.1316, p2). An additional factor that must be considered in this context is that Congress affirmed the need for microbial ground water regulations but also clearly contemplated that such standards might not be promulgated until issuance of Stage 2 DBPR (no later than May, 2002).

Alternative Approaches

In light of the 1996 SDWA amendments and their conflicting implications for different elements of the compliance strategy agreed to by the Negotiating Committee and set forth in the 1994 IESWTR and Stage 1 DBPR proposals, EPA is today requesting comment on four alternative compliance approaches. The Agency also requests comment on any other compliance approaches or modifications to these options that commenters believe may be appropriate.

OPTION 1.—IMPLEMENT 1994 PROPOSAL SCHEDULE

Rule (promulgation)	Surface water PWS		Ground water PWS	
	≥10k	<10k	≥10k	<10k
DBP 1 (11/98)	5/00	5/02	5/02	11/03
IESWTR (11/98)	5/00	NA	NA	NA
LTESWTR (11/00)	5/02 (if required)	5/02	NA	NA
GWDR (11/00)	NA	NA	(1)	(1)

1 Not addressed.

Option 1 (schedule as proposed in 1994) simply continues the compliance strategy laid out in the 1994 Stage 1 DBPR and IESWTR proposals. This would provide that medium and large surface water PWSs (those serving at least 10,000 people) comply with the final Stage 1 DBPR and IESWTR within 18 months after promulgation, and that surface water systems serving fewer than 10,000 comply within 42 months of Stage 1 DBPR promulgation. This option also would provide that ground water systems serving at least 10,000 and that disinfect comply within 42 months, while ground water systems serving fewer than 10,000 comply within 60 months.

This approach was agreed to by EPA and other stakeholder members of the 1992 Negotiating Committee. However, it has been at least in part superseded by both the general 36 month PWS compliance period and the 24 month State adoption and implementation period provided under the 1996 SDWA amendments. If the proposed 1994 compliance schedule were to be retained, EPA would need to make a determination that the statutory compliance provision of 36 months was

not necessary for large and medium surface systems because compliance within 18 months is ''practicable''. To maintain simultaneous compliance, the Agency would also have to make the same practicability determination for small surface water systems in complying with the LTESWTR and for ground water systems serving at least 10,000 in complying with the GWDR. In addition, the Agency would need to justify 42 months for small surface water systems and 60 months for small ground water systems with disinfection by making a national determination that the additional time was required due to the need for capital improvements at each of these small systems. EPA also would need to articulate a rationale for why States should not be provided the statutorily specified 24 months to implement new complex regulatory provisions before PWSs are required to comply. Finally, to implement this approach, the Agency would be required to modify the timing associated with the microbial backstop provision agreed to on July 15, 1997 by the M–DBP Advisory Committee (since a 18 month schedule would not allow time after promulgation for medium surface water systems (10,000–99,999) to collect HAA data prior to having to determine whether disinfection benchmarking is necessary).

EPA requests comment on the issues outlined above in connection with this option. In particular, the Agency requests comment and information to support a finding that compliance by specified systems in 18 months is practicable for some rules, and that extensions to 42 or 60 months for other systems are required to allow for capital improvements.

OPTION 2.—ADD 18 MONTHS TO 1994 PROPOSAL SCHEDULE

Rule (promulgation)	Surface water PWS		Ground water PWS	
	≥10k	<10k	≥10k	<10k
DBP 1 (11/98)	11/01	11/03	11/03	5/05
IESWTR (11/98)	11/01	NA	NA	NA
LTESWTR (11/00)	11/03 (if required)	11/03	NA	NA
GWDR (11/00)	NA	NA	(1)	(1)

1 Not addressed.

Option 2 (each date in proposed 1994 compliance strategy extended by 18 months) reflects the fact that the 1996 SDWA amendments generally extended the previous statutory deadlines by 18 months (to three years) and established an overall compliance period not to extend beyond 5 years. This second approach would result in simultaneous compliance for surface water systems. Large surface water systems (those serving at least 10,000) would have three years to comply in accordance with the baseline 3 year compliance period established under Section 1412(b)(10) of the 1996 Amendments.

Small surface water systems (under 10,000) would be required to comply with Stage 1 D/DBPR requirements within five years and applicable LTESWTR requirements within three years. Since the LTESWTR will be promulgated two years after Stage 1 DBPR (in accordance with the new SDWA M–DBP regulatory deadlines discussed above), the net result of this approach is that small surface water systems would be required to comply with both Stage 1 DBPR and IESWTR requirements by the same end date of November 2003, thus assuring simultaneous compliance. This meets the objective of both the reg-neg process and Congress to address risk-risk tradeoffs in implementing new M–DBP requirements.

USEPA believes that providing a five year compliance period for small surface water systems under the Stage 1 DBPR is appropriate and warranted under section 1412(b)(10), which expressly allows five years where necessary for capital improvements. Of necessity, capital improvements require preliminary planning and evaluation. Such planning requires, perhaps most importantly, identification of final compliance objectives. This then is followed by an evaluation of compliance alternatives, site assessments, consultation with appropriate state and local authorities, development of final engineering and construction designs, financing, and scheduling. In the case of the staggered M–DBP regulatory schedule established as part of the 1996 SDWA amendments, LTESWTR microbial requirements for small systems are required to be promulgated two years after the establishment of Stage 1 DBPR requirements. Under these circumstances, small systems will not even know what their final combined M–DBP compliance obligations are until **Federal Register** publication of the final LTESWTR. As a result, an additional two year period reflecting the two year Stage 1 DBPR/LTESWTR regulatory development interval established by Congress is required to allow for preliminary planning and evaluation which is an inherent component of any capital improvement process. EPA believes this approach is consistent with both the objective of assuring simultaneous compliance and not exceeding the overall statutory compliance period of five years. This same logic would also apply to ground water systems serving at least 10,000, since such systems would need the final GWDR to determine and implement a compliance strategy.

With regard to extended compliance schedules, EPA notes that the economic analysis developed as part of the M–DBP Advisory Committee indicates that there will be capital costs associated with implementation of both the IESWTR as well as the Stage I DBP rules. As outlined above, the 1996 SDWA amendments provide that a two year extension may be provided by EPA at the national level or by States on a case-by-case basis if either EPA or a State determines that additional time is necessary for capital improvements. EPA does not believe there is data presently in the record for either of these rulemakings to support a national determination by the Agency that a two-year extension is justified. EPA requests comment on this issue and, if a commenter believes such an extension is warranted, requests that the comments provide data to support such a position.

Adding 18 months to the 1994 proposed compliance strategy would result in 78 month (six and a half year) compliance period for small ground water systems. This is beyond the overall five year compliance period established by Congress under Section 1412(b)(10). EPA is not aware of a rationale to support this result that is consistent with both the objectives of the reg-neg process and the new SDWA amendments; however, the Agency

requests comment on this issue. As discussed below, EPA believes there is a reasonable compliance strategy for addressing ground water systems that reflects the requirements of the SDWA amendments as well as the intent of the reg-neg process.

OPTION 3.—REQUIRE COMPLIANCE WITH ALL RULES WITHIN THREE YEARS OF PROMULGATION

Rule (promulgation)	Surface water PWS		Ground water PWS	
	≥10k	<10k	≥10k	<10k
DBP 1 (11/98)	11/01	11/01	11/01	11/01
IESWTR (11/98)	11/01	NA	NA	NA
LTESWTR (11/00)	11/03 (if required)	11/01	NA	NA
GWDR (11/00)	NA	NA	11/03	11/03

Under this approach, all systems would be required to comply with Stage 1 DBPR, IESWTR, and LTESWTR within three years of final promulgation. This approach reflects the baseline three year compliance period included as part of the new SDWA compliance provisions. Unlike option 2 outlined above which simply adds an 18 month extension to the 1994 proposed compliance approach, this option is not tied to the 1994 proposal. Rather it applies the new baseline three year compliance period to the staggered M–DBP regulatory development schedule which was also established as part of the 1996 SDWA amendments.

This approach would result in simultaneous compliance for large surface water systems. However, it would eliminate the possibility of simultaneous compliance for small surface water systems and all ground water systems. Contrary to reg-neg objectives and Congressional intent, it would create an incentive for risk/risk tradeoffs on the part of small surface water systems who would be required to take steps to comply with Stage 1 DBPR provisions two years before coming into compliance with the LTESWTR, and for all ground water systems who would be required to take steps to comply with Stage 1 DBPR provisions two years before coming into compliance with the GWDR.

OPTION 4.—MERGE SDWA PROVISIONS WITH NEGOTIATED RULEMAKING OBJECTIVES

Rule (promulgation)	Surface water PWS		Ground water PWS	
	≥10k	<10k	≥10k	<10k
DBP 1 (11/98)	11/01	11/03	11/03	11/03
IESWTR (11/98)	11/01	NA	NA	NA
LTESWTR (11/00)	11/03 (if required)	11/03	NA	NA
GWDR (11/00)	NA	NA	11/03	11/03

This option combines the principle of simultaneous compliance with the revised compliance provisions reflected in the 1996 SDWA amendments. Large surface water systems would be required to comply with Stage 1 DBPR and IESWTR within 3 years of promulgation, thus assuring simultaneous compliance and consistency with the baseline statutory compliance period of 3 years. Small surface water systems under 10,000 would comply with the provisions of the Stage 1 DBPR at the same time they are required to come into compliance with the analogous microbial provisions of the LTESWTR. This would result in small surface water systems simultaneously complying with both the LTESWTR and Stage 1 DBPR requirements. Under this approach, small systems would comply with LTESWTR requirements three years after promulgation and Stage 1 DBPR requirements five years after promulgation. For the reasons articulated under option two above, EPA believes providing a five year compliance period under Stage 1 DBPR is appropriate and necessary to provide for capital improvements.

For ground water systems, the 1994 proposed Stage 1 DBPR compliance schedules provided for only one half of the risk-risk tradeoff balance. They did not include a companion rule development and compliance schedules for the analogous microbial provisions of a Ground Water Disinfection Rule. The 1996 SDWA amendments provide an outside date for promulgation of ground water microbial requirements of ''no later than'' May 2002, but leave to EPA the decision of whether an earlier promulgation is more appropriate. In light of the reg-neg emphasis and Congressional affirmation of the principal of simultaneous compliance to assure no risk-risk tradeoffs, EPA has developed a ground water disinfection rule promulgation schedule that will result in a final GWDR by November 2000, the same date as the Congressional deadline for the LTESWTR. Ground water systems would be required to comply with the GWDR by November 2003, three years after promulgation, and to assure simultaneous compliance with DBP provisions, such systems would be required to comply with Stage 1 DBPR requirements by the same date. Again, for the reasons outlined under option 2, USEPA believes a five year compliance period for ground water systems is necessary and appropriate.

Option 4 assures that ground water systems will be required to comply with Stage 1 DBPR provisions at the same time that they comply with the microbial provisions of the Ground Water Disinfection Rule (GWDR). Successful implementation of this option requires that EPA develop and promulgate the GWDR by November 2000 as indicated above. The Agency recognizes that this is an ambitious schedule, but believes it is necessary to meet the twin objectives of simultaneous implementation and consistency with the new statutory compliance provisions of the 1996 SDWA. In evaluating this option, the Agency also considered the possibility of meeting these twin objectives in a somewhat different fashion by delaying final promulgation of the Stage I DBP

rule as it applies ground water systems until the promulgation of the GWDR. This alternative possibility would assure simultaneous compliance and also provide a ''safety net'' in the event that the GWDR November 2000 promulgation schedule is delayed. EPA is concerned, however, that this approach may not meet or be consistent with new SDWA requirements which provide that the Stage I DBPR be promulgated by November 1998. The Agency requests comment on this issue.

Recommendation

EPA has evaluated each of the considerations identified in Options 1 through 4. On balance, the Agency believes that Option 4 is the preferred option. The primary reasons are 1) to allow States at least two years to adopt and implement M–DBP rules consistent with new two year time frame provided for under the 1996 SDWA amendments, 2) to match the compliance schedules for the LTESWTR and Stage 1 DBPR for small (<10,000 served) surface water systems to allow time for capital improvements and addressing risk-risk tradeoff issues, and 3) to assure that all ground water systems simultaneously comply with newly applicable microbial and Stage 1 DBPR requirements on the same compliance schedule provided for small surface water systems.

Request for Comments

EPA requests comment on both the compliance schedule options discussed above and on any other variations or combinations of these options. EPA also requests comment on its preferred option 4 and on the underlying rationale for allowing a five year compliance schedule for ground water and small surface water systems under the Stage 1 DBPR.

B. Compliance Violations and State Primacy Obligations

A public water system that fails to comply with any applicable requirement of the SDWA (as defined in 1414 (i)) is subject to an enforcement action and a requirement for public notice under the provisions of section 1414. Applicable requirements include, but are not limited to, MCLs, treatment techniques, monitoring and reporting. These regulatory requirements are set out in 40 CFR l41.

The SDWA also requires States that would have primary enforcement responsibility for the drinking water regulations (''primacy'') to adopt regulations that are no less stringent than those promulgated by EPA. States must also adopt and implement adequate procedures for the enforcement of such regulations, and keep records and make reports with respect to these activities in accordance with EPA regulations. 5 U.S.C. 1413. EPA may promulgate regulations that require States to submit reports on how they intend to comply with certain requirements (e.g., how the State plans to schedule and conduct sanitary surveys required by the IESWTR), how the State plans to make certain decisions or approve PWS-planned actions (e.g., approve significant changes in disinfection under the IESWTR or approve Step 2 DBP precursor removals under the enhanced coagulation requirements of the Stage I DBPR), and how the State will enforce its authorities (e.g., correct deficiencies identified by the State during a sanitary survey within a specified time). The primacy regulations are set out in 40 CFR 142.

EPA drafted requirements for both the PWSs (part 141) and the primacy States (part 142) in the proposed rules. EPA is requesting comments on whether there are elements of the Advisory Committee's recommendations in this Notice that should be treated as applicable requirements for the PWS and included in part l41 as enforceable requirements. Similarly, EPA requests comments on whether there are elements of the Advisory Committee's recommendations in this Notice that should be treated as requirements for States and included in part 142 as primacy requirements.

C. Compliance With Current Regulations

EPA reaffirms its commitment to the current Safe Drinking Water Act regulations, including those related to microbial pathogen control and disinfection. Each public water system must continue to comply with the current rules while new microbial and disinfectants/disinfection byproducts rules are being developed.

VIII. Economic Analysis of the M–DBP Advisory Committee Recommendations

The Regulatory Impact Analysis (RIA) for the 1994 proposed rule (USEPA, 1994b) was based on information generated from the Disinfection Byproducts Regulatory Analysis Model (DBPRAM) and modified by a Technologies Working Group (TWG), which consisted of technical representatives of members of the regulatory negotiation committee. The regulatory impact analysis (RIA), which provided information on the costs and benefits of the proposed rule, was developed using the DBPRAM in conjunction with the TWG. Since the proposal, new information has become available which EPA has used to modify the estimated costs and benefits. This new information is discussed below. EPA requests comments on the adequacy of the new data, how the new data have been used, and any additional data that would improve the assessment of costs and benefits.

A. Plant-Level DBP Treatment Effectiveness and Cost

The 1994 RIA analysis was supported by modeling apparatus known as the DBPRAM. The DBPRAM, which was actually a collection of analytical models, utilized Monte Carlo simulation techniques to produce national forecasts of compliance and resulting exposure reductions for different regulatory scenarios. For a complete discussion of the DBPRAM model, see the RIA from the proposed rule (USEPA, 1994b).

Initially, the TWG revisited the modeling tools to re-examine the results with new assumptions regarding the effectiveness of enhanced coagulation in the presence of predisinfection. A central component of the DBPRAM apparatus is the Water Treatment Plant model (WTP). Initial investigations by Malcolm Pirnie, Inc., concluded that the manner in which predisinfection is characterized in the WTP model makes it impossible to distinguish the effects of the proposed change in the Stage 1 Disinfectants and Disinfection Byproducts Rule (DBPR). The model makes simplifying assumptions about the point of predisinfection and does not permit marginal analysis of shifting this point. In the 1994 RIA analysis, the point of predisinfection did not matter since the proposal called for elimination of Enhanced Surface Water Treatment Rule (ESWTR) credit for predisinfection and the analyses or models developed for the RIA assumed predisinfection would be eliminated.

Based on TWG analysis, the cost and effectiveness of enhanced coagulation (as captured in the 3-by-3 matrix) was made more consistent with the assumptions made in the DBPRAM for the 1994 RIA analysis. The TWG believed that the changes in the enhanced coagulation matrix should not therefore affect the decision tree.

The major role of the DBPRAM modeling apparatus in the 1994 RIA analysis was to help the TWG verify assumptions for a compliance decision tree forecast that is suitable as the basis for national cost calculations. The driving factor in the 1994 RIA analysis became the degree to which water systems would have to cross over the threshold from standard treatment technologies to more expensive technologies such as GAC, ozone,

chlorine dioxide, and membranes. Keying on this feature, the TWG formed in 1997 to provide technical support to the M–DBP Advisory Committee designed an approach to re-evaluating the 1994 national cost analysis by re-evaluating the manner in which newly available information and changes in the proposed rules would affect this advanced technology threshold in the compliance decision tree forecast.

The TWG evaluated two sets of data that documented levels of TOC, TTHM, HAA5, and predisinfection practices for groups of water systems. The 1996 Water Industry Data Base (WIDB) data set provided data for 308 [1] water systems nationwide. The American Waterworks Service Company (AWWSCo.) data set provided two years of data (1991 and 1992) for 52 plants, located primarily in the Northeast and Midwest.

Using these two data sets and experience and personal knowledge of many of these particular plants, the 1997 TWG was able to undertake a plant-by-plant assessment of the prospective compliance choices of the plants likely to have to change treatment in order to comply with the Advisory Committee recommendations for the Stage 1 DBPR. By computing the percentage of systems forecast to require the more expensive advanced treatments, it was possible to see if results were in the same range as that projected in the 1994 RIA analysis. This decision tree analysis is detailed below.

B. Decision Tree Analysis—Compliance Forecasts

A sub-group of the 1997 TWG consisting of individuals familiar with the 1994 DBPRAM analyses, and also familiar with the WIDB and AWWSCo. data sets, performed the re-evaluation of the compliance decision tree forecast based upon the Advisory Committee recommendations. This was performed by making case-by-case evaluations of each water system in the data set for which total trihalomethane (TTHM) or haloacetic acids (HAAs) exceeded 64 µug/L or 48 µg/L, respectively. These numbers are design targets for maximum contaminant levels (MCLs) of 80 µg/L and 60 µg/L, reflecting the variation in DBP levels from year to year.

Table VIII–1 presents a side-by-side comparison of compliance forecasts developed for the 1994 RIA and analyses of the 1996 WIDB data and the 1991 and 1992 AWWSCo. data.

TABLE VIII–1.—STAGE 1 DBP COMPLIANCE FORECAST

Treatment technology to be implemented	1993 stage 1 RIA (percent)	Analysis of 1996 WIDB data	Analysis of AWWSCo 1991–1992 data (percent)
Maintain Current Treatment	28	39.0	22
Chlorine/Chloramine	3	16.6	28
Enhanced Coagulation + Cl_2/NH_2Cl	10	19.0	35
Enhanced Coagulation + Cl_2	43	19.0	.....
Ozone/Chloramine	5	2.2	7.5
Enhanced Coagulation + O_3/NH_2Cl	6	2.2	7.5
Enhanced Coagulation + GAC10/GAC20	6	0.3	.....
Chlorine Dioxide	.....	1.6	.....
Membrane	0	0.3	.....

The compliance forecast developed for the 1994 RIA using the DBPRAM (column 2 of Table VIII–1) predicted that 17 percent of systems would adopt advanced treatments (ozone, chlorine dioxide, GAC, or membranes) in order to comply with the Stage 1 MCLs. In many instances, the adoption of advanced technologies was forecast as a result of the companion requirements of the proposed IESWTR to increase disinfection to assure a 10^{-4} risk level for *Giardia*.

Since the 1994 proposal, the IESWTR requirement to achieve a 10^{-4} risk level for *Giardia* has been replaced with a ''disinfection benchmark'' requirement intended to preserve the status quo of disinfection practices. As a result, the TWG predicted fewer systems to adopt advanced technologies. In addition, probable compliance choices can be evaluated based on the existing treatment configuration and performance rather than having to first predict the effects of changes in disinfection, as was done with the DBPRAM previously.

The 1997 TWG reviewed the data for the 73 of 308 [2] systems in the 1996 WIDB data set (23.7%) that had either TTHM ≥64 µg/l or HAA(5) ≥48 µg/l. The systems were evaluated at a plant-by-plant level, incorporating multiple plant compliance strategies where applicable and other data, such as that available from the ICR plant schematics. Results are tabulated in Table VIII–1. Based on the case-by-case analysis of this sample, the TWG predicted that 20 of the 73 systems would require advanced technologies in order to comply with the proposed MCLs. This equates to a decision tree percentage of 6.4% (20/308) based on WIDB data to 15% (based on AWWSCo data). The TWG assigned another 51 systems (16.6%) to a compliance category consisting of various combinations of relatively low cost strategies, such as moving the point of predisinfection and using chloramines. Only two of the 73 systems were projected to install enhanced coagulation purely for purposes of meeting the MCLs.

The 1997 TWG did not forecast the number of systems in the WIDB data set that would have to install enhanced coagulation in compliance with the treatment technique requirements in the Stage 1 proposal. Because several years have passed since the negotiated rulemaking process, some water systems have probably already moved ahead with implementation of enhanced coagulation. Indeed, some systems were achieving enhanced coagulation standards even before it was given its name during the negotiated rulemaking

[1] Percentages reported here differ from those computed earlier by members of the TWG due to a correction in the denominator. Previous calculations used 399 systems as a denominator, but since 91 of them did not report TTHM or HAA data, they were not included in these computations.

[2] Percentages reported here differ from those computed earlier by members of the TWG due to a correction in the denominator. Previous calculations used 399 systems as a denominator, but since 91 of them did not report TTHM or HAA data, they were not included in these computations.

process. In order to complete a compliance forecast (decision tree analysis) for the final Stage 1 Rule, the Agency needs to know what proportion of the universe is already achieving enhanced coagulation and what proportion will have to install enhanced coagulation. The 1996 WIDB data is the best available source of information from which to develop these estimates.

The 1996 WIDB provides data on influent total organic carbon (TOC), effluent TOC, and alkalinity by plant, as well as TTHM and HAA5 data by system. Using this information, the 1997 TWG developed an assessment of the extent to which enhanced coagulation is already in place. The resulting decision tree percentages are summarized in Table VIII–1. These percentages are used to estimate national cost.

The 1997 TWG performed a parallel case-by-case analysis using the AWWSCo. 1991–92 data representing 52 systems; results are in Table VIII–1. The AWWSCo. and WIDB results are clearly different, and potentially reflect a number of factors: (1) more adverse DBP control conditions in the waters represented in this data set; (2) greater use of chloramines as a residual disinfectant by AWWSCo. plants, and (3) the influence of having 2 years of data illustrates how TTHM and HAA5 values threshold exceedances can change from year to year for a given system. (These features of the AWWSCo. data are discussed in Chapter 4 of the Economic Analysis of the M-DBP Advisory Committee Recommendations document).

The compliance decision tree analyses discussed above and summarized in Table VIII–1 pertain to large systems serving more than 10,000 persons. The small systems (less than 10,000 population served) decision tree is likely to be different. As a default, EPA assumed that the small systems decision tree would be exactly the same as that used in the 1994 RIA. The small systems face a different set of compliance choices because the current TTHM standard of 0.10 mg/L (100 μg/L) does not apply to them; they are therefore applying DBP controls for the first time.

C. National Cost Estimates

A national cost analysis, based on the TWG's decision tree analyses discussed above, is summarized in this section. The analysis incorporates updated unit cost estimates for alternative treatment technologies.

A national cost model has been developed to evaluate modified Stage 1 decision trees. The total annual cost for surface water systems in the 1994 RIA was $645 million per year (in 1992 dollars) or $728 million (in 1997 dollars). These data are presented in Table VIII–2.

EPA initially assessed the proportion of the total national cost in the 1994 RIA that was attributable to enhanced coagulation. While enhanced coagulation by itself is not very expensive in terms of the cost per household, national costs are large when it is broadly implemented and its inexpensive cost per-thousand-gallon is multiplied by many billions of gallons. Enhanced coagulation accounted for $272 million of the total $645 million per year (42 percent) documented in the 1994 RIA.

When EPA applied the decision tree predictions derived from the 1996 WIDB data (Table VIII–1) to the large surface water system portion of the cost model, while holding the 1994 decision tree assumptions constant for small systems, results indicated a reduction in total national cost to surface water systems from $728 million per year to $453 million, of which $135 million is for enhanced coagulation. Two major factors cause this drop in costs: (1) the halving of the number of systems estimated to employ advanced technologies, and (2) some systems are assumed to have already implemented enhanced coagulation.

The decision tree predictions derived from the AWWSCo. data were also run through the national cost model. The results indicate a total national cost for surface water systems of $399 million per year, of which $222 million is enhanced coagulation. In this scenario, there are twice as many systems as in the 1996 WIDB data adopting advanced technologies, and only half as many able to comply with no action. The cost reductions are, however, comparable to those observed in the scenario based on the WIDB decision tree. The reasons this scenario has comparable cost advantages relate to the emphasis placed on ozone and chloramines. The alternate disinfectants are less costly than the precursor removal strategies (e.g., GAC, membranes).

The above compliance scenarios and cost estimates are subject to considerable uncertainty. Although there is no better forecasting method available than case-by-case analysis, the data employed here consist only of a few snapshots of each situation. EPA believes that national costs are lower than those estimated in the 1994 RIA, due to Advisory Committee Recommendations for significant modifications in the IESWTR and in the Stage 1 DBPR that would result in reductions in total national costs. EPA believes that the order of magnitude indicated by the WIDB and AWWSCo. decision tree analyses is reasonable.

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Table VIII-2: A Comparison of 1992 Disinfection By-Product Compliance Cost Forecast in 1992 and 1997 Dollars (in thousands of $s)

Costs	In December 1992 Dollars	In April 1997 Dollars
Utility Cost	**All Water Systems (Surface Water & Ground Water)**	**All Water Systems (Surface Water & Ground Water)**
Treatment Costs		
Total Capital	$4,400,000	$4,967,600
Total Annual Cost	$1,035,000	$1,168,515
Annualized Capital	$546,000	$616,434
Annual O&M	$489,000	$552,081
Monitoring & Reporting Cost		
Start-up/One-time Activities	$8,841	$9,981
Annual Monitoring	$54,924	$62,009
State Costs		
Annual Implementation	$80,224	$90,572
Total Annualized DBPR Costs[1]	**$1,170,148**	**$1,321,096**

Note:

(1) The start-up/one-time activities cost is not included in the total annualized DBPR cost.

TABLE VIII-3: 1997 Disinfection By-Product Compliance Cost Forecast

(annual costs in thousands of $, based on Advisory Committee recommendations)

	Ground Water Systems			Surface Water Systems			All Water Systems		
	Small < 10,000	Large ≥ 10,000	Total	Small < 10,000	Large ≥ 10,000	Total	Small <10,000	Large ≥ 10,000	Total
Utility Costs									
Treatment Costs									
Total Capital[1]	1,486,078	920,101	$2,406,179	930,900	528,148	$1,459,048	2,416,978	1,448,249	$3,865,227
Total Annual Cost[2]	226,756	223,031	$489,787	162,983	290,186	$453,169	429,739	513,217	$942,956
Monitoring & Reporting Cost									
Start-up/One-time Activities	8,184	371	$8,555	897	530	$1,426	9,081	901	$9,981
Annual Monitoring	17,722	16,696	$34,419	12,603	14,987	$27,590	30,325	31,684	$62,009
Total Annualized Utility Cost	284,478	239,727	$524,206	175,586	305,173	$480,759	460,064	544,901	$1,004,965
State Annual Implementation Costs									$90,572
Total Annualized DBPR Cost									**$1,095,537**

Notes:

(1) Total Capital Cost (1991 June dollars) is the cost of installing required equipment; the amount to be financed.

(2) Total Annual Cost is the sum of annual debt service payments and annual operation and maintenance costs.

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1. System Level Costs

The unit cost estimates in the proposal were developed for each of the different treatment technologies in each system size category. The unit cost estimates were derived from a cost model described in the Cost and Technology Documents (USEPA, 1992c) and adjusted after discussion among TWG members to reflect site-specific factors (USEPA, 1994b). For systems in six categories serving greater than 10,000 people, the estimated system-level costs for achieving compliance ranged from $0.01/1000 gallons (chlorine/chloramines) to $1.87/1000 gallons (membrane technology). For systems in size categories serving less than 10,000 people the estimated system level costs for achieving compliance ranged from $0.03/1000 gallons (chlorine/chloramines) to $3.49/1000 gallons (membranes). Although some technologies cost more than $3.49/1000 gallons in the smallest size categories, such technologies would not be used because the systems would be able to achieve compliance with membrane technology.

Revised unit costs were not available during the deliberations of the M-DBP Advisory Committee. Table VIII–4 is an analysis of the implications of the revised decision tree for national costs using the updated unit cost assumptions.

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Table VIII-4: Total Annualized Costs of Compliance ($/Year)

Treatment Technologies	Total Annualized Cost	
	Surface Water Systems	Ground Water Systems
Cl_2/NH_2Cl	8,680,504	14,046,091
Enhanced Coagulation	109,488,776	0
EC/NH_2Cl	106,221,902	-----
Oz/NH_2Cl	26,455,305	7,125,032
$EC+Oz/NH_2Cl$	41,836,288	-----
EC+GAC10	2,932,837	0
EC+GAC20	8,027,006	0
Chlorine Dioxide	3,497,116	-----
Membranes	146,029,198	468,615,599
TOTALS	**$453,168,933**	**$489,786,721**

Table VIII-5: Total Annualized Enhanced Coagulation Costs ($/Year)

Treatment Technology	Surface Water Systems	Surface Water Systems AWWSCo Data
Enhanced Coagulation	109,488,776	0.00
EC/NH_2Cl	11,762,811	183,105,479
$EC+Oz/NH_2Cl$	12,175,334	39,236,888
EC+GAC10	717,683	0.00
EC+GAC20	717,683	0.00
TOTALS	**$135,682,949**	**222,342,367**

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2. Household Costs

In the 1994 proposal, EPA estimated that about 45 million households would incur no additional treatment costs for compliance with the Stage 1 DBPR. Of the 49 million households incurring treatment costs for compliance with Stage 1, EPA estimated that about 99% (48.6 million households) would incur costs ranging between $10 per year to $300 per year and 1% (0.2 million households) would incur costs of more than $300 per year. Annual household costs above $200 are projected predominantly for small systems that may be required to install membrane treatment. Some of these systems could find that there are less expensive options available, such as connecting into a larger regional water system. See Table VIII–6.

TABLE VIII–6.—AVERAGE COST PER HOUSEHOLD FOR COMPLIANCE TECHNOLOGIES ($/YEAR)

Treatment technology	Total surface water systems		Total ground water systems	
	<10,000	>10,000	<10,000	>10,000
Cl_2/NH_2Cl	$4.36	$0.69	$9.39	$1.10
Enhanced coagulation	10.48	6.70	0.00	0.00
EC/NH_2Cl	14.84	7.39	0.00	0.00
Oz/NH_2Cl	69.10	8.36	0.00	14.74
$EC+Oz/NH_2Cl$	79.58	15.06	0.00	0.00
EC+GAC10	0.00	27.39	0.00	0.00
Chlorine dioxide	0.00	74.97	0.00	0.00
EC+GAC20	0.00	3.06	0.00	0.00
Membranes	413.10	193.02	379.91	220.82

Monitoring and State Implementation Costs

Since the Advisory Committee made no recommendations that affected monitoring or State implementation, there are no changes to the cost analysis presented in the 1994 RIA accompanying the proposed Stage 1 DBPR. The estimates of monitoring and reporting costs to utilities and implementation costs to states have been adjusted for inflation and included in the total national cost summary presented in Table VIII–3.

D. DBP Exposure Estimates

The proposed rule included estimates of the baseline exposures and exposure after the Stage 1 DBPR for influent bromide levels; influent and effluent TOC levels; percent TOC removal; TTHM levels; and HAA5 levels (Table VIII–7). These data were applicable only to large surface water systems which filter but did not soften. Quantitative changes in exposure for TOC and DBPs were not predicted for ground water systems because of insufficient data.

Table VIII–7 presents profiles of exposure reflecting the baseline condition and the Stage 1 DBPR. The change in exposure is characterized in terms of TOC, TTHM, and HAA5. These data are applicable only to large systems (>10,000 population) which filter but do not soften.

TABLE VIII–7.—BASELINE COMPARISONS

	Influent TOC (mg/L)	% removal of TOC (%)	TTHM s (µg/L)	HAA5s (µg/L)
DBPRAM Baseline:				
Median	3.9	30	46	28
90th	8.4	57	90	65
DBPRAM Stage 1:				
Median	3.9	45	31	20
90th	8.4	67	52	40
WIDB 1996:				
Median	3.2	32	40	29
90th	6.1	62	70	60
AWWSCo 1991:				
Median	3.9	26	59	42
90th	7.8	58	83	88
AWWSCo 1992:				
Median	3.9	26	65	34
90th	7.8	58	87	79

Table VIII–7 presents a tabular comparison of distributional parameters for influent TOC, TOC removal, and distribution system TTHM and HAA5 levels from several different data sets. The table compares the DBPRAM baseline assumptions used in the 1994 Stage 1 RIA to the 1996 WIDB data and the 1991 and 1992 AWWSCo. data.

- The influent TOC levels assumed in the DBPRAM baseline are similar to those of the AWWSCo. data set. The median in both data sets is 3.9 mg/L. The 1996 WIDB data set, in contrast, has a median influent TOC of 3.2 mg/L.
- The DBPRAM assumed a baseline distribution of TOC removal of 30 percent at the median. This is comparable to a median TOC removal of 32 percent in the 1996 WIDB data. Median TOC removal in the 1991–92 AWWSCo. data is only 26 percent.
- The DBPRAM baseline assumptions are roughly similar to the 1996 WIDB data at the medians for TTHMs (46 vs. 40 µg/l) and HAA5 (28 vs 29 µg/l). The 1991 and 1992 AWWSCo. data are higher for both TTHM (59 and 65 µg/l)

and HAA5 (42 and 34 μg/l) at the medians.

AWWSCo. data consists of higher influent TOC levels and higher levels of DBPs than the 1996 WIDB data. Another conclusion to be drawn from Table VIII–7 is that the two different years of data provided by AWWSCo. are rather different from each other, illustrating year-to-year variability.

E. National Benefits Estimates

EPA developed a complete regulatory impact analysis (May 25, 1994) in support of the Negotiated Rulemaking process that ended with the proposed Stage 1 D/DBP Rule. Since the proposed rule, new data have become available that can be used to evaluate the impact forecasts made in the 1994 RIA. In addition, Advisory Committee recommendations, if incorporated into the rule (and into the companion IESWTR), would have effects on national benefit estimates.

The Advisory Committee recommendations that were evaluated for possible effects on the national benefit estimates include: allowance of ESWTR credit for disinfection prior to the point of coagulant addition; re-definition of TOC removal requirements for enhanced coagulation; and modification of disinfection requirements for an ESWTR.

The major new sources of information that were evaluated included: 1996 data from the WIDB on TOC, TTHM, HAA5, and disinfection practices; 1991 and 1992 data on TTHM and HAA5 from the AWWSCo.; as well as TOC data; plant schematics for ICR utilities; research data from numerous sources regarding the efficacy of enhanced coagulation (Krasner, 1997); and new research results produced in jar tests by TWG members documenting the effect of moving the point of predisinfection under varying conditions (Krasner, 1997).

1. Recap of Previous Benefits Analysis

The 1992–93 Regulatory Negotiation Committee, formed under the FACA, considered the full range of information and expert opinion available on the short-and long-term health risks associated with the complete catalogue of disinfection byproducts. Committee members had very different views. Some believed that cancer risks account for less than one case of cancer per year, while others believed that 10,000 cases per year was the correct order of magnitude. The lower bound baseline risk estimate was based on the maximum likelihood estimates of toxicological risk (best case estimates as opposed to upper 95% confidence bound estimates) associates with TTHM levels predicted by the DBPRAM (USEPA, 1994b). Not included in the lower bound estimate were any risks resulting from exposure to haloacetic acids (HAA5), bromate, or chloral hydrate. The upper bound estimated risk was based upon a study by Morris et al. (1992) in which the results from ten previously published epidemiology studies were combined. As discussed above, the use of the Morris study was questioned by some members of the negotiating committee.

In the end, the assessment of health risks was left in this broad range. Based on the DBPRAM modeling work, however, the 1994 RIA concludes that the proposed rule would have reduced median TTHM and HAA5 exposures by 33 and 29 percent, respectively. TOC exposure would be reduced by 12 percent at the median (*DBP RIA*, EPA, 1994. and Table VIII–7). In addition, this was achieved without triggering massive shifts to alternative disinfectants (ozone, chlorine dioxide, and chloramines), the health effects of which are not fully understood.

EPA received a comment addressing the concern for increasing the risk to the bromate exposure due to the increased number of systems that will switch to ozone. The compliance decision tree that was developed for the 1994 RIA using the DBPRAM indicated that 17 percent of systems would adopt advanced treatments (ozone, chlorine dioxide, GAC, or membranes) in order to comply with the Stage 1 MCLs. After a case-by-case reevaluation of the 1996 WIDB and AWWSCo. data sets by the members of the TWG, it was decided that fewer systems would require to shift to advanced technologies (6.5%). The TWG reevaluated the 1994 decision tree by considering the bromide levels for some systems. The TWG assumed that systems with high raw water bromide levels will not pick ozonation as their advanced technology and will choose other treatments like chlorine dioxide or GAC; therefore, there is no expected increase in bromate risk.

2. Current Benefits Analysis

When USEPA considered modifications to both the IESWTR and Stage 1 DBPR, the Stage 1 DBPR could result in reductions in TTHM and HAA5 exposures at the medians that are in a comparable range to these forecast in the original Stage 1 proposal. The extent of TOC removal may be somewhat less than forecast for the proposed rule, but not by as much as the difference in the proposed rule and NODA decision trees, because some of the previously estimated use of advanced technology may have been driven by increased IESWTR disinfection requirements. Also, it is possible that the use of chloramines will be greater under Advisory Committee recommendations than under the proposal. Based on this, USEPA estimates the level of benefits to be the same.

F. Cost-Effectiveness

The central requirement of regulatory impact analyses under Executive Order 12866 is to perform an analysis of net benefits and to consider the regulatory alternatives in light of a criterion of maximizing net benefits. This section summarizes the problem of regulating disinfection byproducts in terms of this economic perspective.

The understanding of net benefits in DBP control is complicated by the fact that there is a wide gulf in the scientific understanding of the health risks. During the 1992–93 Regulatory Negotiation, various Negotiating Committee members believed that cancer risks due to DBPs ranged from less than 1 case per year to over 10,000 cases per year. Reflecting this uncertainty, the 1994 RIA computed an implied cost per statistical case of cancer avoided in a range of $400,000 to $8 billion, fully bracketing—and underscoring—the range of uncertainty.

In the face of these uncertainties, most of the analyses undertaken by the 1992–93 Negotiation Committee, and the subsequent 1997 M-DBP Advisory Committee that developed the recommendations in this Notice, have used cost-effectiveness and household costs as a decision framework. In the 1994 RIA, EPA estimated that only 17 percent of systems would have to adopt expensive advanced treatments to comply. In the current analysis, that percentage is projected to be as low as 6.4 percent.

The household cost impacts based on the M-DBP Advisory Committee Recommendations and the revised national cost analysis, are summarized in Table VIII–6. The results show that 49 million of the 52 million households affected by the rule will pay about $10 or less per year for compliance. In the small proportion of systems where household costs are much greater (up to several hundreds of dollars per year), costs are driven by the assumption that membrane technology will be the selected treatment. However many of these systems may find less expensive means of compliance (e.g., purchased water). If systems do install membranes, they may realize additional water quality and compliance benefits beyond those associated with DBPs, such as

additional pathogen and turbidity removal.

IX. National Technology Transfer and Advancement Act

Under section 12(d) of the National Technology Transfer and Advancement Act (''NTTAA''), the Agency is required to use voluntary consensus standards in its regulatory activities unless to do so would be inconsistent with applicable law or otherwise impractical. Voluntary consensus standards are technical standards (e.g., materials specifications, test methods, sampling procedures, business practices, etc.) that are developed or adopted by voluntary consensus standards bodies. Where available and potentially applicable voluntary consensus standards are not used by EPA, the Act requires the Agency to provide Congress, through the Office of Management and Budget, an explanation of the reasons for not using such standards.

The analytical methods that are discussed in this Notice were, with two exceptions, developed and proposed prior to the enactment of the NTTAA. Since EPA is now requesting public comment on potential changes to the methods for the Stage 1 DBPR, the Agency felt it would be appropriate to also explain the requirements of the NTTAA and seek comment on these methods and possible modifications to these methods in that context as well.

EPA's process for developing the analytical test methods in the proposal and the potential modifications to those methods is similar to the requirements of the NTTAA. EPA performed literature searches to identify analytical methods from industry, academia, voluntary consensus standards bodies, and other parties that could be used to measure disinfectants, disinfection byproducts, and other parameters. In addition, EPA's development of the methods benefited from the recommendations of an Advisory Committee established under the Federal Advisory Committee Act to assist the Agency with the Stage 1 DBPR. The Committee made available additional technical experts who were well-versed in both existing analytical methods and new developments in the field. The results of these efforts formed the basis for the analytical methods in the 1994 proposed rule in which EPA included: six methods for measuring different disinfection byproducts, of which five are EPA methods and one is a voluntary consensus standard; nine methods for measuring disinfectants, all of which are voluntary consensus standards; two voluntary consensus methods for measuring total organic carbon (TOC); an EPA method for measuring bromide; and both governmental and voluntary consensus methods for measuring alkalinity. See proposed DBP regulations (USEPA 1994b) at 38751–38752 (July 29, l994). Where the only method proposed is an EPA method, there were either no voluntary consensus standards available or the standards did not meet EPA's data quality objectives.

In this Notice, as discussed in section V, above, EPA is requesting comment on possible changes to the proposed analytic methods, These possible changes are based on information received during public comment on the proposed regulations, or on new information that has become available since the l994 proposal. In general, the suggested modifications to the proposed methods are the result of improvements in both voluntary consensus methods and EPA methods, or the addition of methods that have been approved for other regulatory uses and might be used for the DBPR (e.g., Specific Ultraviolet Absorbance (SUVA) and TOC).

In this Notice, EPA discusses potential changes to the proposed methods and the reasons for the changes, and requests public comment on the possible modifications. The Agency also solicits comments on whether there are voluntary consensus standards that have not been addressed and should be considered for addition to the list of approved analytical methods in the final Stage 1 DBPR.

X. References

1. Adler, I.D. 1993. Synopsis of the in vivo results obtained with 10 known or suspected aneugens tested in the CEC collaborative study. Mutat Res 287:131–137.
2. Aieta, E.M., Roberts, P.V. and M. Hernandez. 1984. Determination of Chlorine Dioxide, Chlorine, Chlorite, and Chlorate in Water. Jour. Amer. Water Works Assoc. 76(1):64–70.
3. Allen, J.W., Collins, B.W., and P.A. Evansky. 1994. Spermatid micronucleus analysis of trichloroethylene and chloral hydrate in mice. Mutat Res 323:81–88.
4. Amy, G., et al. 1987. Comparing GPC and UF for the Molecular Weight Characterization of Aquatic Organic Matter. Jour. AWWA, 79:1:43.
5. APHA. Standard Methods for the Examination of Water and Wastewater, 18th Edition. American Public Health Association, Washington D.C., 1992.
6. APHA. Standard Methods for the Examination of Water and Wastewater, 19th Edition. American Public Health Association, Washington D.C., 1995.
7. APHA. Standard Methods for the Examination of Water and Wastewater, 19th Edition, Supplement. American Public Health Association, Washington D.C., 1996.
8. Austin, E.W., Parish, J.M., Kinder, D.H. and R. J. Bull 1996. Lipid peroxidation and formation of 8-hydroxydeoxyguanisine from acute doses halogenated acetic acids. Fundam Appl Toxicol. 31: 77–82.
9. Banerji, A.P. and A.O. Fernandes. 1996. Field bean protease inhibitor mitigates the sister-chromatid exchanges induced by bromoform and depresses the spontaneous sister-chromatid exchange frequency of human lymphocytes in vitro. Mutat. Res. 360(1):29–35.
10. Bove, F.J. M. Fulcomer, J. Klotz, et al., 1992a. Public Drinking Water Contamination and Birthweight, Fetal Deaths, and Birth Defects: A Cross Sectional Study (Phase IV–A), New Jersey Department of Health. April 1992.
11. Bove, F.J. M. Fulcomer, J. Klotz, et al., 1992b. Public Drinking Water Contamination and Birthweight, and Selected Birth Defects: A Case Control Study (Phase IV–B), New Jersey Department of Health. May 1992.
12. Bove, F.J., et al. 1995. Public Drinking Water Contamination and Birth Outcomes. Amer. J. Epidemiol., 141(9), 850–862.
13. CMA. 1997. Sodium Chlorite: Drinking Water Rat Two-Generation Reproductive Toxicity Study. Chemical Manufacturers Association. Quintiles Report Ref. CMA/17/96.
14. Cheng, R. C., Yates, R. S., Krasner, S. W. and S. Liang. 1995. Bench-Scale Evaluation of the Effects of Seasonal Change on TOC Removal by Enhanced Coagulation. Proc. 1995 AWWA Ann. Conf. (Water Quality), Anaheim, CA, June 18–22, 1995, pp. 197–216.
15. Chiu, N., Orme-Zavaleta, J., Chiu, A., Chen, C., DeAngelo, A., Brattin, W. and J. Blancato. 1996. Characterization of cancer risk associated with exposure to chloroform. Environ. Carcino. and Ecotox. Revs. C14(2):81–104.
16. Chowdhury, Z. 1997. Presentation to Technical Work Group January, 1997. Cincinnati, OH.
17. Clark, S.C., J. Wiginton, and J.T. Musgrove. 1994. Enhanced Lime Softening: Is Your TOC Removal Maxed Out? AWWA Enhanced Coagulation Workshop, December 1994.
18. Clark, S.C, D. Lawler. 1997. Enhanced Softening: Calcium, Magnesium, TOC and Geography. To be presented at the 1997 AWWA Water Quality Technology Conference, Denver, CO, November 9–12, 1997.
19. DeAngelo, A. B., Daniel, F. B., Most, B. M. and G. R. Olsen. 1997. The failure of monochloroacetic acid and trichloroacetic acid administered in the drinking water to produce liver cancer in male F344/N rats. J. Toxicol. Environ. Health (in press).
20. Dees, C. and C. Travis. 1994. Hyperphosphorylation of P53 induced by benzene, toluene, and chloroform. Cancer Letters. 84(2)117–123.

21. Dietrich, A.M. 1992. Drinking Water Issues Comprative Analytical Methods. 2nd International Symposium, Chlorine Dioxide and Drinking Water Issues. Houston, Texas; 163–173.
22. Edwards, M. 1997. Predicting DOC Removal During Enhanced Coagulation. Jour. AWWA (89:5:78).
23. Edwards, M., Benjamin, M. M. and J. N. Ryan. 1996. Role of Organic Acidity in Sorption of Natural Organic Matter (NOM) to Oxide Surfaces. Colloids and Surfaces A: Physicochemical and Engineering Aspects. V., 10:297.
24. Edzwald, J. K., and J. E. Van Benschoten. 1990. Aluminum Coagulation of Natural Organic Matter. Proc. Fourth Int'l Gothenburg Symposium on Chemical Treatment, Madrid, Spain (Oct. 1990).
25. Fox, A.W, Yang, X., Murli, H., et al. 1996. Absence of mutagenic effects of sodium dichloroacetate. Fundam Appl Toxicol 32:87–95.
26. Fox, T.R, A.M. Schumann, P.G. Watanabe, B.L. Yano, V.M. Maher and J.J. McCormick. 1990. Mutational analysis of the H-RAS oncogene in spontaneous C57BL/6 x C3H/HE mouse liver tumors and tumors induced with genotoxic and nongenotoxic hepatocarcinogens. Cancer Res. 50(13):4014–9.
27. Fujie, K., Aoki, T., Ito, Y. and S. Maeda. 1993. Sister-chromatid exchanges induced by trihalomethanes in rat erythroblastic cells and their suppression by crude catechin extracted from green tea. Mutat Res. 300(3–4):241–246.
28. Fuscoe, J. C., Afshari, A. J., George, M. H., DeAngelo, A. B., Tice, R. R., Salman, T. and J.W. Allen. 1996. In vivo genotoxicity of dichloroacetic acid: evaluation with the mouse peripheral blood micronucleus assay and the single cell gel assay. Environ Mol Mutagen 27:1–9.
29. Gao, P., Thornton-Manning, J. R. and R.A. Pegram. 1996. Protective effects of glutathione on bromodichloromethane in vivo toxicity and in vitro macromolecular binding in Fischer 344 rats. J. Toxicol. Environ. Health. 49(2):145–59.
30. Gates, D.J. 1988. Improvements in Chlorine Dioxide Use: A Two-Step Method for Determining Residual Oxidants in the Presence of Other Chlorine Species in Finished Water. Amer. Water Works Assoc. WQTC–16; 689–703.
31. Gemma, S., Ade, P., Sbraccia, M., Testai, E. and L. Vittozzi. 1996a. In vitro quantitative determination of phospholipid adducts of chloroform intermediates in hepatic and renal microsomes from different rodent strains. Environmental Toxicology and Pharmacology. 2(2–3):233–242.
32. Gemma. S., Faccioli, S., Chieco, P., Sbraccia, M., Testai, E. and L. Vittozzi. 1996b. In vivo CHCl3 bioactivation, toxicokinetics, toxicity, and induced compensatory cell proliferation in B6C3F1 male mice. Toxicol. Appl. Pharmacol. 141(2):394–402.
33. Gibson, D. P., Aardema, M. J. and G. A. Kerkaert. 1995. Detection of aneuploidy-inducing carcinogens in the Syrian hamster embryo (SHE) cell transformation assay. Mutat Res 343:7-24.
34. Haller, J.F. and S.S. Listek. 1948. Determination of Chlorine Dioxide and Other Active Chlorine Compounds in Water. Anal. Chem. 20, 639–642.
35. Harrington, RM, R.R Romano, D Gates, P. Ridgeway. 1995a. Subchronic Toxicity of Sodium Chlorite in the Rat. Journal of the American College of Toxicology. 14(1): 21–33.
36. Harrington, RM, R.R Romano, and L. Irvine. 1995b. Developmental Toxicity of Sodium Chlorite in the Rabbit. Journal of the American College of Toxicology. 14(2): 109–118.
37. Hayashi, M., Norppa, H., Sofuni T. and M. Ishidate Jr. 1992. Flow cytometric micronucleus test with mouse peripheral erythrocytes. Mutagenesis 7(4):257–264.
38. Hunter, E.D., E.H Rogers, J.E.Schmid, and A. Richard. 1996. Comparative Effects of Haloacetic Acids in Whole Embryo Culture. Teratology 54:57–64.
39. ILSI. 1995. Disinfection By-products in Drinking Water: Critical Issues in Health Effects Research. Workshop Report. International Life Sciences Institute October 23–25, 1995.
40. Kanitz, S. et al. 1996. Association Between Drinking Water Disinfection and Somatic Parameters at Birth. Environ. Health Perspectives, 104(5), 516–520.
41. King, W. D. and L. D. Maraud. 1996. Case-Control Study of Water Source and Bladder Cancer. Cancer Causes and Control, 7:596–604.
42. Klinefelter, G. R, Suarez, J. D. and N. L. Roberts. 1995. Preliminary screening test for the potential of drinking water disinfectant by-products to alter male reproduction. Reprod Toxicol 9:571–578.
43. Krasner, S. W. and G. Amy. 1995. Jar-test Evaluations of Enhanced Coagulation. Jour. AWWA (87:10:93).
44. Krasner, S. W., D. M. Owen, and J. E. Cromwell, III. 1996. Regulatory Impact Analysis of the Disinfectants—Disinfection By-Products Rule. In Water Disinfection and Natural Organic Matter: Characterization and Control (R. A. Minear & G. L. Amy, ed.). American Chemical Society, Washington, DC.
45. Krasner, S. W. 1997. Issue Paper on Enhanced Coagulation. Communication too the M-DPB Advisory Committee. April 4, 1997.
46. Larson, J. L., Wolf, D. C. and B. E. Butterworth. 1993. Acute hepatotoxic and nephrotoxic effects of chloroform in male F–344 rats and female B6C3F1 mice. Fundam. Appl. Toxicol. 20(3)302–15.
47. Larson, J. L., Wolf, D. C. and B. E. Butterworth. 1994a. Induced Cytotoxicity and cell proliferation in hepatocarcinogenicity of chloroform in Female B6C3F1 mice: comparison of administration by gavage in corn oil vs ad libitum in drinking water. Fundam. Appl. Toxicol. 22:90–102.
48. Larson, J. L., Wolf, D. C. and B. E. Butterworth. 1994b. Induced cytolethality and regenerative cell proliferation in the livers and kidneys of male B6C3F1 mice given chloroform by gavage. Fundam. Appl. Toxicol. 23(4):537–43.
49. Larson, J. L., Wolf, D. C., Morgan, K. T., Mery, S. and B. E. Butterworth. 1994c. The toxicity of 1-week exposures to inhaled chloroform in female B6C3F1 mice and male F344 rats. Fund. Appl. Toxicol. 22(3):431–446.
50. Larson, J. L., Sprankle, C. S. and B. E. Butterworth. 1994d. Lack of chloroform-induced DNA repair in vitro and in vivo in hepatocytes of female B6C3F1 mice. Environ. Mol. Mutagen. 23(2):132–6. 48. Larson, J. L., Wolf, D. C. and B. E. Butterworth. 1995a. Induced regenerative cell proliferation in livers and kidneys of male F344 rats. Toxicol. 95:73–86.
51. Larson, J. L., Wolf, D. C., Mery, S., Morgan, K. T. and B. E. Butterworth. 1995b. Toxicity and cell proliferation in the liver, kidneys, and nasal passages of female F–344 rats, induced by chloroform administered by gavage. Food Chem Toxicol 33(6):443–456.
52. Larson, J. L., Templin, M. V., Wolf, D. C. et al. 1996. A 90-day chloroform inhalation study in female and male B6C3F1 mice: Implications for cancer risk assessment. Fundam. Appl. Toxicol. 30:118–137.
53. Le Curieux, F., Gauthier, L., Erb, F. and D. Marzin. 1995. Use of the SOS chromotest, the Ames-fluctuation test and the newt micronucleus test to study the genotoxicity of four trihalomethanes. Mutagenesis. 10(4):333–41.
54. Lilly, P. D., Simmons, J. E. and R. A. Pegram. 1996. Effect of subchronic corn oil gavage on the acute toxicity of orally administered bromodichloromethane. Toxicol. Lett. 87(2–3):93–102.
55. Lilly, P. D.,Simmons, J. E. and R. A. Pegram. 1994. Dose-dependent vehicle differences in the acute toxicity of bromodichloromethane. Fundam. Appl. Toxicol. 23(1):132–140.
56. Linder, R.E., Klinefelter, G.R., Strader, L.F., Rao Veeramachaneni, D.N., Roberts, N.L. and J.D. Suarez. 1997a. Histopathologic changes in the testis of rats exposed to dibromoacetic acid. Reprod. Toxicol. (in press).
57. Linder, R.E., Klinefelter, G.R., Strader, L.F., Suarez, J.D. and N.L. Roberts. 1997b. Spermatotoxicity of dichloroacetic acid. Reprod. Toxicol. (in press).
58. Linder, R.E., Klinefelter, G.R., Strader, L.F., Narotsky, M.G., Suarez, J.D., Roberts, N.L. and S.D. Perreault. 1995. Dibromoacetic acid affects reproductive competence and sperm quality in the male rat. Fund. Appl. Toxicol. 28:9–17.
59. Linder, R.E., Klinefelter, G.R., Strader, L.F., Suarez, J.D. and C.J. Dyer. 1994. Acute spermatogenic effects of bromoacetic acids. Fund. Appl. Toxicol. 22:422–430.

60. Mackay, J. M., Fox V., Griffiths, K. et al. 1995. Trichloroacetic acid: investigation into the mechanism of chromosomal damage in the in vitro human lymphocyte cytogenetic assay and the mouse bone marrow micronucleus test. Carcinogenesis 16:1127–1133.
61. Matsuoka, A., Yamakage, K., Kusakabe, H., Wakuri, S., Asakura, M., Noguchi, T., Sugiyama, T., Shimada, H., Nakayama, S., Kasahara, Y., Takahashi, Y., Miura, K. F., Hatanaka, M., Ishidate Jr., M., Morita, T., Watanabe, K., Hara, M., Odawara, K., Tanaka, N., Hayashi, M. and T. Sofuni. 1996. Re-evaluation of chromosomal aberration induction on nine mouse lymphoma assay ''unique positive'' NTP carcinogens. Mutat. Res. 369(3–4):243–52.
62. McGeehin, M. A. et al. 1993. Case-Control Study of Bladder Cancer and Water Disinfection Methods in Colorado. Am. J. Epidemiology, 138:492–501.
63. Miyagawa, M., Takasawa, H., Sugiyama, A., Inoue, Y., Murata, T., Uno, Y. and K. Yoshikawa. 1995. The *in vivo-in vitro* replicative DNA synthesis (RDS) test with hepatocytes prepared from male B6C3F1 mice as an early prediction assay for putative nongenotoxic (Ames-negative) mouse hepatocarcinogens. Mutat. Res. 343(2–3)157–183.
64. Mobley, S.A, D.H. Taylor, R.D. Laurie, and R.J. Pfohl. 1990. Chlorine dioxide depresses T3 uptake and delays development of locomotor activity in young rats. In: Water Chlorination: Chemistry, Environmental Impact and Health Effects. Vol 6. Lolley, Condie, Johnson, Katz, Mattice and Jacobs, ed. lewis Publ., Inc. Chelsea MI., pp. 347–360.
65. Morris, R. D. et al. 1992. Chlorination, Chlorination By-products, and Cancer: A Meta-Analyis. American Journal of Public Health, 82(7): 955–963.
66. Nakajima, T., E. Elovaara, T. Okino, H.V. Gelboin, M. Klockars, V. Riihimaki, T. Aoyama and H. Vainio. 1995. Different contributions of cytochrome P450 2E1 and P450 2B1/2 to chloroform hepatotoxicity in rat. Toxicology and Applied Pharmacology. 133(2):215–222.
67. Ni, Y. C., Wong, T.Y., Lloyd, R. V., et al. 1996. Mouse liver microsomal metabolism of chloral hydrate, trichloroacetic acid, and trichloroethanol leading to induction of lipid peroxidation via a free radical mechanism. Drug Metab Dispos 24:81–90.
68. NTP. 1990. National Toxicology Program. NTP technical report on the toxicology and carcinogenesis studies of monochloroacetic acid (CAS No. 79–11–8) in F344/N rats and B6C3F1.
69. Orme, J. D.H. Taylor, R.D. Laurie, and R.J. Bull. 1985. Effects of Chlorine Dioxide on Thyroid Function in Neonatal Rats. J. Tox. and Environ. Health. 15:315–322.
70. Owen, D. M.; Amy, G. L. and Z. K. Chowdhury. 1993. Characterization of Natural Organic Matter and Its Relationship to Treatability. AWWA Research Foundation & AWWA, Denver, CO.
71. Parrish, J. M., Austin, E. W., Stevens, D. K., Kinder, D. H. and R. J. Bull 1996. Haloacetate-induced oxidative damage to DNA in the liver of male $B6C3F_1$ mice. Toxicology 110:103–111.
72. Parry, J. M., Parry, E. M., Bourner, R., et al. 1996. The detection and evaluation of aneugenic chemicals. Mutat Res 353:11–46.
73. Pegram, R. A., Andersen, M. E., Warren, S. H., Ross, T. M. and L. D. Claxton. 1997. Glutathione S-transferase-mediated mutagenicity of trihalomethanes in *Salmonella typhimurium:* Contrasting results with bromodichloromethane and chloroform. Toxicol. Appl. Pharmacol. 144:183–188.
74. Pereira, M. A. 1996. Carcinogenic activity of dichloroacetic acid and trichloroacetic acid in liver of female $B6C3F_1$ mice. Fundam. Appl.. Toxicol. 31:192–199.
75. Pereira, M.A. and J.B. Phelps. 1996. Promotion by dichloroacetic acid and trichloroacetic acid of N-methyl-N-nitrosourea-initiated cancer in the liver of female $B6C3F_1$ mice. Cancer Lett. 102:133–141.
76. Potter, C.L., L.W. Chang, A.B. DeAngelo and F.B. Daniel. 1996. Effects of four trihalomethanes on DNA strand breaks, renal hyaline droplet formation and serum testosterone in male F–344 rats. Cancer Letters. 106 (2):235–242.
77. Randtke, S. J.; Hoehn, R. C.; Knocke, W. R.; Dietrich, A. M.; Long, B. W.; and N. A. Wang. Comprehensive Assessment of DBP Precursor Removal by Enhanced Coagulation and Softening. Proc. 1994 AWWA Ann. Conf. (Water Quality), New York, NY, pp. 737–777.
78. Reif, J. S. et al. 1996. Reproductive and Developmental Effects of Disinfection By-products in Drinking Water. Environmental Health Prospectives. 104(10):1056–1061.
79. Richard, A.M. and E.M Hunter. 1996. Quantitative Structure-Activity Relationships for the Developmental Toxicity of Haloacetic Acids in Mammalian Whole Embryo Culture. Teratology 53:352–360.
80. Roldan-Arjona, T. and C. Pueyo. 1993. Mutagenic and lethal effects of halogenated methanes in the Ara test of *Salmonella typhimurium:* Quantitative relationship with chemical reactivity. Mutagenesis. 8 (2):127–131.
81. Saillenfait, A. M., Langonne, I. and J. P. Sabate, 1995. Developmental toxicity of trichloroethylene, tetrachloroethylene and four of their metabolites in rat whole embryo culture. Arch Toxicol 70:71–82.
82. Savitz, D. A., Andrews, K. W. and L. M. Pastore. 1995. Drinking Water and Pregnancy Outcome in Central North Carolina: Source, Amount, and Trihalomethane levels. Environ. Health Perspectives. 103(6), 592–596.
83. Shelby, M. D. and K. L. Witt. 1995. Comparison of results from mouse bone marrow chromosome aberration and micronucleus tests. Environmental and Molecular Mutagenesis. 25(4):302–313.
84. Shorney, H. L. and S. J. Randtke. 1994. ''Enhanced Lime softening for Removal of Disinfection By-Product Precursors,'' Proceedings 1994 AWWA Annual Conference, New York, NY.
85. Shorney, H. L., Randtke, S. J., Hargette, P. H., Mann, P. D., Hoehn, R.C., Knocke, W. R., Dietrich, A. M. and B. W. Long. ''The Influence of Raw Water Quality on Enhanced Coagulation and Softening for the Removal of NOM and DBP Formation Potential'', Proceedings 1996 AWWA Annual Conference, Toronto, Ontario, Canada.
86. Singer, P. C., Harrington, G. W., Thompson, J. D. and M. C. White. 1995. Enhanced Coagulation and Enhanced Softening for the Removal of Disinfection By-Product Precursors: An Evaluation. Report prepared for the AWWA Government Affairs Office, Washington, DC, by the Dept. of Environmental Sciences and Engineering, UNC, Chapel Hill, NC.
87. Singer, P. C., Harrington, G. W., Thompson, J. and M. White. ''Enhanced Coagulation and Enhanced Softening for the Removal of Disinfection By-Product Precursors: An Evaluation,'' Report to AWWA Disinfectants/Disinfection By-Products Technical Advisory Workgroup of the Water Utility Council, December 1996.
88. Sofuni, T., Honma, M., Hayashi, M., Shimada, H., Tanaka, N., Wakuri, S., Awogi, T., Yamamoto, K. I., Nishi, Y. and M. Nakadate. 1996. Detection of in vitro clastogens and spindle poisons by the mouse lymphoma assay using the microwell method: interim report of an international collaborative study. Mutagenesis 11(4):349–55.
89. Solarik, G., V.A. Hatcher, R.S. Isabel, J.F. Stile, and R.S. Summers. 1997. Prechlorination and DBP Formation: The Impact of Chlorination Point and Enhanced Coagulation, *Proceedings*, AWWA Water Quality Technology Conference, Denver, CO.
90. Sprankle, C.S., J.L. Larson, S.M. Goldsworthy and B.E.Butterworth. 1996. Levels of myc, fos, Ha-ras, met and hepatocyte growth factor mRNA during regenerative cell proliferation in female mouse liver and male rat kidney after a cytotoxic dose of chloroform. Cancer Lett 101(1):97–106.
91. Summers, R.S., S.M. Hooper, H.M. Shukairy, G. Solarik, and D.M. Owen. 1996. Assessing DBP Yields: Uniform Formation Conditions, *Journal AWWA*, 88:6:80.
92. Summers, R.S., G. Solarik, V.A. Hatcher, R.S. Isabel, and J.F. Stile. 1997. Analyzing the Impacts of Predisinfection Through Jar Testing, *Proceedings*, AWWA Water Quality Technology Conference, Denver, CO.
93. Tao, L., Li, K., Kramer, P.M., et al. 1996. Loss of heterozygosity on chromosome 6 in dichloroacetic acid and trichloroacetic acid-induced liver tumors in female $B6C3F_1$ mice. Cancer Lett 108:257–261.

94. Templin, M.V., Jamison, K.C., Wolf, D.C., Morgan, K.T. and B.E. Butterworth. 1996a. Comparison of chloroform-induced toxicity in the kidneys, liver, and nasal passages of male Osborne-Mendel and F–344 rats. Cancer Lett. 104(1):71–8.
95. Templin, M.V., Larson, J.L., Butterworth, B.E., Jamison, K.C., Leininger, J.R., Mery, S., Morgan, K.T., Wong, B.A. and D.C. Wolf. 1996b. A 90-day chloroform inhalation study in F-344 rats: Profile of toxicity and relevance to cancer studies. Fund. Appl. Toxicol. 32:109–125.
96. Testai, E., Di Marzio, S., Di Domenico, A., Piccardi, A. and L. Vittozzi. 1995. An in vitro investigation of the reductive metabolism of chloroform. Arch. Toxicol. 70(2):83–8.
97. Thornton-Manning, J.R., J.C. Seely and R.A. Pegram. 1994. Toxicity of bromodichloromethane in female rats and mice after repeated oral dosing. Toxicology 94(1–3):3–18.
98. Thurman, E.M., and R.L. Malcolm. 1981. Preparative Isolation of Aquatic Humic Substances. Envir. Sci. Technol., 15:4:463 (April 1981).
99. Tseng, T. and M. Edwards. 1997. Considerations in Optimizing Coagulation. Proc. 1996 AWWA Water Qual. Technol. Conf., Boston, Mass.
100. U.S. EPA. 1979. National Interim Primary Drinking Water Regulations; Control of Trihalomethanes in Drinking Water. Fed. Reg., 44:231:68624. (November 29, 1979.)
101. U.S. EPA. 1989a. National Primary Drinking Water Regulations; Filtration, Disinfection; Turbidity, *Giardia lamblia*, Viruses, *Legionella*, and Heterotrophic Bacteria; Final Rule. Part II. Fed. Reg., 54:124:27486. (June 29, 1989)
102. U.S. EPA 1989b. Natioanl Primary Drinking Water Regulations; Total Coliforms (Including Fecal Coloform and E. Coli); Final Rule. Fed. Reg., 54:124:27544. (June 29, 1989)
103. U.S. EPA. 1992a. Occurrence and Assessment for Disinfectants and Disinfection By-products (Phase 6a) in Drinking Water. U.S. Environmental Protection Agency.
104. U.S. EPA. 1992b. Methods for the Determination of Organic Compounds in Drinking Water-Supplement II. EPA/600R–92/129. NTIS, PB92–207703.
105. U.S.EPA. 1992c. Technologies and Costs for Control of Disinfectant By-Products. USEPA, December, 1992.
106. U.S. EPA. 1993a. Methods for the Determination of Inorganic Substances in Environmental Samples. EPA–600/R–93/100. NTIS, PB94120821.
107. U.S. EPA/ILSI. 1993b. A Review of Evidence on Reproductive and Developmental Effects of Disinfection By-Products in Drinking Water. Washington: U.S. Environmental Protection Agency and International Life Sciences Institute.
108. U.S. EPA. 1994a. Workshop Report and Recommendations for Conducting Epidemiologic Research on Cancer and Exposure to Chlorinated Drinking Water. U.S. EPA, July 19–21, 1994.
109. U.S. EPA. 1994b. National Primary Drinking Water Regulations; Disinfectants and Disinfection Byproducts; Proposed Rule. Fed. Reg., 59:145:38668. (July 29, 1994).
110. U.S. EPA. 1994c. National Primary Drinking Water Regulations; Enhanced Surface Water Treatment Requirements; Proposed Rule. Fed. Reg., 59:145:38832. (July 29, 1994).
111. U.S. EPA. 1994d. National Primary Drinking Water Regulations; Monitoring Requirements for Public Drinking Water Supplies; Proposed Rule. Fed. Reg., 59:28:6332. (February 10, 1994).
112. U.S. EPA. 1995. Methods for the Determination of Organic Compounds in Drinking Water. Supplement III. EPA–600/R–95/131. NTIS, PB95261616.
113. U.S. EPA. 1996a. Proposed Guidelines for Carcinogen Risk Assessment. U.S.EPA, April 23, 1996.
114. U.S. EPA. 1996b. National Primary Drinking Water Regulations: Monitoring Requirements for Public Drinking Water Supplies; Final Rule. Fed. Reg., 61:94:24354. (May 14, 1996)
115. U.S. EPA. 1997a. Occurrence and Assessment for Disinfectants and Disinfection Byproducts in Public Drinking Water Supplies. Preliminary Draft. U.S. Environmental Protection Agency.
116. U.S. EPA. 1997b. Summaries of New Health Effects Data. Office of Science and Technology, Office of Water. October 1997.
117. U.S. EPA. 1997c. Method 300.1, Determination of Inorganic Anions in Drinking Water by Ion Chromatography. Revision 1.0. USEPA National Exposure Research Laboratory, Cincinnati, OH.
118. U.S. EPA. 1997d. Guidance Manual for Enhanced Coagulation and Enhanced Precipitative Softening. Preliminary Draft. U.S. Environmental Protection Agency.
119. Vena, J.E. et al. 1993. Drinking Water, Fluid Intake, and Bladder Cancer in Western New York. Arch. of Environ. Health, 458(3):191–198.
120. Vorce, R.L. and J.I. Goodman. 1991. Hypomethylation of ras oncogenes in chemically induced and spontaneous B6C3F1 mouse liver tumors. J. Toxicol Environ Health 34(3):367–84.
121. White, M.C., Thompson, J.D., Harrington, G.W., and P.S. Singer. 1997. Evaluating Criteria for Enhanced Coagulation Compliance. AWWA, 89:5:64.
122. Wolfe, G., and Kaiser, L. 1996. Final Report. Sodium Bromate: Short Term Reproductive and Developmental Toxicity Study when administered to sprague-Dawley Rats in the Drinking water. Study No. NTP–REST. 94007. NTP/NIEHS No. NOI–ES–15323.
123. Xie, Yuefeng. 1995. Effects of Sodium Chloride on DBP Analytical Results, Extended Abstract, Division of Environmental Chemistry, American Chemical Society Annual Conference, Chicago, IL, Aug. 21–26, 1995.

Dated: October 22, 1997.

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Appendix 1—U.S. Environmental Protection Agency; Microbial Disinfection By-Products (M/DBP), Federal Advisory Committee

Agreement in Principle

1.0 Introduction

Pursuant to requirements under the Safe Drinking Water Act (SDWA), the Environmental Protection Agency (EPA) is developing interrelated regulations to control microbial pathogens and disinfectants/disinfection byproducts (D/DBPs) in drinking water. These rules are collectively known as the microbial/disinfection byproducts (M/DBP) rules.

The regulations are intended to address complex risk trade-offs between the two different types of contaminants. In keeping with the agreement reached during the 1992–93 negotiated rulemaking on these matters, EPA issued a Notice of Proposed Rulemaking for Disinfection By-Products Stage I on July 29, 1994. EPA also issued a Notice of Proposed Rulemaking for an Interim Enhanced Surface Water Treatment Rule (IESWTR) on July 29, 1994. Finally, in May 1996, EPA promulgated a final Information Collection Rule (ICR), to obtain data on source water quality, byproduct formation and drinking water treatment plant design and operations.

As part of recent amendments to the SDWA, Congress has established deadlines for all the M/DBP rules, beginning with a November 1998 deadline for promulgation of both the IESWTR and the Stage I D/DBP Rule. To meet this new deadline, EPA initiated an expedited schedule for development of these two rules. Building on the 1994 proposals, EPA intends to issue a Notice of Data Availability (NODA) in November 1997 for public comment. EPA also decided to establish a committee under the Federal Advisory Committee Act (FACA) for development of the rules.

The M/DBP Advisory Committee is made up of organizational members (parties) named by EPA (see Attachment A). The immediate task of the Committee has been to discuss, evaluate and provide advice on data, analysis and approaches to be included in the NODA to be published in November 1997. This Committee met four times from March through June 1997, with the initial objective to reach consensus, where possible, on the elements to be contained in the D/DBP Stage I and IESWTR NODA. Where consensus was not reached, the Committee sought to develop options and/or to clarify key issues and areas of agreement and disagreement. This document is the Committee's statement on the points of agreement reached.

2.0 Agreement in Principle

The Microbial and Disinfection By-Products Federal Advisory Committee considered the technical and policy issues involved in developing a DBP Stage I rule and an IESWTR under the Safe Drinking Water Act and recommends that the Environmental Protection Agency base the

applicable sections of its anticipated M/DBP Notice of Data Availability (NODA) on the elements of agreement described below.

This agreement in principle represents the consensus of the parties on the best conceptual principles that the Committee was able to generate within the allocated time and resources available.

The USEPA, a party to the negotiations, agrees that:

1. The person signing this agreement is authorized to commit this party to its terms.

2. EPA agrees to hold a meeting in July 1997 following circulation of a second draft of the NODA to obtain comments from the parties and the public on the extent to which the applicable sections of the draft NODA are consistent with the agreements below.

3. Each party and individual signatory that submits comments on the NODA agrees to support those components of the NODA that reflect the agreements set forth below. Each party and individual signatory reserves the right to comment, as individuals or on behalf of the organization he or she represents, on any other aspect of the Notice of Data Availability.

4. EPA will consider all relevant comments submitted concerning the Notice(s) of Proposed Rulemaking and in response to such comments will make such modifications in the proposed rule(s) and preamble(s) as EPA determines are appropriate when issuing a final rule.

5. Recognizing that under the Appointments Clause of the Constitution governmental authority may be exercised only by officers of the United States and recognizing that it is EPA's responsibility to issue final rules, EPA intends to issue final rules that are based on the provisions of the Safe Drinking Water Act, pertinent facts, and comments received from the public.

6. Each party agrees not to take any action to inhibit the adoption of final rule(s) to the extent it and corresponding preamble(s) have the same substance and effect as the elements of this agreement in principle.

2.1 MCLs

MCLs should remain at the levels proposed: 0.080 mg/l for TTHMs, 0.060 mg/l for HAA5, and 0.010 mg/l for bromate.

2.2 Enhanced Coagulation

The proposed enhanced coagulation provisions should be revised as follows:

a. The top row of the TOC removal table (3x3 matrix) should be modified for systems that practice enhanced coagulation by lowering the TOC removal percentages by 5 percent across the top row, while leaving the other rows the same.

b. SUVA (specific UV absorbance) should be used for determining whether systems would be required to use enhanced coagulation. The use of a raw water SUVA < 2.0 liter/mg-m as a criterion for not requiring a system to practice enhanced coagulation should be added to those proposed in § 141.135(a)(1) (i)–(iv).

c. For a system required to practice enhanced coagulation or enhanced softening, the use of a finished water SUVA < 2.0 liter/mg-m should be added as a step 2 procedure. Such a criterion would be in addition to the proposed step 2 procedure, not in lieu of it.

d. The proposed TOC removals for softening systems should be modified by lowering the value for TOC removal in the matrix at alkalinity > 120 mg/l and TOC between 2–4 mg/l by 5 percent (which would make it equal to the value for non-softening systems) and leaving the remaining values as proposed.

e. If a system is required to practice enhanced softening, lime softening plants would not be required to perform lime soda softening or to lower alkalinity below 40–60 mg/l as part of any step 2 procedure.

f. There is no need to separately address softening systems in the 3x3 matrix or the Step 1 regulatory language, which was identical to enhanced coagulation regulatory language in the proposed D/DBPR. The revised matrix should appear as follows:

	Alkalinity (mg/l)		
TOC (mg/l)	0 – <60	60 – <120	≥120
2–4	35	25	15
4–8	45	35	25
>8	50	40	30

2.3 Microbial Benchmarking/Profiling

A microbial benchmark to provide a methodology and process by which a PWS and the State, working together, assure that there will be no significant reduction in microbial protection as the result of modifying disinfection practices in order to meet MCLs for TTHM and HAA5 should be established as follows:

A. *Applicability.* The following PWSs to which the IESWTR applies must prepare a disinfection profile:

(1) PWSs with measured TTHM levels of at least 80% of the MCL (0.064 mg/l) as an annual average for the most recent 12 month compliance period for which compliance data are available prior to November 1998 (or some other period designated by the State),

(2) PWSs with measured HAA5 levels of at least 80% of the MCL (0.048 mg/l) as an annual average for the most recent 12 month period for which data are available (or some other period designated by the State)—In connection with HAA5 monitoring, the following provisions apply:

(a) PWSs that have collected HAA5 data under the Information Collection Rule must use those data to determine the HAA5 level, unless the State determines that there is a more representative annual data set.

(b) For those PWSs that do not have four quarters of HAA5 data 90 days following the IESWTR promulgation date, HAA5 monitoring must be conducted for four quarters.

B. *Disinfection profile.* A disinfection profile consists of a compilation of daily *Giardia lamblia* log inactivations (or virus inactivations under conditions to be specified), computed over the period of a year, based on daily measurements of operational data (disinfectant residual concentration(s), contact time(s), temperature(s), and where necessary, pH(s)). The PWS will then determine the lowest average month (critical period) for each 12 month period and average critical periods to create a ''benchmark'' reflecting the lower bound of a PWS's current disinfection practice. Those PWSs that have all necessary data to determine profiles, using operational data collected prior to promulgation of the IESWTR, may use up to three years of operational data in developing those profiles. Those PWSs that do not have three years of operational data to develop profiles must conduct the necessary monitoring to develop the profile for one year beginning no later than 15 months after promulgation, and use up to two years of existing operational data to develop profiles.

C. *State review.* The State will review disinfection profiles as part of its sanitary survey. Those PWSs required to develop a disinfection profile that subsequently decide to make a significant change in disinfection practice (i.e., move point of disinfection, change the type of disinfectant, change the disinfection process, or any other change designated as significant by the State) must consult with the State prior to implementing such a change. Supporting materials for such consultation must include a description of the proposed change, the disinfection profile, and an analysis of how the proposed change will affect the current disinfection.

D. *Guidance.* EPA, in consultation with interested stakeholders, will develop detailed guidance for States and PWSs on how to develop and evaluate disinfection profiles, identify and evaluate significant changes in disinfection practices, and guidance on moving the point of disinfection from prior to the point of coagulant addition to after the point of coagulant addition.

2.4 Disinfection Credit

Consistent with the existing provisions of the 1989 Surface Water Treatment Rule, credit for compliance with applicable disinfection requirements should continue to be allowed for disinfection applied at any point prior to the first customer.

EPA will develop guidance on the use and costs of oxidants that control water quality problems (e.g., zebra mussels, Asiatic clams, iron, manganese, algae) and whose use will reduce or eliminate the formation of DBPs of public health concern.

2.5 Turbidity

Turbidity Performance Requirements. For all surface water systems that use conventional treatment or direct filtration, serve more than 10,000 people, and are required to filter: (a) the turbidity level of a system's combined filtered water at each plant must be less than or equal to 0.3 NTU in at least 95 percent of the measurements taken each month and, (b) the turbidity level of a system's combined filtered water at each plant must at no time exceed 1 NTU. For both the maximum and the 95th percentile requirements. Compliance shall be determined based on measurements of the combined filter effluent at four-hour intervals.

Individual Filter Requirements. All surface water systems that use rapid granular filtration, serve more than 10,000 people, and are required to filter shall conduct continuous monitoring of turbidity for each individual filter and shall provide an exceptions report to the State on a monthly

basis. Exceptions reporting shall include the following: (1) any individual filter with a turbidity level greater than 1.0 NTU based on 2 consecutive measurements fifteen minutes apart; and (2) any individual filter with a turbidity level greater than 0.5 NTU at the end of the first 4 hours of filter operation based on 2 consecutive measurements fifteen minutes apart. A filter profile will be produced if no obvious reason for the abnormal filter performance can be identified.

If an individual filter has turbidity levels greater than 1.0 NTU based on 2 consecutive measurements fifteen minutes apart at any time in each of 3 consecutive months, the system shall conduct a self-assessment of the filter utilizing as guidance relevant portions of guidance issued by the Environmental Protection Agency for Comprehensive Performance Evaluation (CPE). If an individual filter has turbidity levels greater than 2.0 NTU based on 2 consecutive measurements fifteen minutes apart at any time in each of two consecutive months, the system will arrange for the conduct of a CPE by the State or a third party approved by the State.

State Authority. States must have rules or other authority to require systems to conduct a Composite Correction Program (CCP) and to assure that systems implement any follow-up recommendations that result as part of the CCP.

2.6 Cryptosporidium MCLG

EPA should establish an MCLG to protect public health. The Agency should describe existing and ongoing research and areas of scientific uncertainty on the question of which species of *Cryptosporidium* represents a concern for public health (e.g. *parvum, muris, serpententious*) and request further comment on whether to establish an MCLG on the genus or species level.

In the event the Agency establishes an MCLG on the genus level, EPA should make clear that the objective of this MCLG is to protect public health and explain the nature of scientific uncertainty on the issue of taxonomy and cross reactivity between strains. The Agency should indicate that the scope of MCLG may change as scientific data on specific strains of particular concern to human health become available.

2.7 Removal of Cryptosporidium

All surface water systems that serve more than 10,000 people and are required to filter must achieve at least a 2 log removal of *Cryptosporidium*. Systems which use rapid granular filtration (direct filtration or conventional filtration treatment—as currently defined in the SWTR), and meet the turbidity requirements described in Section 2.5 are assumed to achieve at least a 2 log removal of *Cryptosporidium*. Systems which use slow sand filtration and diatomaceous earth filtration and meet existing turbidity performance requirements (less than 1 NTU for the 95th percentile or alternative criteria as approved by the State) are assumed to achieve at least a 2 log removal of *Cryptosporidium*.

Systems may demonstrate that they achieve higher levels of physical removal.

2.8 Multiple Barrier Concept

EPA should issue a risk-based proposal of the Final Enhanced Surface Water Treatment Rule for *Cryptosporidium* embodying the multiple barrier approach (e.g. source water protection, physical removal, inactivation, etc.), including, where risks suggest appropriate, inactivation requirements. In establishing the Final Enhanced Surface Water Treatment Rule, the following issues will be evaluated:

- Data and research needs and limitations (e.g. occurrence, treatment, viability, active disease surveillance, etc.);
- Technology and methods capabilities and limitations;
- Removal and inactivation effectiveness;
- Risk tradeoffs including risks of significant shifts in disinfection practices;
- Cost considerations consistent with the SDWA;
- Reliability and redundancy of systems;
- Consistency with the requirements of the Act.

2.9 Sanitary Surveys

Sanitary surveys operate as an important preventive tool to identify water system deficiencies that could pose a risk to public health. EPA and ASDWA have issued a joint guidance dated 12/21/95 on the key components of an effective sanitary survey. The following provisions concerning sanitary surveys should be included.

I. Definition

(A) A sanitary survey is an onsite review of the water source (identifying sources of contamination using results of source water assessments where available), facilities, equipment, operation, maintenance, and monitoring compliance of a public water system to evaluate the adequacy of the system, its sources and operations and the distribution of safe drinking water.

(B) Components of a sanitary survey may be completed as part of a staged or phased state review process within the established frequency interval set forth below.

(C) A sanitary survey must address each of the eight elements outlined in the December 1995 EPA/STATE Guidance on Sanitary Surveys.

II. Frequency

(A) Conduct sanitary surveys for all surface water systems (including groundwater under the influence) no less frequently than every three years for community systems except as provided below and no less frequently than every five years for noncommunity systems.

—May ''grandfather''sanitary surveys conducted after December 1995, if they address the eight sanitary survey components outlined above.

(B) For community systems determined by the State to have outstanding performance based on prior sanitary surveys, successive sanitary surveys may be conducted no less than every five years.

III. Follow Up

(A) Systems must respond to deficiencies outlined in a sanitary survey report within at least 45 days, indicating how and on what schedule the system will address significant deficiencies noted in the survey.

(B) States must have the appropriate rules or other authority to assure that facilities take the steps necessary to address significant deficiencies identified in the survey report that are within the control of the PWS and its governing body.

Agreed to by:

_____

Name, Organization

_____

Date

Signed By:

Peter L. Cook, National Association of Water Companies
Michael A. Dimitriou, International Ozone Association
Cynthia C. Dougherty, US Environmental Protection Agency
Mary J.R. Gilchrist, American Public Health Association
Jeffrey K. Griffiths, National Association of People with AIDS
Barker Hamill, Association of State Drinking Water Administrators
Robert H. Harris, Environmental Defense Fund
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Rosemary Menard, Large Unfiltered Systems
Erik D. Olson, Natural Resources Defense Council
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